FINAL REPORT

LOS ANGELES COUNTY 1994-2000 INTEGRATED RECEIVING WATER IMPACTS REPORT

July 31, 2000

Prepared by

Los Angeles County Department of Public Works
900 South Fremont Avenue
Alhambra, California 91803

And

Southern California Coastal Waters Research Project
SCCWRP

7171 Fenwick Lane
Westminster, California 92683

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Oakland, California 94607

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Upon 72 hours' notice, the Los Angeles County Department of Public Works (DPW) can provide program information and publications in alternate formats or make other accommodations for people with disabilities. In addition, program documents are available at the DPW main office in Alhambra (900 So. Fremont Ave.), which is accessible to individuals with disabilities. To request accommodations ONLY, or for more ADA information, please contact the DPW's departmental ADA Coordinator at (626) 458-4081 or TDD (626) 282-7829, Monday through Thursday, from 7:00 a.m. to 5:30 p.m.

ACOE	Army Corps of Engineers
ACWM	Department of Agricultural Commissioner/Weights and Measures
ADA	Americans with Disabilities Act
ANOVA	analysis of variance
BMPs	Best Management Practices
BOD_5	biochemical oxygen demand (five day)
COD	chemical oxygen demand
CV	coefficient of variation
DDT	dichlorodiphenyltrichloroethane
DF	degrees of freedom
DL	detection limit
EC_{50}	effective concentration for 50% reduction in fertilization
EMCs	Event Mean Concentrations
GIS	Geographical Information Systems
HDSFR	high density single family residential
ID	identification
LACDPW	Los Angeles County Department of Public Works
LAX	Los Angeles International Airport
mg/l	milligrams per liter
µg/l	micrograms per liter
NOEC	no observed effects concentration
NPDES	National Pollutant Discharge Elimination System
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
pH	negative logarithm of hydrogen ion concentration
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
ROWD	Report of Waste Discharge
RWQCB	Regional Water Quality Control Board
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Waters Research Project
SIC	Standard Industrial Classification
SID	statistically invalid data

TMDL	total maximum daily load
TKN	total Kjeldahl nitrogen
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TU	toxicity units
UCLA	University of California, Los Angeles
USEPA	United States Environmental Protection Agency
WDR	waste discharge requirements
WMA	Watershed Management Area
WQC	water quality criteria

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EXECUTIVE SUMMARY

Since the 1994-95 storm season, the County of Los Angeles Department of Public Works has endeavored to monitor and characterize stormwater water quality under the Los Angeles NPDES Municipal Stormwater Permits. The first two years of monitoring fell under the 1990 Permit, while the current monitoring program is defined in the 1996 Permit. The current monitoring program has consisted of four major elements: Santa Monica Bay receiving water impacts study, mass emission monitoring, land use runoff monitoring, and critical industry monitoring. Other peripheral and supportive studies were conducted since 1996. Those consisted of a study of sampling in wide channels (see Appendix E), a study of the feasibility of sampling storms down to 0.1" rainfall (see Appendix D), an El Niño season supplemental study (see Appendix F), and freshwater toxicity studies on the Los Angeles and San Gabriel Rivers (see Appendix G). In 1999, the County also voluntarily funded half of a study of impacts on stormwater quality from aerial deposition (see Appendix H for progress reports).

HYDROLOGIC CONDITIONS AND SAMPLING SUCCESS

The last six years have experienced a range of climatological events, ranging from the 1997-98 El Niño season (twice the normal annual rainfall) to the 1998-99 La Niña season (less than half the normal annual rainfall). Nevertheless, the County's resourcefulness allowed it to respond to many different and unexpected circumstances as they arose. Since January 1995, 212 mass emission and 396 land use monitoring station events have been sampled. The major objective of runoff characterization of mass emission, land use, and critical industry drainage areas was achieved.

OBJECTIVES ACHIEVED

The goal of the monitoring program has been to provide technical data and information to support effective watershed stormwater quality management programs in Los Angeles County. The monitoring program has been successful in meeting those goals, namely:

- Track Water Quality Status, Pollutant Trends and Pollutant Loads, and Identify Pollutants of Concern

  Water quality status, pollutant trends and loads were successfully addressed by all of the major monitoring program elements: the Santa Monica Bay receiving waters impact study, the mass emission monitoring element, the land use monitoring element, and the critical source monitoring element. The total cost incurred by the monitoring program to date has been more than $4.8 million.

- Monitor and Assess Pollutant Loads from Specific Land Uses and Watershed Areas

  Both the mass emission and land use monitoring elements were successful at assessing loading, and the County's GIS Loading Model has been recognized as an innovative solution to estimating loading in unmonitored watersheds.

- Identify, Monitor, and Assess Significant Water Quality Problems Related to Stormwater Discharges Within the Watershed

  The monitoring program was successful at identifying toxic levels of zinc and copper from Ballona Creek discharge, toxicity in the Los Angeles and San Gabriel Rivers, and the extent and severity of bacterial indicators in both dry and wet weather.

- Identify Sources of Pollutants in Stormwater Runoff

  In addition to the Bay receiving water impacts study's identifying Ballona Ck., and not Malibu Ck., as a contributor of stormwater toxicity, the mass emission monitoring identified the Los Angeles River as consistently contributing the most zinc, copper, and suspended solids. The land use monitoring identified light industrial, transportation, and retail/commercial land uses as developing the highest median concentrations for total and dissolved zinc. Light industrial and transportation land uses displayed the highest median concentrations for total and dissolved copper, and light industrial produced the highest concentrations of suspended solids. Finally, the critical source monitoring program identified fabricated metal businesses as producing the highest median concentrations for zinc, copper, and suspended solids.

- Identify and Eliminate Illicit Discharges

  Each Permittee has a program to identify and eliminate illicit connections to the storm drain system to the maximum extent practicable. The County has been successful in the inspection of open channels and underground storm drains to identify illicit connections.

  Most Permittees perform random area surveillance during dry and wet weather to inspect for potential illegal discharges. The Permittees also conduct educational site visits at businesses. During these visits, flyers with information on Best Management Practices (BMPs) applicable to that business are distributed.

  The Department has also been successful in developing and implementing a standard program for public reporting of illicit discharges and reporting hazardous substances via the 1-888-CleanLA hotline.

- Evaluate the Effectiveness of Management Programs, including Pollutant Reductions Achieved by Implementation of Best Management Practices (BMPs)

  The Critical Source element of the monitoring program was successful at examining the potential effectiveness of voluntary good housekeeping and preventive types of Best Management Practices at one critical source industry. There was no significant difference at other critical source industries at which BMPs were implemented. The inability to control the voluntary usage of good housekeeping BMPs at these critical industries may have compromized the study's effectiveness for those industries.

- Assess the Impacts of Stormwater Runoff on Receiving Waters

  The receiving waters impact study, one of the first in the nation to assess stormwater impacts on the marine environment, was very successful at assessing stormwater impacts on Santa Monica Bay. The study was able to discern the existence and extent of the stormwater plume in the Bay, identify two trace metals in Ballona Creek. stormwater discharge that are toxic to simple sea creatures, and conclude that sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants. The findings related to toxicity and sediments, along with bacterial indicators, set the stage for the rest of this report.

WATER QUALITY CHEMICAL ANALYSES

Monitoring in Los Angeles county from 1994 to date has been performed in compliance with the Municipal Stormwater Permits of June, 1990, and July, 1996, which have required a broad suite of chemical analyses, including solids, minerals, bacteria, metals, organics, and nutrients. The Los Angeles county Department of Agricultural Commissioner/Weights and Measures, Environmental toxicology Laboratory, provided the water quality laboratory and related services to the Department of Public works. The laboratory implemented a Quality Assurance/Quality Control program to ensure that the analyses conducted were scientifically valid, defensible, and of known precision and accuracy.

WATER AND SEDIMENT QUALITY RESULTS

Conclusions on the status and trends of water quality over the past six years have been derived from the monitoring program's Santa Monica Bay receiving waters impact study, mass emissions monitoring element, land use runoff monitoring element, and critical industry monitoring element. Findings regarding sediment quality were derived from the Santa Monica Bay receiving waters impact study and the County's involvement with the California Sediment Task Force and the Corps of Engineers' Sediment Control Management Plan.

- The nonprofit Center for Watershed Protection has linked overall watershed imperviousness to stormwater quality problems. The Dominguez Channel/L. A. Harbor Watershed Management Area has the highest overall imperviousness (62%) based on 1993 SCAG land use distribution, followed by the Ballona Creek (45%), Los Angeles River (35%), San Gabriel River (30%), Malibu Creek (6%), and Santa Clara River (5%) Watershed Management Areas.

- The monitoring program has identified the nearly ubiquitous existence of indicator bacteria in both dry and wet weather throughout the urbanized part of the coastal basin. Total coliforms, fecal coliforms, fecal streptococcus, and fecal enterococcus were detected in all stormwater samples tested since 1994 at densities (or most probable number, MPN) between several hundreds to several million cells per 100 ml., exceeding the public health criteria of AB411.

- The Malibu Creek station appears to have consistently lower indicator bacteria counts than other mass emission stations and is consistently lower for all four groups of bacteria.

- The 1995-96 season appears to have higher mean densities of indicator bacteria than other years. At 75% of normal, this was not a particularly rainy season.

- In a number of instances, peak fecal coliform counts occurred at different monitoring stations in different parts of the county during the same storm. Further, in 1995-96, the highest fecal coliform readings at five stations coincided with the largest storm of the season. Also, in 1996-97, the highest fecal coliform readings at two stations coincided with the first storm of the season greater than 0.1" rainfall. These observations suggest that peak fecal coliform levels may be related to regional hydrologic conditions.

- Except for somewhat lower bacteria densities at Malibu Creek, there was no seasonal or regional consistency in cell densities. There was a very wide range of densities for all stations.

- There was one storm event, January 9, 1998, that yielded extremely high counts in all stations for all bacterial strains. The available data do not provide an explanation, or suggest whether this could be a contamination artifact.

- The 1996-97 season had one event, November 21, 1996, that yielded runoff with high counts in all stations for all bacteria species.

- During the 1998-99 season, the event of March 15, 1999 was associated with high bacterial counts for most stations and the events of March 25, 1999 and April 4, 1999, were associated with unusually low counts for most stations.

- Virtually every sample of Ballona Creek stormwater tested in the Santa Monica Bay receiving water impacts study was toxic to sea urchin fertilization.

- The first storms of the year produced the most toxic stormwater in Santa Monica Bay during the receiving water impacts study.

- The toxic portions of the observed stormwater plume were variable in size, extending from 1/4 to 2 miles offshore of Ballona Creek.

- Surface water toxicity caused by unidentified sources was frequently encountered during dry weather in Santa Monica Bay during the receiving water impacts study.

- Zinc was the most important toxic constituent identified in stormwater in Santa Monica Bay, but zinc concentrations in the toxic portion of the discharge plume were usually below levels shown to cause toxicity in the laboratory.

- Copper and other unidentified constituents may also be responsible for some of the toxicity measured in Santa Monica Bay.

- The measured concentrations of zinc and copper in Ballona Creek stormwater were estimated to account for only 5% - 44% of the observed toxicity.

- The fate of most stormwater constituents discharged to Santa Monica Bay is unknown.

- For two years in a row, wet weather toxicity was significant in the Los Angeles River. Dry weather toxicity was significant the second year, but not the first.

- For the San Gabriel River, wet weather toxicity was significant the first year, but not the second. Dry weather toxicity was not significant either year.

- For both the Los Angeles and San Gabriel Rivers, wet weather toxicity was higher for the first storm tested, suggesting a seasonal "first flush" phenomenon for toxicity.

- The sea floor is where stormwater particles, and associated contaminants, eventually settle.

- The sediments on the sea floor can accumulate runoff inputs over an entire storm, over several storms, or over several seasons.

- Sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants, including common stormwater constituents such as lead and zinc.

- Sediments offshore of Ballona Creek showed evidence of stormwater impacts over a large area.

- Sampled biological communities offshore of Ballona Creek were similar to those offshore of Malibu Creek. Both areas had comparable abundance and similar species composition.

- Sampled biological communities offshore of Ballona and Malibu Creeks were also similar to background reference conditions established in previous studies of southern California.

- According to the Los Angeles Basin Contaminated Sediment Task Force, informal surveys of potential marina and harbor users and past dredging projects suggest that the major sources of contaminated dredge material will continue to be Marina del Rey, the ports of Los Angeles and Long Beach, and the mouth of the Los Angeles River.

- According to the Los Angeles Basin Contaminated Sediment Task Force, some of the sediments dredged from these harbors contain elevated levels of heavy metals, pesticides, and other contaminants. In most cases, the concentrations of these contaminants do not approach hazardous levels.

- According to the U. S. Army Corps of Engineers, four of 21 sites in the bottom of Ballona Creek and major tributaries were without any chemical concentration exceeding the National Oceanographic and Atmospheric Administration's "Effect Range-Low" (ERL) values: storm drain Bond Issue Project 9408, Project 425, Ballona Creek at Sawtelle Blvd., and Centinela Channel.

- According to the U. S. Army Corps of Engineers, sediments on the bottoms of storm drain Bond Issue Projects 648, 51, 494, and 503 ranked by dry weight most consistently as the most contaminated sites with respect to metals and polycyclic aromatic hydrocarbons (PAHs).

- According to the U. S. Army Corps of Engineers, the two areas of the main Ballona Ck. channel that ranked by dry weight as most contaminated and exceeding ERLs were just downstream of Madison Ave. and Fairfax Ave.

- According to the U. S. Army Corps of Engineers, with respect to the potential for contamination from PAHs, sites in Ballona Ck. at Pickford St. and Fairfax Ave., Higuera St. drain, Projects 51 and 3867, and Culver City Acquisition and Improvement District No. 4 drain appeared most contaminated.

- According to the U. S. Army Corps of Engineers, bed load sediment in the major tributary drains of Sepulveda and Centinela Channels were among the least contaminated samples.

- According to the U. S. Army Corps of Engineers, the area within the Ballona Ck. drainage area having expected highest stormwater loading of metals, oil, and grease extends from Hollywood to Culver City in a 1- to 2-mile wide, 5- to 6-mile long strip parallel and east of the San Diego (I-405) Freeway.

- Only two PAH compounds, phenanthrene and pyrene, exceeded the California Ocean Plan objective. This occurred at the Malibu Creek station. No other PAH compound exceedences appeared through the comparison of mass emission concentrations to the California Ocean Plan, although 1999-2000 was the first year of lower detection limits for PAHs.

- The Los Angeles River is the largest contributor of suspended solids of the five mass emission stations monitored.

- After exceedence of bacterial indicators, when compared to the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule, the next most numerous "virtual" exceedences occurred with total and dissolved copper and bis(2-ethylhexyl)phthalate, followed by turbidity, total zinc, and total lead.

- The El Niño season, 1997-98, contributed the most virtual mass emission exceedences at all monitoring stations except Coyote Creek.

- The Los Angeles River produced the most virtual exceedences of any other mass emission monitoring station.

- Loading to the ocean was greatest during 1997-98, the El Niño season, during which the Los Angeles River delivered the highest loadings of total suspended solids (approx. 220,000 tons), dissolved copper (approx. 28 tons), total copper (approx. 40 tons), dissolved zinc (approx. 170 tons), and total zinc (approx. 230 tons).

- It appears that Los Angeles River loading for metals is disproportionate by drainage area to the other watersheds.

- According to the GIS Loading Model, the unmonitored Dominguez Channel/L. A. Harbor Watershed Management Area was estimated to contribute the highest loadings for dissolved zinc (approx. 2.3 tons) and dissolved copper (approx. 30 tons) and contribute the highest loadings of the unmonitored watersheds for each year since 1995. Comparison of loadings between monitored and unmonitored watersheds should not be made at this time because the model is not yet fully calibrated.

CONSTITUENTS OF CONCERN

- Sixteen chemical constituents were identified from the comparison of mass emission annual concentrations to the objectives of the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule. Exceedence of these objectives, however, do not constitute noncompliance with the Permit.

- While Total Maximum Daily Loads (TMDLs) are not part of the Los Angeles Municipal Stormwater Permit, constituents identified by the 303d list that were not already identified through the comparison process, namely nutrients, are also constituents of concern. It should be noted, however, that a report by the Las Virgenes Municipal Water District found that beneficial use impairment due to algal growth is not a problem in Malibu Creek during storm season.

- Two organophosphate pesticides, diazinon and chlorpyrifos, are also among the constituents of concern due to their identification with stormwater toxicity in independent studies.

- Indicator bacteria (total coliform and fecal coliform, streptococcus, and enterococcus) are included as constituents of concern due their exceedence of AB411 (assembly bill).

IDENTIFICATION OF POSSIBLE SOURCES

- Light industrial, transportation, and retail/commercial land uses displayed the highest median values for total and dissolved zinc, with light industrial the highest at about 300 μg/l for

dissolved zinc and about 360 μg/l for total zinc. Runoff concentrations for metals from the high density single family residential, education, multifamily residential, and mixed residential land uses were significantly less.

- Light industrial and transportation land uses displayed the highest median values for total and dissolved copper, with transportation the highest at about 28 μg/l for dissolved copper and about 40 μg/l for total copper.

- Median concentrations of total suspended solids were highest coming off of the light industrial land use category, at about 130 mg/l.

- Among all the critical industry monitoring sites, the highest median value for total zinc (approx. 450 μg/l), dissolved zinc (approx. 360 μg/l), total copper (approx. 240 μg/l), and dissolved copper (approx. 110 μg/l) were produced at the fabricated metal business sites.

- Levels for total and dissolved zinc did not appear to be significantly different between any of the industry types.

- Levels for total and dissolved copper did appear significantly higher for the fabricated metals sites over the other critical industry categories.

- The highest median level for suspended solids was also produced at the fabricated metals sites, but no industry was significantly higher or lower than another for suspended solids.

EVALUATION OF CRITICAL INDUSTRY BMP EFFECTIVENESS

- Limited success was achieved in evaluating BMPs for the auto dismantling and auto repair industries. The reasons for no discernable differences in concentrations before and after BMP implementation at the two industries are not obvious, but may include the voluntary nature of the BMP usage.

- For total and dissolved zinc, the median concentration lowered or stayed nearly the same with the implementation of BMPs at the auto dismantling, auto repair, and fabricated metals industries.

- For total and dissolved copper, where the fabricated metal industry had displayed the highest median concentrations, levels were significantly reduced with the implementation of BMPs.

- The auto dismantling and auto repair businesses showed no significant difference for copper pre- and post-BMP.

RECOMMENDATIONS

The following recommendations are made based on all the monitoring and studies to date, from within the Los Angeles County Department of Public Works and other sources. These recommendations include monitoring, research, and studies that should be considered or undertaken to advance the understanding of stormwater quality science and support future TMDL development. Because of their scope, such studies should be undertaken by various entities, such as the Regional Water Quality Control Board, NPDES permittees, or collaborative efforts between private and public organizations.

- Mass emission monitoring should continue at the five existing sites for up to five storm events per season.

- Those constituents that have been detected in less than 25% of ten consecutive sampling events (Table ES-1a) should be removed from the analytical suite for the associated mass emission monitoring stations. However, the constituents of concern should remain.

- As a result of the 25% Event (or Seasonal) Mean Concentration error rate (Table ES-1b), land use monitoring should only sample the following constituents:

LAND USE SITE	CONSTITUENTS
Retail/Commercial	Ammonia, total and dissolved copper, nitrate, total lead, TSS, PAH, diazinon, chlorpyrifos
Vacant	TKN, TSS, PAH, diazinon, chlorpyrifos
High Density Single Family Residential	Total lead, PAH, diazinon, chlorpyrifos
Transportation	PAH, diazinon, chlorpyrifos
Light Industrial	Total copper, PAH, diazinon, chlorpyrifos
Education	Total copper, total zinc, TSS, PAH, diazinon, chlorpyrifos
Multifamily Residential	Ammonia, ammonia nitrogen, nitrite nitrogen, TSS, PAH, diazinon, chlorpyrifos
Mixed Residential	Ammonia, nitrate, total zinc, PAH, diazinon, chlorpyrifos

- Receiving water impact studies should be performed on significant impaired water bodies to identify impacts due to stormwater. Such impact studies could include assessments of bioassessment.

- Support and cooperation should continue with the Southern California Coastal Waters Research Project in conducting current research and calibrating water quality models for the Santa Monica Bay and Los Angeles River.

- Similar water quality models should be initiated for other parts of the County where indicator bacteria impair beneficial uses.

- Support and cooperation should continue with the Corps of Engineers' Sediment Control Management Plan and the Coastal Commission Sediment Task Force.

- Studies of receiving water and stormwater impacts due to aerial deposition should be conducted on inland watersheds.

- Major tributaries to Ballona Creek should be surveyed to find possible contributing areas and sources of trace zinc and copper.

- Two dry weather and two wet weather Toxicity Identification Evaluations should be conducted for a full range of constituents on freshwater species for the L. A. River and Dominguez Channel.

- Two wet weather Toxicity Identification Evaluations should be conducted for a full range of constituents on freshwater species for the San Gabriel River.

- Follow-up studies should be conducted in Santa Monica Bay that address the persistence of stormwater plumes following storm events, the toxicity of stormwater on other representative species, and the fate of sediments in the Bay.

- A study should be conducted assessing the impacts due to stormwater on San Pedro Bay.

- Support and cooperation should continue toward local and regional monitoring programs, including but not limited to the Santa Monica Bay Restoration Project, the City of Long Beach, and the developing Southern California Regional Stormwater Monitoring Coalition.

- Best Management Practices and impacts should be formally evaluated in controlled cases. Current examples might include the City of Santa Clarita demonstration projects, catch basin inserts and deflectors, groundwater impacts due to stormwater infiltration, the Department of Public Works' parking lot retrofit, and storm drain low flow diversions.

- Continue the IC/ID model program as approved by the Regional Board on March 23, 1999.

- Calibrate the GIS Loading Model between monitored and unmonitored watersheds.

Table ES-1a. 1994-2000 Mass Emission Constituent Detection Rates

	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Miscellaneous Constituents					
Cyanide*	X	X	X	&	X
TPH	X	X	-	&	X
Oil and Grease	X	X	-	&	X
Total Phenols	X	X	X	&	X
Indicator Bacteria*	-	-	-	&	-
General Minerals					
Ammonia	-	X	-	-	X
Calcium	-	-	-	-	-
Magnesium	-	-	-	-	-
Potassium	-	-	-	-	-
Sodium	-	-	-	-	-
Bicarbonate	-	-	-	-	-
Carbonate	X	X	X	X	X
Chloride	-	-	-	-	-
Flouride	-	-	-	-	-
Nitrate	-	-	-	-	-
Sulfate	-	-	-	-	-
Alkalinity	-	-	-	-	-
Hardness	-	-	-	-	-
COD	-	-	-	-	-
pH	-	-	-	-	-
Specific Conductance	-	-	-	-	-
Total Dissolved Solids*	-	-	-	-	-
Turbidity*	-	-	-	-	-
Total Suspended Solids*	-	-	-	-	-
Volatile Suspended Solids	-	-	-	-	-
MBAS	-	X	X	X	X
Total Organic Carbon	-	-	-	-	-
BOD	-	-	-	-	-
Nutrients					
Dissolved Phosphorus*	-	-	-	-	-
Total Phosphorus*	-	-	-	-	-
NH3-N*	-	X	X	-	X
Nitrate-N*	-	-	-	-	-
Nitrite-N*	-	X	-	-	-
TKN*	-	-	-	-	-
Metals					
Dissolved Aluminum	X	X	-	X	X
Total Aluminum*	-	-	-	-	-
Dissolved Antimony	X	X	X	X	X
Total Antimony	X	X	X	X	X
Dissolved Arsenic	X	X	X	X	X
Total Arsenic	X	X	X	X	X
Dissolved Barium	-	-	-	-	-
Total Barium	-	-	-	-	-
Dissolved Beryllium	X	X	X	X	X
Total Beryllium	X	X	X	X	X
Dissolved Boron	-	-	-	-	-
Total Boron	-	-	-	-	-
Dissolved Cadmium*	X	X	X	X	X
Total Cadmium	X	X	X	X	X
Dissolved Chromium	X	X	X	X	X

Table ES-1a. 1994-2000 Mass Emission Constituent Detection Rates

	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Total Chromium	X	X	X	X	X
Dissolved Chromium +6	X	X	X	X	X
Total Chromium +6	X	X	X	X	X
Dissolved Copper*	-	X	-	-	X
Total Copper*	-	-	-	-	-
Dissolved Iron	X	X	-	-	X
Total Iron	-	-	-	-	-
Dissolved Lead*	X	X	X	X	X
Total Lead*	X	X	-	X	X
Dissolved Manganese	X	X	X	X	X
Total Manganese	X	X	X	X	X
Dissolved Mercury	X	X	X	X	X
Total Mercury*	X	X	X	X	X
Dissolved Nickel*	X	X	-	X	X
Total Nickel*	-	-	-	-	X
Dissolved Selenium	X	X	X	X	X
Total Selenium	X	X	X	X	X
Dissolved Silver	X	X	X	X	X
Total Silver	X	X	X	X	X
Dissolved Thallium	X	X	X	X	X
Total Thallium	X	X	X	X	X
Dissolved Zinc*	X	X	X	X	X
Total Zinc*	-	X	-	X	X
SVOCs					
Bis(2-ethylhexyl)phthalate*	&	&	&	&	&
PAHs					
Phenanthrene*	&	&	&	&	&
Pyrene*	&	&	&	&	&
All other PAHs	&	&	&	&	&
All other SVOCs	X	X	X	X	X
Pesticides					
Organochlorine Pesticides & PCBs	X	X	X	X	X
Carbofuran	X	X	X	X	X
Glyphosate	X	X	X	X	X
Organo-Phosphate Pesticides					
Diazinon*	X	X	X	X	X
Chlorpyrifos*	X	X	X	X	X
N- and P-Containing Pesticides					
Thiobencarb	X	X	X	X	X
All other N- and P- Pesticieds	X	X	X	X	X
Phenoxyacetic Acid Herbicides					
2,4-D	X	X	X	X	X
2,4,5-TP	X	X	X	X	X
Bentazon	X	X	X	X	X

X = less than 25% detection in ten consecutive samples

- = more than 25% detection in ten consecutive samples

& = less than 10 samples tested

* Constituent of concern

Table ES-1b. 1994-2000 Land Use Constituent Detection Rates

	Commercial	Vacant	High Density Single Family Residential	Trans-portation	Light Industrial	Educational	Multi-Family Residential	Mixed Residential
Miscellaneous Constituents								
Cyanide*	&	X	&	&	&	&	&	&
TPH	&	X	&	&	&	&	&	&
Oil and Grease	&	X	&	&	&	&	&	&
Total Phenols	&	X	&	&	&	&	&	&
Indicator Bacteria*	&	-	&	&	&	&	&	&
General Minerals								
Ammonia	-	X	-	-	-	X	-	-
Calcium	-	-	-	-	-	-	-	-
Magnesium	-	-	-	-	-	-	-	-
Potassium	-	-	-	-	-	-	-	-
Sodium	-	-	-	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-	-
Carbonate	X	X	X	X	X	X	X	X
Chloride	-	-	-	-	-	-	-	-
Flouride	X	-	X	X	X	X	X	X
Nitrate	-	-	-	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-	-
Alkalinity	-	-	-	-	-	-	-	-
Hardness	-	-	-	-	-	-	-	-
COD	-	X	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-
Specific Conductance	-	-	-	-	-	-	-	-
Total Dissolved Solids*	-	-	-	-	-	-	-	-
Turbidity*	-	-	-	-	-	-	-	-
Total Suspended Solids*	-	-	-	-	-	-	-	-
Volatile Suspended Solids	-	-	-	-	-	-	-	-
MBAS	X	X	X	X	-	X	X	X
Total Organic Carbon	-	-	-	-	-	-	-	-
BOD	-	-	-	-	-	-	-	-
Nutrients								
Dissolved Phosphorus*	-	X	-	-	-	-	-	-
Total Phosphorus*	-	X	-	-	-	-	-	-
NH3-N*	-	X	-	-	-	X	-	-
Nitrate-N*	-	-	-	X	-	X	X	X
Nitrite-N*	-	X	-	-	-	X	-	-
TKN*	-	-	-	-	-	-	-	-
Metals								
Dissolved Aluminum	X	X	X	X	X	-	X	X
Total Aluminum*	X	X	-	X	-	-	-	-
Dissolved Antimony	X	X	X	X	X	X	X	X
Total Antimony	X	X	X	X	X	X	X	X
Dissolved Arsenic	X	X	X	X	X	X	X	X
Total Arsenic	X	X	X	X	X	X	X	X
Dissolved Barium	-	-	-	-	-	-	-	-
Total Barium	-	-	-	-	-	-	-	-
Dissolved Beryllium	X	X	X	X	X	X	X	X
Total Beryllium	X	X	X	X	X	X	X	X
Dissolved Boron	-	X	X	-	X	-	-	X
Total Boron	-	-	-	-	-	-	-	X
Dissolved Cadmium*	X	X	X	X	X	X	X	X
Total Cadmium	X	X	X	X	X	X	X	X

Table ES-1b. 1994-2000 Land Use Constituent Detection Rates

	Commercial	Vacant	High Density Single Family Residential	Trans-portation	Light Industrial	Educational	Multi-Family Residential	Mixed Residential
Dissolved Chromium	X	X	X	X	X	X	X	X
Total Chromium	X	X	X	X	X	X	X	X
Dissolved Chromium +6	X	X	X	X	X	X	X	X
Total Chromium +6	X	X	X	X	X	X	X	X
Dissolved Copper*	-	X	-	-	-	-	-	-
Total Copper*	-	-	-	-	-	-	-	-
Dissolved Iron	-	X	X	X	-	-	X	X
Total Iron	-	-	-	-	-	-	-	-
Dissolved Lead*	X	X	X	X	X	X	X	X
Total Lead*	X	X	-	X	X	X	X	X
Dissolved Manganese	X	X	X	X	X	X	X	X
Total Manganese	X	X	X	X	X	X	X	X
Dissolved Mercury	X	X	X	X	X	X	X	X
Total Mercury*	X	X	X	X	X	X	X	X
Dissolved Nickel*	X	X	X	X	X	X	X	X
Total Nickel*	-	X	X	X	-	X	X	X
Dissolved Selenium	X	X	X	X	X	X	X	X
Total Selenium	X	X	X	X	X	X	X	X
Dissolved Silver	X	X	X	X	X	X	X	X
Total Silver	X	X	X	X	X	X	X	X
Dissolved Thallium	X	X	X	X	X	X	X	X
Total Thallium	X	X	X	X	X	X	X	X
Dissolved Zinc*	-	X	X	-	-	-	-	-
Total Zinc*	-	X	X	-	-	-	-	-
SVOCs								
Bis(2-ethylhexyl)phthalate*	&	&	&	&	&	&	&	&
PAHs								
Phenanthrene*	&	&	&	&	&	&	&	&
Pyrene*	&	&	&	&	&	&	&	&
All other PAHs	&	&	&	&	&	&	&	&
All other SVOCs	X	X	X	X	X	X	X	X
Pesticides								
Organochlorine Pesticides & PCBs	X	X	X	X	X	X	X	X
Carbofuran	X	X	X	X	X	X	X	X
Glyphosate	X	X	X	X	X	X	X	X
Organo-Phosphate Pesticides								
Diazinon*	X	X	X	X	X	X	X	X
Chlorpyrifos*	X	X	X	X	X	X	X	X
N- and P-Containing Pesticides								
Thiobencarb	X	X	X	X	X	X	X	X
All other N- and P- Pesticieds	X	X	X	X	X	X	X	X
Phenoxyacetic Acid Herbicides								
2,4-D	X	X	X	X	X	X	X	X
2,4,5-TP	X	X	X	X	X	X	X	X
Bentazon	X	X	X	X	X	X	X	X

X = less than 25% detection in ten consecutive samples

- = more than 25% detection in ten consecutive samples

& = less than 10 samples tested

* Constituent of concern

Table ES-1c. Summary of Mean Standard Error of Land Use Stations

Land Use Type	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
Transportation	Ammonia	40	0.40	0.51	0.08	0.39	0.42	0.06	0.0001	0.3012	Lognormal	16.4%	Y
Transportation	Bis(2-ethylhexyl)phthalate	29	13.41	17.30	3.21	14.57	25.95	4.47	0.0001	0.8236	Lognormal	30.7%	N
Transportation	Dissolved Copper	52	31.70	21.14	2.93	33.77	31.58	4.28	0.0002	0.0123		9.2%	Y
Transportation	Dissolved Nickel	22	5.69	5.15	1.10	5.55	4.05	0.86	0.0001	0.0028		19.3%	Y
Transportation	Dissolved Phosphorus	47	0.32	0.20	0.03	0.35	0.31	0.04	0.0116	0.0083		9.2%	Y
Transportation	Dissolved Zinc	52	201.02	140.87	19.53	219.04	229.64	30.90	0.0001	0.0005		9.7%	Y
Transportation	NH3-N	39	0.34	0.43	0.07	0.33	0.35	0.05	0.0001	0.1621	Lognormal	16.3%	Y
Transportation	Nitrate	50	3.65	4.06	0.57	3.55	3.38	0.47	0.0001	0.6601	Lognormal	13.2%	Y
Transportation	Nitrate-N	49	0.96	1.29	0.18	0.92	1.04	0.14	0.0001	0.541	Lognormal	15.6%	Y
Transportation	Nitrite-N	50	0.10	0.07	0.01	0.10	0.08	0.01	0.0001	0.4081	Lognormal	10.5%	Y
Transportation	TKN	50	2.02	1.81	0.26	1.97	1.47	0.21	0.0001	0.2096	Lognormal	10.4%	Y
Transportation	Total Cadmium	26	1.40	1.22	0.24	1.39	1.14	0.22	0.0001	0.0032		17.1%	Y
Transportation	Total Chromium	31	6.70	5.46	0.98	6.64	5.55	0.98	0.0001	0.0021		14.6%	Y
Transportation	Total Copper	52	59.18	58.93	8.17	56.89	40.86	5.61	0.0001	0.1899	Lognormal	9.9%	Y
Transportation	Total Lead	37	15.03	19.40	3.19	14.60	20.91	3.25	0.0001	0.004		21.2%	Y
Transportation	Total Nickel	38	7.64	7.26	1.18	7.57	6.40	1.02	0.0001	0.0156		15.4%	Y
Transportation	Total Phosphorus	47	0.44	0.32	0.05	0.46	0.39	0.06	0.0001	0.2144	Lognormal	12.2%	Y
Transportation	Total Suspended Solids	50	90.76	108.00	15.27	86.19	81.14	11.22	0.0001	0.1717	Lognormal	13.0%	Y
Transportation	Total Zinc	52	306.96	296.30	41.09	297.66	220.71	30.26	0.0001	0.2052	Lognormal	10.2%	Y
Light Industrial	Ammonia	45	0.60	0.81	0.12	0.62	1.05	0.14	0.0001	0.0132		20.1%	Y
Light Industrial	Bis(2-ethylhexyl)phthalate	21	9.71	9.68	2.11	10.78	17.06	3.56	0.0007	0.6052	Lognormal	33.1%	N
Light Industrial	Dissolved Copper	39	14.12	10.02	1.60	14.86	14.34	2.25	0.0011	0.065	Lognormal	15.1%	Y
Light Industrial	Dissolved Nickel	23	5.40	4.18	0.87	5.52	4.76	0.98	0.0001	0.0784	Lognormal	17.8%	Y
Light Industrial	Dissolved Phosphorus	44	0.21	0.16	0.02	0.22	0.23	0.03	0.0001	0.1935	Lognormal	14.9%	Y
Light Industrial	Dissolved Zinc	47	360.66	373.51	54.48	428.35	682.33	92.09	0.0001	0.0002		15.1%	Y
Light Industrial	NH3-N	46	0.49	0.66	0.10	0.49	0.77	0.11	0.0001	0.0077		19.9%	Y
Light Industrial	Nitrate	46	4.44	4.56	0.67	4.38	4.72	0.67	0.0001	0.3263	Lognormal	15.4%	Y
Light Industrial	Nitrate-N	45	1.03	1.22	0.18	1.00	1.15	0.17	0.0001	0.4249	Lognormal	16.6%	Y
Light Industrial	Nitrite-N	46	0.09	0.07	0.01	0.09	0.06	0.01	0.0001	0.0687	Lognormal	9.9%	Y
Light Industrial	TKN	45	2.68	1.97	0.29	2.72	2.24	0.33	0.0001	0.7043	Lognormal	12.1%	Y
Light Industrial	Total Chromium	29	6.51	5.08	0.94	6.49	5.44	1.00	0.0001	0.0015		14.5%	Y
Light Industrial	Total Copper	47	47.66	141.91	20.70	35.11	41.24	5.78	0	0.0122		43.4%	N
Light Industrial	Total Lead	33	15.41	15.58	2.71	15.78	19.77	3.31	0.0001	0.1001	Lognormal	21.0%	Y
Light Industrial	Total Nickel	33	10.01	13.60	2.37	9.33	8.43	1.44	0.0001	0.0231		23.6%	Y
Light Industrial	Total Phosphorus	43	0.36	0.30	0.05	0.38	0.42	0.06	0.0001	0.3174	Lognormal	16.4%	Y
Light Industrial	Total Suspended Solids	42	174.33	192.35	29.68	179.77	203.07	30.28	0.0001	0.3733	Lognormal	16.8%	Y
Light Industrial	Total Zinc	47	491.64	543.39	79.26	488.33	428.35	61.37	0.0001	0.0384		16.1%	Y
Mixed Residential	Ammonia	28	0.83	0.88	0.17	0.98	1.90	0.33	0.0001	0.0834	Lognormal	33.5%	N
Mixed Residential	Dissolved Copper	27	16.70	21.06	4.05	17.16	24.94	4.58	0.0001	0.0205		24.3%	Y
Mixed Residential	Dissolved Phosphorus	25	0.23	0.21	0.04	0.24	0.26	0.05	0.0001	0.5799	Lognormal	20.7%	Y
Mixed Residential	Dissolved Zinc	27	178.63	216.58	41.68	174.09	193.27	36.25	0.0001	0.3782	Lognormal	20.8%	Y

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Table ES-1c. Summary of Mean Standard Error of Land Use Stations

Land Use Type	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
Mixed Residential	NH3-N	28	0.69	0.73	0.14	0.80	1.51	0.26	0.0001	0.0479		20.0%	Y
Mixed Residential	Nitrate	24	9.91	31.61	6.45	7.29	15.48	2.90	0.0001	0.0001		65.1%	N
Mixed Residential	Nitrate-N	24	0.77	0.46	0.09	0.83	0.76	0.15	0.1754	0.0196	Normal	12.4%	Y
Mixed Residential	Nitrite-N	24	0.15	0.21	0.04	0.14	0 17	0.03	0.0001	0.187	Lognormal	23.0%	Y
Mixed Residential	TKN	29	3.04	2.67	0.49	3.51	4.85	0.86	0.0001	0.0048		16.3%	Y
Mixed Residential	Total Copper	27	23.82	29.68	5.71	22.81	21.64	4.10	0.0001	0.3478	Lognormal	17.9%	Y
Mixed Residential	Total Phosphorus	25	0.31	0.31	0.06	0.31	0.34	0.07	0.0001	0.6015	Lognormal	21.2%	Y
Mixed Residential	Total Suspended Solids	23	82.13	89.10	18.58	79.81	80.22	16.44	0.0001	0.3618	Lognormal	20.6%	Y
Mixed Residential	Total Zinc	27	255.96	342.39	65.89	236.79	245.20	46.19	0.0001	0.0226		25.7%	N
Multi-Family Residential	Ammonia	26	0.55	0.81	0.16	0.60	1.39	0.24	0.0001	0.008		28.7%	N
Multi-Family Residential	Bis(2-ethylhexyl)phthalate	17	30.04	54.21	13.15	29.61	78.55	17.98	0.0001	0.7204	Lognormal	60.7%	N
Multi-Family Residential	Dissolved Copper	26	9.26	7.29	1.43	9.47	8.52	1.65	0.0004	0.0487		15.4%	Y
Multi-Family Residential	Dissolved Zinc	26	118.50	158.83	31.15	112.38	119.44	22.91	0.0001	0.0778	Lognormal	20.4%	Y
Multi-Family Residential	NH3-N	26	0.47	0.67	0.13	0.48	1.00	0.18	0.0001	0.0086		28.2%	N
Multi-Family Residential	Nitrate	24	7.25	4.59	0.94	7.68	7.06	1.42	0.0741	0.0786	Normal	12.9%	Y
Multi-Family Residential	Nitrate-N	24	1.64	1.04	0.21	1.73	1.59	0.32	0.076	0.0787	Normal	12.9%	Y
Multi-Family Residential	Nitrite-N	24	0.13	0.20	0.04	0.11	0.10	0.02	0.0001	0.0332		31.7%	N
Multi-Family Residential	TKN	28	2.40	2.52	0.48	2.29	1.70	0.32	0.0001	0.1133	Lognormal	13.9%	Y
Multi-Family Residential	Total Copper	31	13.44	6.63	1.19	13.65	7.51	1.34	0.007	0.2523	Lognormal	9.8%	Y
Multi-Family Residential	Total Suspended Solids	23	60.87	77.51	16.16	58.52	79.87	16.07	0.0001	0.1461	Lognormal	27.5%	N
Multi-Family Residential	Total Zinc	31	173.90	235.31	42.26	164.12	185.23	32.31	0.0001	0.0611	Lognormal	19.7%	Y
Educational	Ammonia	28	0.23	0.21	0.04	0.25	0.33	0.06	0.0001	0.0001		17.4%	Y
Educational	Bis(2-ethylhexyl)phthalate	10	14.50	15.30	4.84	16.99	30.88	10.17	0.031	0.5983	Lognormal	59.9%	N
Educational	Dissolved Copper	29	15.00	13.28	2.47	15.19	14.54	2.65	0.0001	0.5367	Lognormal	17.4%	Y
Educational	Dissolved Phosphorus	25	0.29	0.26	0.05	0.29	0.25	0.05	0.0001	0.1323	Lognormal	17.4%	Y
Educational	Dissolved Zinc	24	78.58	64.44	13.15	79.32	67.24	13.57	0.0001	0.0103		16.7%	Y
Educational	NH3-N	28	0.20	0.17	0.03	0.21	0.24	0.04	0.0001	0.0002		16.6%	Y
Educational	Nitrate	26	3.05	1.86	0.36	3.15	2.35	0.46	0.0176	0.2314	Lognormal	14.5%	Y
Educational	Nitrate-N	25	0.65	0.35	0.07	0.65	0.37	0.07	0.0111	0.3601	Lognormal	11.3%	Y
Educational	TKN	27	1.81	1.31	0.25	1.78	1.00	0.19	0.0001	0.0522	Lognormal	10.8%	Y
Educational	Total Copper	29	28.89	42.45	7.88	25.73	21.75	3.99	0.0001	0.001		27.3%	N
Educational	Total Phosphorus	25	0.33	0.21	0.04	0.33	0.19	0.04	0.0001	0.287	Lognormal	11.6%	Y
Educational	Total Suspended Solids	27	120.44	110.41	21.25	140.69	217.18	39.59	0.0003	0.2178	Lognormal	28.1%	N
Educational	Total Zinc	29	155.90	286.82	53.26	137.70	148.76	26.94	0.0001	0.007		34.2%	N
HDSFR	Ammonia	22	0.48	0.52	0.11	0.56	1.04	0.21	0.0002	0.0179		22.8%	Y
HDSFR	Bis(2-ethylhexyl)phthalate	15	14.22	21.84	5.64	13.51	23.86	6.03	0.0001	0.1512	Lognormal	44.6%	N
HDSFR	Dissolved Copper	20	11.56	8.77	1.96	12.26	12.94	2.85	0.0295	0.0624	Lognormal	23.2%	Y
HDSFR	Dissolved Phosphorus	21	0.34	0.17	0.04	0.34	0.20	0.04	0.1261	0.5482	Normal	11.2%	Y
HDSFR	NH3-N	22	0.43	0.42	0.09	0.50	0.84	0.17	0.0009	0.0137		20.8%	Y
HDSFR	Nitrate	21	5.29	6.32	1.38	5.07	5.51	1.18	0.0001	0.3442	Lognormal	23.3%	Y
HDSFR	Nitrate-N	21	1.19	1.43	0.31	1.15	1.26	0.27	0.0001	0.3775	Lognormal	23.5%	Y

R0011968

R0011969

The Integrated Receiving Water Impacts Report is a requirement of the Los Angeles County Municipal Stormwater Permit No. CAS0061654. Part VII.D of the Permit states:

"The Principal Permittee shall not later than July 31, 2000, prepare and submit an Integrated Receiving Water Impacts Report. The report shall include, but not be limited to a comprehensive analysis of the results of the different monitoring data (land use, mass emissions, critical source, load assessment, receiving waters, and other pertinent studies available), and feasible environmental indicators. It should also include recommendations on future monitoring requirements, e.g., integration of storm water receiving water monitoring with regional receiving water monitoring, if applicable. This report will be an integral part of the ROWD."

1.1 PURPOSE

The goal of the Monitoring Program is to develop information to support effective watershed stormwater quality management programs. The purpose of these management programs is to reduce pollutants in stormwater discharges to the maximum extent practicable. The major objectives of the Monitoring Program outlined in the Municipal Permit are to:

- track water quality status, pollutant trends and pollutant loads, and identify pollutants of concern;
- monitor and assess pollutant loads from specific land uses and watershed areas;
- identify, monitor, and assess significant water quality problems related to stormwater discharges within the watershed;
- identify sources of pollutants in the stormwater runoff;
- identify and eliminate illicit discharges;
- evaluate the effectiveness of management programs, including pollutant reductions achieved by implementation of BMPs; and
- assess the impacts of stormwater runoff on receiving waters.

These objectives are met through three major types of monitoring and additional studies as their need arises.

1.2 REPORT ORGANIZATION

Section 2 contains a brief history of the station selection process and site descriptions. Maps and tabular descriptions of the tributary areas of each monitored watershed are displayed as Figures 2-1 through 2-14. Section 3 covers methods used for measuring, sampling and analyzing stormwater. Section 4 presents and interprets results, and Section 5 draws conclusions and makes recommendations.

Tables and figures are labeled with two numbers. The first identifies their corresponding section number, and the second is for identification only.

Appendix A contains rainfall contour maps. Program costs are included in Appendix B. An Executive Summary of the Santa Monica Bay Receiving Waters Study by SCCWRP is included in Appendix C. Appendices D and E contain the Low Flow and Wide Channel Pilot Studies respectively. River Toxicity Test results are included in Appendix G. Aerial Deposition Progress Reports are included in Appendix H. A list of people to contact for more information is included in Appendix I.

1.3 RECAP OF MAJOR MONITORING ELEMENTS

The 1994-95 storm season was the first for which stormwater monitoring was accomplished under the 1990 Los Angeles County NPDES Municipal Stormwater Permit, No. CA0061654. During the 1994-95 and 1995-96 seasons, automated and manual sampling was conducted to characterize stormwater quality and quantity in accordance with the 1990 Municipal Permit. The 1994-95 monitoring data is summarized in *Report of Stormwater Monitoring, Winter of 1994-95* (LACDPW, 1996).

The 1996-97 season was the first storm season in which stormwater monitoring was conducted under the new 1996 Municipal Permit (No. CAS614001). For the 1996-97 season the scope of the Monitoring Program was expanded to incorporate further data collection and new pilot studies. The one-year pilot studies, consisting of "Wide Channel" and "Low Flow" analyses, were completed and reported in the *Los Angeles County 1996-97 Stormwater Monitoring Report, July 15, 1997* (LACDPW and Woodward-Clyde, 1997) and are reproduced in Appendices D and E.

The monitoring program, including the Mass Emission, Land Use, and Critical Source elements continued in the 1997-98, 1998-99 and 1999-2000 storm seasons. The 1998-99 storm season also included funding from the Los Angeles County Department of Public Works (LACDPW) to the Southern California Coastal Waters Research Project (SCCWRP) to study the impacts to receiving waters by aerial deposition of pollutants.

At the request of the Natural Resources Defense Council (NRDC), the 1998-99 and 1999-2000 reports include results of the industrial stormwater permit sampling within the county. Due to the limitations of the data set, only summaries of maximum and minimum results can be provided.

In an effort to analyze the presence of PAH in stormwater, Los Angeles County Public Works lowered the detection limit of semi-volatile organics in stormwater samples in the 1999-2000 season by using modified EPA method 625.

1.3.1 Santa Monica Bay Receiving Waters Impact Study

The Santa Monica Bay Receiving Waters Impact Study was conducted for three consecutive storm seasons (1995-98). Three components were studied:

- Stormwater plume characterization
- Water column biology
- Seafloor biology

High turbidity and low salinity characterized stormwater plumes. Generally, the stormwater plumes extended 2-10 meters below the surface and up to several miles offshore. They also persisted for several days.

Toxicity tests found toxic concentrations of dissolved materials in the water column. Zinc was the main toxicant identified in stormwater. There was also toxicity detected from sources other than stormwater.

The benthic community structure remained stable throughout the study. However, there was a high accumulation of contaminants in sea urchins offshore of Ballona Creek. The effects of the bioaccumulation are unknown.

The executive summary is presented in Appendix C, and is excerpted from the *Study of the Impact of Stormwater Discharge on the Beneficial Uses of Santa Monica Bay, July 8, 1999* (SCCWRP, 1999).

1.3.2 Mass Emissions

Mass emission stations capture runoff from major Los Angeles County watersheds that generally have heterogeneous land use. There were ten mass emission stations during the 1990 Municipal Permit and there were five under the 1996 permit. The objectives of the mass emissions stations are to update estimated pollutant loads to the ocean and to identify long term trends in pollutant concentrations, if possible. Four mass emission stations under the 1990 Municipal Permit were equipped with automated samplers to collect composite samples during storms. Grab samples were also taken at these stations. All five mass emission stations under the 1996 NPDES permit had automated samplers where composite and grab samples were taken in accordance with the Municipal Permit.

During the 1998-99 storm season, the station shelter on the Los Angeles River at Wardlow Road was under reconstruction during the entire season due to the raising of the levee walls by the Army Corps of Engineers (ACOE), and the automated sampling equipment was removed. Water quality samples from the Los Angeles River were collected manually at Wardlow Road and were not composited. Results from these manually collected samples were not included in event mean concentration (EMC) calculations. Stream flow data for the Los Angeles River at Wardlow Road was synthesized from three upstream flow stations.

R0011972

1.3.2.1 Pollutant Loading

Total pollutant loading, as a result of stormwater runoff was first calculated under the 1990 NPDES permit for the 1994-95 storm season. The results were presented in the *Report of Stormwater Monitoring, Winter of 1994-95* (Los Angeles County Department of Public Works, March 1996).

The 1996 NPDES permit in its Section B.4, Attachment C, states that a loads assessment for each of the six WMA's is to be conducted following the 1998-99 storm season. Results were presented in the *Los Angeles County 1998-99 Stormwater Monitoring Report* (Los Angeles County Department of Public Works, July 1999). For those rivers where mass emissions were monitored, loads were calculated from observed flow volumes and observed pollutant concentrations. For those drainage areas that were not monitored, a newly developed GIS model was employed to estimate loads.

Summaries of Total Pollutant Loading, including data from the 1999-2000 storm season, are included in this report.

1.3.3 Land Use Program

The drainage area tributary to each land use monitoring station is comprised predominantly of a single land use and is relatively homogeneous. The major objectives of this monitoring effort are to evaluate the effects of certain land uses on water quality, to identify the relative importance of specific land uses as pollution sources, and to provide data that can be used to project watershed loads from watersheds that do not have mass emission stations.

There were 14 land use monitoring stations under the 1990 Municipal Permit. Five of these stations were equipped with automated samplers to collect composite samples during storms. The 1996 NPDES permit required the re-evaluation of the location of land use specific monitoring stations. The land use monitoring program under the 1996 NPDES permit is a result of a site selection study entitled *Evaluation of Land Use Monitoring Stations* (Woodward-Clyde and Psomas and Associates, 1996). The study identified the most significant land use categories within the permit area regarding stormwater quality. The selection study yielded eight land use stations. These eight land use categories represent over 86% of all the land use within the permit area. These stations monitor flow and have automated samplers to collect flow weighted composite stormwater samples during storm events.

The Santa Monica Pier station was down due to construction during the 1999-2000 storm season.

1.3.4 Critical Sources

The Critical Source/BMP Monitoring Study was introduced under the 1996 NPDES permit and is designed to gather baseline water quality data and assess the effectiveness of BMP implementation for critical industries and businesses. A list of critical sources were identified and ranked by their potential significance to stormwater quality (Woodward-Clyde, 1997) and are listed below:

R0011973

Industrial Category	SIC code	Industrial Stormwater Permits*
• Wholesale trade (including scrap yards and auto dismantling)	50	Yes
• Automotive repair/parking	75	No
• Fabricated metal products (including electroplating)	34	Yes
• Motor freight (including trucking)	42	Yes
• Chemical manufacturing facilities	28	Yes
• Automotive dealers/gas stations	55	No
• Electric/gas/sanitary	49	No
• Miscellaneous manufacturing	39	Yes

* Industrial facilities requiring general industrial stormwater permits.

For each critical source industry, there is a multi-year study monitoring the stormwater runoff from six sites. During the first year of each study, runoff is sampled and analyzed from five storms. During subsequent years, BMPs are implemented at three of the six sites (test sites). BMP effectiveness is estimated from monitoring data gathered at the pooled test sites and pooled control sites during ten additional storms. A complete study plan is included in *Critical Source Selection and Monitoring Report* (Woodward-Clyde, 1997).

The first critical source monitoring was conducted during the 1997-98 storm season. Sites at six automotive repair shops and six auto dismantlers were monitored. These sites, plus six fabricated metal shops were monitored during the 1998-99 storm season. Six motor freight companies and six automobile dealers were added during the 1999-2000 storm season.

1.4 OTHER STUDIES

Two pilot studies were conducted during the 1996-97 storm season to identify a potential need for modifying monitoring practices. Both studies concluded that existing practices were satisfactory.

Other studies were conducted to explore the effects by aerial deposition, El Niño climatology on stormwater quality, and river toxicity.

1.4.1 Wide Channel Pilot Study

The Wide Channel Pilot Study was developed to evaluate the accuracy of a single point intake in wide channels. Samples were taken at the same time at various depths and widths across the channel to determine the level of mixing achieved.

1.4.2 Low Flow Pilot Study

The Low Flow Pilot Study was conducted to assess the feasibility of monitoring storms as small as 0.1 inches of rainfall. An existing land use monitoring station (Project 1202, Light Industrial) was used for this study.

1.4.3 Aerial Deposition

Data is currently being accumulated to estimate toxic loads deposited into the Santa Monica Bay and inland from atmospheric sources. The Data Assessment Report is scheduled for completion in September 2000. Quarterly progress reports are included in the 1998-99 Los Angeles County Stormwater Monitoring Report and herein Appendix H.

This year, the US EPA, Los Angeles County Department of Public Works, and Southern California Coastal Waters Research Project (SCCWRP) are funding the project. Other parties involved include UCLA's Institute of the Environment, the Santa Monica Bay Restoration Project (SMBRP), the US EPA's Great Water Program, and the South Coast Air Quality Management District (AQMD).

1.4.4 El Niño Study by SCCWRP

The objective of this research was to determine whether El Niño conditions influenced the toxicity of Ballona Creek stormwater or the characteristics of the stormwater discharge plume in Santa Monica Bay. The results indicated that storm size and cumulative amount of prior rainfall had little influence on stormwater toxicity. However, stormwater from rainfall preceded by more than 20 days of dry weather was found to have the highest toxicity. This relationship appeared to be independent of El Niño weather patterns.

The executive summary of the El Niño Study appears in Appendix F.

1.4.5 River Toxicity

During the 1997-98 and 1998-99 storm seasons, tests were conducted for toxicity of samples of dry and wet weather flow from the Los Angeles and San Gabriel Rivers. This testing was performed by the Southern California Coastal Waters Research Project. Toxicity was measured as impairment to sea urchin fertilization.

More details on the study are presented in Appendix G. A summary of finding is listed in Section 4.2.3.

SECTION 2

R0011976

To characterize the quality of stormwater runoff in Los Angeles County, sampling of single Land Use sites and large area Mass Emissions sites has been performed under the 1990 and the 1996 NPDES permits.

2.1 1990 NPDES PERMIT – SAMPLING SITES

2.1.1 Automated Sampling Program – 1990 NPDES permit

Starting in January 1995, in compliance with Phase I requirements of the 1990 NPDES stormwater permit, nine automated sampling stations began sampling runoff from combinations of mass emissions and land use specific watersheds within the Santa Monica Bay drainage area. Phases II and III added 15 more inland stations in 1995-1996. The 24 stations were:

Location	Land Use/ Mass Emission
Ballona Creek, Culver Dr. and Beloit Ave., City of Los Angeles.	Mass Emissions
Malibu Creek, Malibu Cyn. Rd. s/o Piuma Rd., Los Angeles Co.	Mass Emissions
Trancas Canyon, North end of Paseo Cyn. Dr., City of Malibu.*	Open Space/Rec.
Kenter Cyn. Drain, Main St. and Colorado Ave., City of Santa Monica.*	Mass Emissions
Bond Issue Proj. 1105, Herondo St. and Valley Dr., City of Redondo Beach.*	Mass Emissions
Bond Issue Proj. 558, Paseo Lunado and Via Anacapa, City of Palos Verdes Estates.*	Single Family Residential
Bond Issue Proj. 5401, Redondo Ave. and 11th St., City of Manahattan Beach.*	Single Family Residential
Santa Monica Pier Drain, Appian and Moss Ave, City of Santa Monica.	Commercial
Drain No. 2361, Grand Ave. and 21st St., City of Los Angeles.*	Industrial /Commercial
Coyote Creek, below Spring Street, City of Long Beach	Mass Emissions
Rio Hondo Channel, Above Beverly Blvd., Pico Rivera*	Mass Emissions
Los Angeles River, at Tujunga Ave., City of Los Angeles	Mass Emissions

R0011977

Location	Land Use/ Mass Emission
Bouquet Creek, Upstream of Newhall Ranch Rd., Private Drain No. 2225, Santa Clarita.	Mass Emissions
San Gabriel River, downstream of San Gebriel River Parkway, Pico Rivera	Mass Emissions
Browns Creek, Rinaldi Street, Chatsworth*	Open Space Recreation
Monrovia Creek/Sawpit Creek, Arcadia	Open Space Recreation
Project 1402, Near Foothill Blvd. And Don Diablo Dr., Arcadia*	Low Density Single Family Residential
Project 3857, Near Hamlin St. and Oso Ave., Warner Center*	High Density Single Family Residential
Project 620, near Glenwood Rd. and Bruce Ave., Glendale	High Density Single Family Residential
Project 1, near Alcoa Ave. and Randolph St, Vernon *	Industrial
Dominguez Channel, near 116th St. and Isis Ave. Lennox	Transportation
Private Drain 314, near Firestone Blvd. And Phoebe Ave., La Mirada*	Commercial
Project 1202, near Wilmington Ave. and 220th St., Carson	Industrial
Los Angeles River, between Willow St. and Wardlow Rd., City of Long Beach	Mass Emissions

* Discontinued under 1996 permit.

2.2 1996 NPDES PERMIT – SAMPLING SITES

2.2.1 SITE SELECTION

2.2.1.1 Mass Emission Site Selection

The Department of Public Works monitored four major drainage areas near their outfalls to the ocean. Four of the mass emission monitoring stations installed under the original 1990 Permit were retained under the 1996 Permit; specifically the Los Angeles River, San Gabriel River, Ballona Creek, and Malibu Creek. The Coyote Creek mass emission station, which was required under the 1990 Permit but not under the 1996 Permit, was also monitored during the 1997-98, 1998-99, and 1999-2000 seasons. This station was retained in the program to provide data for the calculation of mass loading in the San Gabriel River watershed. The five mass emission monitoring stations were used to collect water quality data from over 1619 square miles and have produced the data used to calculate total loading to the ocean from these watersheds.

During the 1998-99 season, the station shelter on the Los Angeles River at Wardlow Road was under reconstruction during the entire season due to the raising of the levee walls by ACOE, and the automated sampling equipment was removed. Samples from the Los Angeles River were collected manually and were not composited. This station has been reinstalled and was fully operational for 1999-2000 season.

For mass emission sites, the Permit requires sampling a minimum of five events per station per year. These sampling events may be either dry weather or wet weather events. The Los Angeles and San Gabriel River stations were also the sites of the freshwater toxicity testing required by the permit. The 1998-99 season was the final season for freshwater toxicity testing.

2.2.1.2 Land Use Site Selection

The following is a brief summary of the land use site selection process completed between the spring and fall of 1996. The complete methods and results of this study are provided in *Evaluation of Land Use Monitoring Stations* (Woodward-Clyde and Psomas and Associates, 1996).

An initial list of 104 land use types based on the Southern California Association of Governments (SCAG) database was sorted into 37 categories. Of these, the top 12 urban uses based on total area were chosen for a field survey. The survey was performed to identify characteristics that would assist in the aggregation or subdivision of the 12 top land use categories. For each of the 12 land uses, 8 representative areas no larger than a city block were selected for the field survey during the spring of 1996. One issue investigated in the field surveys was whether the age of a development of high-density single family residential areas warranted additional monitoring sites. However, the survey indicated that there were no apparent differences between the five different age categories for high-density single-family residential land use so this land use was considered one category.

A loading model for all land uses was applied for four constituents (copper, phosphorus, COD, and TSS). The model used local and regional field-derived estimates of imperviousness and water quality. For each constituent, the land use categories were ranked by total loading. A marginal benefit analysis was applied to the ranked land uses to determine the most important for monitoring. The top land use types that ranked above or equal to the land use with the maximum marginal benefit were identified for monitoring. They were:

- Vacant
- High Density Single Family Residential
- Light Industrial
- Transportation
- Retail/Commercial
- Multifamily Residential
- Educational Facilities

The first 5 of the 7 land use types listed above (Vacant, High Density Single Family Residential, Light Industrial, Transportation, and Retail/Commercial) were already being monitored under the

R0011979

1990 Municipal Permit. To comply with the terms of the 1996 Permit, one site for each of these land uses was retained for continued sampling; the remaining sites were dismantled. New stations to monitor the last two land use types, Multifamily Residential and Educational Facilities, were installed in February 1997 and were operational for the 1997-98, 1998-99, and 1999-2000 storm seasons.

In addition to the pollutant loading analysis, land uses were also ranked by total area within each of the six major Los Angeles County watershed management areas. Four land use types not already on the list were then identified as having significant area in one or more of the watersheds (i.e., ranking in the top five land uses), as follows:

- Heavy Industrial
- Rural Residential
- Utility Facilities
- Mixed Residential

On the basis of this analysis, one mixed residential land use station was installed in October 1997 and was operational for the 1997-98, 1998-99, and 1999-2000 storm seasons; all eight land use monitoring stations were operational during the 1998-99 and seven land use monitoring stations were operational during 1999-2000 season. The Retail/Commercial monitoring station on Pier Drain in Santa Monica (S08) was dismantled and not in use in 1999-2000 storm season, with prior approval from the RWQCB, to accommodate construction by the City of Santa Monica of its stormwater treatment plant.

2.2.1.3 Critical Source Site Selection

The following is a brief summary of the Critical Source selection process undertaken to identify five industrial and/or commercial critical source sites. Each critical source type is to be monitored for a minimum of two years, the first year without BMPs, and subsequent years with BMPs. The complete methods and results of this study are provided in *Critical Source Selection and Monitoring Report* (Woodward-Clyde, 1997).

Similar to the land use monitoring evaluation process, the County undertook a five step process to identify and prioritize a list of critical industries within the county that may contribute significant pollutants to stormwater runoff. Standard Industrial Classification (SIC) codes played a major role in the selection process. Once selected, appropriate sites would be monitored over a minimum two year period for the duration of the permit to measure runoff quality with and without remedial cleanup actions. These remedial actions are referred to as Best Management Practices, or BMPs.

The first step was to develop an initial list of candidate industries. This list contained industries both included and excluded under the State's General Industrial Activities Stormwater permit process. Initial candidate selection was based on prevalence in the county and the extent of outdoor activities. The resulting list yielded a group of 30 candidate industries ranked by the number of facilities.

The next step involved developing a set of criteria to prioritize the list. A number of empirical factors were used to assign levels of significance to each SIC category. Loading (Q) would be

R0011980

addressed by the number of sources at a site and the likelihood of release. Imperviousness (R) of a site would be represented by the percent of paved area. Pollutant toxicity (T) would be denoted by the number of toxic pollutants and the inherent toxicity of the mix. An exposure factor (E) signifies if activities are exposed to rainfall. And finally, number (N) would represent the total number of sites in the county. Each variable would be assigned a qualitative number from 1 to 10, with 10 representing the worst condition. The pollutant potential (P) used to rank the results would thus be the product of all the factors, or

$$P = Q \times R \times T \times E \times N$$

Based on this ranking scheme, the top "critical source" industries were:

- Wholesale Trade (scrap and auto dismantling)
- Automotive Repair/Parking
- Fabricated Metal Products
- Motor Freight
- Automobile Dealers
- Chemical Manufacturing
- Electric/Gas/Sanitary
- Miscellaneous Manufacturing

A literature search was simultaneously conducted to identify what "critical source" industries, if any, have already been analyzed. The search revealed that similar stormwater studies had yet to be performed.

After the identification and prioritization, the Department then had the task of finding six companies of any one of the top five industries to enlist for monitoring runoff from five storms during the 1996-97 storm season. However, all six companies could not be enlisted until the end of that storm season, too late for the collection of runoff data. In 1997-98, twelve companies from two industries, automobile repair and auto dismantling, were enlisted. In the 1998-99 storm season, six companies from the metal fabrication industry were added. In the 1990-2000 storm season, half of the first three critical source industries designated as test sites were fitted with structural or nonstructural BMP at the Department's expense. The other half will remain as controls in order to evaluate BMP effectiveness. In addition, twelve companies from two industries, motor freight and automobile dealers, were enlisted for the 1999-2000 season. Sampling will continue for six years until five critical source industries and remedial BMPs are tested and evaluated.

2.2.2 LOCATION AND DRAINAGE AREA DESCRIPTIONS

Figure 2-1 is an overview of the study area with all mass emission and land use monitoring sites shown. Table 2-1 also indicates the dominant land use associated with each monitoring site and the total drainage area.

R0011981

2.2.2.1 Mass Emission Monitoring Sites

Provided below is a description of the four mass emission stations required by the 1996 Municipal Permit (Ballona Creek, Malibu Creek, Los Angeles River, and San Gabriel River) and one additional mass emission station (Coyote Creek) which is not specifically required. Figures 2-2 through 2-6 show the location of each monitoring station along with a description of its land use and 1990 population.

Ballona Creek Monitoring Station (S01)

The Ballona Creek monitoring station is located at the existing stream gage station (Stream Gage No. F38C-R) between Sawtelle Boulevard and Sepulveda Boulevard in the City of Los Angeles. At this location, which was chosen to avoid tidal influences, the upstream tributary watershed of Ballona Creek is 88.8 square miles. The entire Ballona Creek Watershed is 127.1 square miles. At the gauging station, Ballona Creek is a concrete lined trapezoidal channel.

Malibu Creek Monitoring Station (S02)

The Malibu Creek monitoring station is located at the existing stream gage station (Stream Gage No. F130-9-R) near Malibu Canyon Road, south of Piuma Road. At this location, the tributary watershed to Malibu Creek is 104.9 square miles. The entire Malibu Creek Watershed is 109.9 square miles.

Los Angeles River Monitoring Station (S10)

The Los Angeles River Monitoring Station is located at the existing stream gage station (Stream Gage No. F319-R) between Willow Street and Wardlow Road in the City of Long Beach. At this location, which was chosen to avoid tidal influences, the total upstream tributary drainage area for the Los Angeles River is 825 square miles. This river is the largest watershed outlet to the Pacific Ocean in Los Angeles County. At the site, the river is a concrete lined trapezoidal channel.

San Gabriel River Monitoring Station (S14)

The San Gabriel River Monitoring Station is located at an historic stream gage station (Stream Gage No. F263C-R), below San Gabriel River Parkway in Pico Rivera. At this location the upstream tributary area is 450 square miles. The San Gabriel River, at the gauging station, is a grouted rock-concrete stabilizer along the western levee and a natural section on the eastern side. Flow measurement and water sampling are conducted in the grouted rock area along the western levee of the river. The length of the concrete stabilizer is nearly 70 feet. The San Gabriel River sampling location has been an active stream gauging station since 1968.

Coyote Creek Monitoring Station (S13)

The Coyote Creek Monitoring Station is located at the existing ACOE stream gage station (Stream Gage No. F354-R) below Spring Street in the lower San Gabriel River watershed. Although this site is not required for monitoring per the NPDES Permit, the site was added to assist in determining mass loading for the San Gabriel River watershed. At this location, the

upstream tributary area is 150 square miles (extending into Orange County). The sampling site was chosen to avoid backwater effects from the San Gabriel River. Coyote Creek, at the gauging station, is a concrete lined trapezoidal channel. The Coyote Creek sampling location has been an active stream gauging station since 1963.

2.2.2.2 Land Use Monitoring Sites

The following is a description of the locations selected to monitor runoff from land-use specific drainage areas. Figures 2-7 through 2-14 show the location and drainage area of each monitoring station along with a description of its land use and 1990 population.

Santa Monica Pier Storm Drain Monitoring Station (S08)

The Santa Monica Pier Storm Drain Monitoring Station monitors runoff from land use that is predominantly commercial. The monitoring site is located near the intersection of Appian Way and Moss Avenue in Santa Monica. This storm drain discharges below the Santa Monica Pier. The Santa Monica Mall and Third Street Promenade dominate this watershed. The remaining land uses include: commercial office buildings, small shops, restaurants, hotels, and high density apartments. However, This station was dismantled and not in use in the 1999-2000 storm season to accommodate construction by city of Santa Monica's stormwater treatment plant.

Sawpit Creek Monitoring Station (S11)

The Sawpit Creek Monitoring Station is located in the Los Angeles River Watershed in the City of Monrovia. The monitoring station is in Sawpit Creek, downstream of Monrovia Creek. Sawpit Creek is a natural watercourse at this location. The overall watershed land use is predominantly vacant.

Project 620 Monitoring Station (S18)

The Project 620 Monitoring Station is located in the Los Angeles River Watershed in the City of Glendale. The monitoring station is at the intersection of Glenwood Road and Cleveland Avenue. The overall watershed land use is predominantly high density single family residential.

Dominguez Channel Monitoring Station (S23)

The Dominguez Channel Monitoring Station is located within the Dominguez Channel/ Los Angeles Harbor Watershed in Lennox, near Los Angeles International Airport (LAX). The monitoring station is near the intersection of 116th Street and Isis Avenue. The overall watershed land use is predominantly transportation, and includes areas of LAX and Interstate 105.

Project 1202 Monitoring Station (S24)

The Project 1202 Monitoring Station is located in the Dominguez Channel/Los Angeles Harbor Watershed in the City of Carson. The monitoring station is near the intersection of Wilmington Avenue and 220th Street. The overall watershed land use is predominantly industrial.

R0011983

Project 474 Monitoring Station (S25)

The Project 474 Monitoring Station is located in the Los Angeles River Watershed in the Northridge section of the City of Los Angeles. The monitoring station is located along Lindley Avenue, one block south of Nordhoff Street. The station monitors runoff from the California State University of Northridge. The land use of the drainage area is primarily education.

Project 404 Monitoring Station (S26)

The Project 404 Monitoring Station is located within the Los Angeles River Watershed in the City of Arcadia. The monitoring station is located along Duarte Road, between Holly Avenue and La Cadena Avenue. The land use of the drainage area is primarily multi-family residential.

Project 156 Monitoring Station (S27)

The Project 156 Monitoring Station is located within the Los Angeles Watershed in the City of Glendale. The monitoring station is located along Wilson Avenue, near the intersection of Concord Street and Wilson Avenue. The land use of the drainage area is classified as mixed residential.

2.2.2.3 Critical Source Monitoring Sites

The general locations of the critical source monitoring sites are shown in Figure 2-15. For purposes of anonymity, the agreement reached with each of the businesses keeps the exact locations confidential. Sites C01, C02, and C03 are the control sites for the wholesale trade (auto dismantlers); T01, T02, and T03 are the sites where Best Management Practices (BMPs) will be installed for the wholesale trade industry. Similarly, C04, C05, and C06 are the control sites for automotive repair, while T04, T05, and T06 are the BMP sites for the automotive repair industry. Sites C07, C08, and C09 are the control sites for fabricated metal products; T07, T08, and T09 are the BMP sites for the fabricated metal products industry. Sites C10, C11, and T12C are the control sites for motor freight companies; T10, T11A, T11B, T12A, T12B, and T12C are the BMP sites for the motor freight companies. Sites C13, C14, and C15 are the control sites for the auto dealers; T13, T14, and T15 are the BMP sites for the auto dealers.

SECTION 3

R0011985

This section describes the field and laboratory methods used to conduct the Monitoring Program, which includes precipitation and flow monitoring, stormwater sampling, and laboratory analyses. It also includes statistical test criteria as described in the NPDES permit.

3.1 PRECIPITATION AND FLOW MEASUREMENT

3.1.1 Precipitation Monitoring

For every monitoring station, a minimum of one automatic tipping bucket (intensity measuring) rain gage is located nearby or within the tributary watershed. Large watersheds may require multiple rain gages to accurately characterize the rainfall. The Los Angeles County Department of Public Works operates various automatic rain gages throughout the county. Existing gages near the monitored watersheds are also utilized in calculating stormwater runoff and are essential to develop runoff characteristics for these watersheds.

3.1.2 Flow Monitoring

Flow monitoring equipment is needed to trigger the automated samplers because the Monitoring Program requires flow-weighted composites for many constituents. Flows are determined from measurements of water elevation as described below.

The water elevation in a storm drain is measured by the stage monitoring equipment, and the flow rate is derived from a previously established rating table for the site or calculated with an equation such as Manning's. The Los Angeles County Department of Public Works uses rating tables generated from analysis of storm drain cross sections and upstream/downstream flow characteristics. The rating tables are modified if it is demonstrated in the field through stream velocity measurements that calculated table values are incorrect. Previous stormwater flow measurement efforts indicates that all stations will require multiple storm events to gather the data necessary for calibration of the measurement devices.

The automatic samplers utilize pressure transducers as the stage measurement device. However, pressure transducers are only accurate as flow measurement devices in open channel flow regimes. Therefore, for stations monitoring flows in underground storm drains, efforts were made to select drains that do not surcharge (flow under pressure) during events smaller than a 10-year storm event.

3.2 STORMWATER SAMPLING

3.2.1 Sample Collection Methods

Grab and composite sample collection methods, defined below, are used to collect samples.

- **Grab Sample** - a discrete, individual sample taken within a short period of time, usually less than 15 minutes. This method is used to collect samples for constituents that have very short holding times and specific collection or preservation needs. For example, samples for coliforms are taken directly into a sterile container to avoid non-resident bacterial contamination.

R0011986

- **Composite Sample** - a mixed or combined sample created by combining a series of discrete samples (aliquots) of specific volume, collected at specific flow-volume intervals. Composite sampling is ideally conducted over the duration of the storm event.

During a storm event, grab samples were collected during the initial portion of the storm (on the rising limb of the hydrograph) and taken directly to the laboratory.

Flow composite storm samples were obtained using an automated sampler to collect samples at flow-paced intervals. Samples collected at each station were combined in the laboratory to create a single flow-weighted sample for analysis.

During the storm season, the sampler was programmed to start automatically when the water level in the channel or storm drain exceeded the maximum annual dry weather stage. A sample was collected each time a set volume of water had passed the monitoring point (this volume is referred to as the pacing volume or trigger volume). The sample was stored in glass containers within the refrigerated sampler. A minimum of eight liters of sample was required to conduct the necessary laboratory analyses for all the constituents. The automated sampler was deactivated by field personnel when the water level in the channel or storm drain fell to about 120 percent of the observed maximum annual dry weather flow stage.

Samples were retrieved from the automated samplers as soon as possible to meet laboratory analysis holding time requirements. As samples were collected, rainfall and runoff data were logged and stored for transfer to the office.

Critical Source sampling procedures and equipment are described in the *Critical Source Selection and Monitoring report* (LACDPW and Woodward-Clyde, January 8, 199).

3.2.2 Field Quality Assurance/Quality Control Plan

Properly performed monitoring station set up, water sample collection, sample transport, and laboratory analyses are vital to the collection of accurate data. Quality Assurance/Quality Control (QA/QC) is an essential component of the monitoring program.

Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996a) describes the procedures used for bottle labeling, chain-of-custody tracking, sampler equipment checkout and setup, sample collection, field blanks to assess field contamination, field duplicate samples, and transportation to the laboratory.

An important part of the QA/QC Plan is the continued education of all field personnel. Field personnel were adequately trained from the onset and informed about new information on stormwater sampling techniques on a continuing basis. Field personnel also evaluate the field activities required by the QA/QC Plan, and the Plan is updated if necessary.

Bottle Preparation

For each monitoring station, a minimum of three sets of bottles was available so that up to two complete bottle change-outs could be made for each storm event. Bottle labels contained the following information:

- LADPW Sample ID Number
- Station Number
- Station Name
- Sample Type (Grab or Composite)
- Laboratory Analysis Requested
- Date
- Time
- Preservative
- Temperature
- Sampler's Name

Bottles were cleaned at the laboratory prior to use, then they were labeled and stored in sets. Each station was provided with the same number, types, and volumes of bottles for each rotation unless special grab samples were required. Clean composite sample bottles were placed in the automated sampler when samples were collected. This practice ensured readiness for the next storm event. All bottles currently not in use were stored and later transported in plastic ice chests. Composite sample bottles were limited to a maximum of 2-1/2 gallons each, to ensure ease of handling.

Chain-of-Custody Procedure

Chain-of-custody forms were completed to ensure and document sample integrity. These procedures establish a written record which tracks sample possession from collection through analysis.

Field Setup Procedures

All field sampling locations were fixed sites, with the sampler placed on a public road or flood control right-of-way. After sample collection, field staff prepared the sampler for collection of the next set of samples either in storm mode or in dry weather mode. Inspection of visible hoses and cables was performed to ensure proper working conditions according to the site design. Inspection of the strainer, pressure transducer, and auxiliary pump was performed during daylight hours in nonstorm conditions.

The automated sampler was checked at the beginning of the storm (during grab sample collection) to ensure proper working condition and to see if flow composite samples were being collected properly. Dry weather collection techniques were similar, with grab and 24-hour composite samples being collected.

Bottles were collected after each event and packed with ice and foam insulation inside individually marked ice chests. Chain-of-custody forms were completed by field staff before

R0011988

transportation of the samples to the laboratory. Under no circumstance were samples removed from the ice chest during transportation from the field to the laboratory.

Travel Blanks and Field Duplicates

Potential field contamination was assessed through analysis of travel blanks and duplicate grab samples. Field travel blanks were collected for each monitoring station during every sampling event to quantify post sampling contamination. The monitoring program also included field duplicates to assess the precision of laboratory results. A field duplicate, the origin of which was unknown to the laboratory, was collected for each sampling event. This methodology for assessing post sampling contamination and laboratory testing procedures provided data to measure the precision and accuracy of the laboratory results.

3.2.3 Sampling Frequency

During the 1996-97 storm season, the Permit required the Department to sample up to 100 "station events" for the land use sites. During subsequent years (1997-98, 1998-99, 1999-2000), the Department was required to sample up to 200 "station events". A station event is defined as collection of one sample at one station. The Municipal Permit specifies sampling at mass emission stations to total five events per year during dry weather, storm, or a combination of both for all years.

3.3 LABORATORY ANALYSES

The Department of Agricultural Commissioner/Weights and Measures (ACWM) Environmental Toxicology Laboratory provides water quality laboratory and related services to the LACDPW. The ACWM lab is state certified to perform the water quality analyses contracted by LACDPW. The ACWM Lab maintains a laboratory analysis program that includes Quality Assurance and Quality Control protocols consistent with the objectives of the monitoring program required by the Permit (Section 3.3.3).

3.3.1 Possible Constituents of Concern

Possible constituents of concern for each element of the Monitoring Program are specified in the Municipal Permit. The constituents of concern for land use station monitoring are:

- Total Suspended Solids
- Total Nitrogen
- Total Phosphorus
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc
- Chlordane
- Chlorpyrifos
- Diazinon
- Malathion
- Simazine
- Total DDT
- Total PAHs
- Total PCBs

Constituents of concern for mass emission monitoring include those listed above plus:

- Bacteria
- Total Phenols
- TPH
- Oil and Grease
- Cyanide

3.3.2 Analytical Suite and Analytical Methods

The suite of analytes and associated detection limits for samples collected at the land use stations and mass emission stations are specified in the Municipal Permit. Constituents of concern for derivation of event mean concentrations are also specified by the Permit. All the laboratory methods used for analysis of the stormwater samples are approved by the California Department of Health Services and are in conformance with USEPA approved methods.

The laboratory made an effort to provide the lowest detection limits attainable without compromising the reliability of the data. "Detection limit" (DL) is defined by the USEPA as "the concentration above which we are 99% confident that the analyte is present at a concentration greater than zero" (40 CFR Part 136 Appendix B). For this project the laboratory made some allowance for interference in the analysis due to the complex nature of the sample matrix by performing a DL study using a water sample collected from a channel during dry weather. These 'matrix specific' DLs are the reported DLs in the data tables. Data below the DL are reported as zero. The Practical Quantitation Limit (PQL) is the concentration above which the analyte can be accurately quantified. Reported PQLs were developed by the laboratory during the analysis of stormwater runoff samples using professional judgment to account for matrix interferences. Data that fall between the DL and PQL are reported by the laboratory at the apparent concentrations. When reviewing these data it should be noted that the concentrations below the PQL are estimated.

For some pollutants, the EPA Water Quality Criteria were lower than the required Monitoring Program method detection limits. As a result, detection limits for some constituents were lowered (beginning in the 1996-97 storm season) to a level below the EPA Criteria concentrations. This also enhanced the value of the data by improving the quality of the data sets and allowed for more rigorous statistical analyses and data interpretation techniques.

Detection limits of many semi-volatile organic compounds (SVOCs) were lowered in the 1999-2000 storm season, including all PAHs, for the land use and mass emission studies at the request of the Los Angeles Regional Water Quality Control Board. Modifications to detection limits are presented in Table 3-1.

3.3.3 Quality Assurance and Quality Control

The primary objective of the laboratory quality assurance/quality control program is to ensure that the analyses are scientifically valid, defensible, and of known precision and accuracy. The ACWM laboratory maintains quality assurance/quality control procedures (as described in their Quality Assurance Manual) in accordance with requirements of the California Department of Health Services. The ACWM laboratory standard operation procedures include method validation, equipment calibration, preventive maintenance, data validation procedures, assessment of accuracy and precision, corrective actions, and performance and system audits.

R0011990

The QA/QC review and data validation for the monitoring data was conducted by ACWM Lab, and the QA/QC documentation is available within the ACWM Lab files. The validated data as provided by the ACWM Lab were used for data analysis and interpretation with no further QA/QC review.

3.4 STATISTICAL TEST CRITERIA

3.4.1 Land Use

There are two provisions in the Permit which allow for discontinuing monitoring of specific land use constituents. The first is achieving an event mean concentration (EMC) at an error rate of 25% (Criteria 1). The second is detecting less than 25% of any constituent in 10 consecutive samples (Criteria 2).

Criteria 1

Section B.1.c of Attachment C of the NPDES Permit states: "The land use stations shall be monitored during the term of this Order or until such time that event mean concentrations (EMC) are derived, at the 25% error rate, for the following constituents of concern:"

PAHs	Chlordane	Cadmium
Copper	Nickel	Lead
Chromium	Silver	Zinc
Selenium	Mercury	Total Nitrogen
Total Phosphorus	Total Suspended Solids	Diazinon
Chlorpyrifos	Malathion	Simazine
Total DDT	Total PCBs	

The RWQCB agreed to substitute the mean standard error in place of the error rate (Swamikannu, 1999). The findings are presented in Table 4-14. Constituents appearing have at least 10 samples and an 80% detection rate.

Criteria 2

Section B.1.e of Attachment C of the NPDES Permit states: "If a constituent is not detected at the method detection limit (MDL) for its respective test method listed in Attachment C-3 in more than 25 percent of the first ten sampling events or on a rolling basis using ten consecutive sampling events, it will not be further analyzed unless the observed occurrences show high concentrations and are cause for concern." The results of this test are presented in Table 4-13.

Constituents meeting this criteria (with an X corresponding to a site) can be considered for discontinuation. However, if there is still concern for the constituent, monitoring will continue. Specific constituents of concern are marked with an asterisk in the table.

3.4.2 Mass Emissions

The only criteria required to discontinue monitoring constituents at mass emissions sites is the detection of less than 25% in 10 consecutive samples (Section B.2.c of Attachment C of the NPDES Permit). The results of this test are presented in Table 4-7.

Constituents meeting this criteria (with an X corresponding to a site) can be considered for discontinuation. However, if there is still concern for the constituent, monitoring will continue. Specific constituents of concern are marked with an asterisk in the table.

R0011992

SECTION 4

R0011993

4.1 HYDROLOGY: PRECIPITATION AND FLOW

Over the past six years, Los Angeles County has experienced weather patterns that have resulted in very diverse storm seasons. The two most significant seasons were the 1997-98 El Niño and the 1998-99 La Niña storm seasons.

The term El Niño refers to the disruption of the entire oceanic-atmospheric system in the tropical Pacific Ocean. This occurrence often causes a major departure from average temperatures and precipitation amounts on a global scale. During El Niño, the trade winds relax in the central and eastern Pacific and upwelling of deep colder ocean water is inhibited. Therefore, in the eastern Pacific, the water temperature rises. Increases in temperature in the central and eastern Pacific result in an increase of evaporation and convection, or thunderstorm activity. This activity can be observed, especially in the winter, as the subtropical jet stream flows from Southern California, through the Gulf Coast region.

The effects of the 1997-98 El Niño were the strongest observed for the past 40 years (National Oceanic and Atmospheric Administration). Rainfall associated with El Niño was greater later in the storm season as compared to previous years. The month of February of 1998 produced over fifteen inches of rain at the downtown Los Angeles raingage compared to the 110 year average of 3.17 inches for the same raingage. The previous year, the same raingage recorded only 0.06 inches of rain.

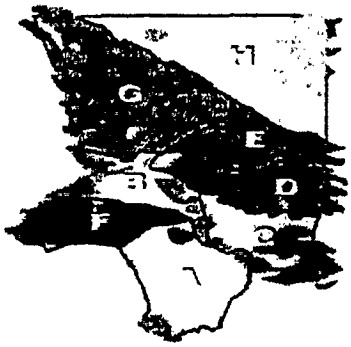
Furthermore, the total wet season runoff volume at the Los Angeles River station as of March, 1998, was nearly 300,000 acre-ft. By comparison, the 1996-97 storm season runoff volume at the same location was 58,309 acre-ft, approximately one-fifth.

In contrast, the 1998-99 storm season was considered a La Niña storm season. La Niña climatology is characterized by unusually cold ocean temperatures in the eastern equatorial Pacific that impact global weather patterns. La Niña tends to bring nearly opposite effects of El Niño to the United States. It often features drier than normal conditions in the Southwest in late summer trough the subsequent winter. La Niña conditions recur every few years and can persist as long as two years.

The month of February of 1999 produced only 0.4 inches of rain at the downtown Los Angeles raingage compared to the 110 year average of 3.17 inches for the same raingage. The same raingage during the El Niño season, by contrast, produced over 15 inches of rain. Similarly, the total rainfall for the 1998-1999 season at the Ballona Creek station was only 9.48 inches, and the total wet season runoff volume at the Ballona Creek station was 10,700 acre-ft. By comparison, the rainfall total during the previous storm season at this station was 28.28 inches and the runoff volume was 18,300 acre-feet.

Figures 4-20 and 4-21 respectively show the Los Angeles annual and monthly wet season rainfall at the downtown Los Angeles station.

Furthermore, the figure and table below display aerial weighted rainfall totals for the Los Angeles County by area. As expected, the San Gabriel and Santa Monica Mountains recorded the highest precipitation totals throughout the years while the dessert areas recorded the lowest. San Gabriel and San Fernando Valleys recorded very similar precipitation values. Again, it can be seen that El Niño season of 1997-98 produced twice as much rainfall as the seasonal normal, while La Niña season of 1998-99 recorded less than half the seasonal normal.



RAINFALL INDICES USING SELECTED STATIONS
for the period of October 1 through September 30

	Seasonal Normal (inches)	94-95 Season (inches)	95-96 Season (inches)	96-97 Season (inches)	97-98 Season (inches)	98-99 Season (inches)	99-00 Season* (inches)
A. Coastal Plain	13.71	25.19	11.38	13.91	29.08	7.73	8.94
B. San Fernando Valley	17.62	35.01	13.22	18.58	39.55	10.35	15.64
C. San Gabriel Valley	17.64	29.61	14.35	17.17	35.63	8.53	13.55
D. San Gabriel Mountains	27.5	44.78	23.56	25.12	54.31	12.17	18.05
E. Little Rock, Big Rock	18.61	30.8	12.77	14.16	30.86	8.16	13.71
F. Santa Monica Mountains	19.96	40.14	14.81	18.02	45.72	10.17	16.82
G. Santa Clara	16.64	28.17	11.05	13.33	36.63	9.83	12.85
H. Desert	7.83	13.35	4.65	5.18	17.57	3.69	4.4
County**	15.65	27.27	11.69	13.72	33.01	8.02	11.17

Notes: * Rainfall from October 1, 1999 through April 30, 2000
** Seasonal Normal and Season sections of this line are derived from Areal Weighted Average.

Table 4-1 summarizes the hydrological data for each station for the 1994-95, 1996-97, 1997-98, 1998-99, and 1999-2000 seasons.

A collection of rainfall contour maps for the 1994-95, 1995-96, 1996-97, 1997-98, 1998-99, and 1999-2000 storm seasons are included in Appendix A.

Refer to Appendices of preceding annual Stormwater Monitoring Reports for hydrographs of monitored sites and rainfall contour maps for each storm event.

4.2 STORMWATER QUALITY

4.2.1 Overall Imperviousness

Overall watershed imperviousness has been linked to stormwater quality problems (Center for Watershed Protection, 1996). The following table gives the overall imperviousness of each of the major Watershed Management Areas under the 1996 Municipal Stormwater Permit:

Imperviousness of Watershed Management Areas

WATERSHED MANAGEMENT AREA	AREA, Sq. Mi.	OVERALL IMPERVIOUSNESS, %
Dominguez Channel/ L. A. Harbor	110	62
Ballona Creek	211	45
Los Angeles River	834	35
San Gabriel River	683	30
Malibu Creek	203	6
Santa Clara River	1029	5

Notes. - Values were calculated using the DPW GIS Pollutant Loading Model
- Land use distribution is based on 1993 SCAG data
- Imperviousness values for each land use were taken from the LACDPW Hydrology Manual, 1991

4.2.2 Bacterial Indicators

Los Angeles County has been monitoring a selection of bacterial indicators, including total coliforms and fecal bacteria (fecal coliforms, fecal streptococcus, and fecal enterococcus), at two of the mass emission monitoring stations (Ballona Creek and Malibu Creek) since the 1994-95 rainy season. Bacteria monitoring in 1994-95 and 1995-96 also involved land use sampling. All four of the mass emission monitoring stations currently required by the Permit (Ballona Creek, Malibu Creek, Los Angeles River, and San Gabriel River) have been sampled for bacteria since the 1995-96 storm season. Bacteria were not sampled at the Coyote Ck. station, which was not a requirement of the Permit, and land use sampling for bacteria was also not a requirement under the current Permit.

In addition to wet weather sampling, a number of dry weather samples were analyzed since 1994 to support other in-house studies, most notably for the low flow diversion projects at various locations along the shore line in Los Angeles County. Dry weather bacteria results are presented in Tables 4-5b and 4-5c.

Fecal bacteria are normal residents of the digestive tracts of humans and other warm-blooded animals. They are usually not pathogenic themselves but they can serve as indicators for the presence of potential pathogens (including bacteria, viruses, and protozoa that may cause human health problems) if contamination of surface waters with sewage had occurred. Fecal coliforms are a subgroup of the total coliform group.

Fecal coliforms, fecal streptococcus, and fecal enterococcus are three independent residents of the gastro-intestinal tracts of warm-blooded animals, and their distribution among warm-blooded species varies. Unfortunately, none of the bacteria is totally specific to humans, so none can serve as the ultimate indicator and warning signal for the presence of potential human pathogens.

Total coliforms and fecal bacteria (fecal coliforms, fecal streptococcus, and fecal enterococcus) were detected in all stormwater samples tested since 1994 at densities (or most probable number, MPN) between several hundreds to several million cells per 100 ml. Table 4-8 and Figure 4-4 show the wet weather sample results obtained between 1994 and 2000 for the different bacterial groups. The geometric mean (labeled as "log mean" for consistency with reports from other Los Angeles agencies) for each storm season is shown as one bar. Results are shown for the four mass-emission stations tested. Dry weather bacteria results are presented in Tables 4-5b and 4-5c.

The Malibu Creek station appears to have consistently lower counts than other mass emission stations and is consistently lower for all four groups of bacteria. There is no apparent pattern of differences between monitoring years, although the 1995-96 season appears to have higher mean densities than other years. At 75% of normal, this was not a particularly rainy season.

A study of the raw microbial data for wet weather and dry weather from 1994 to 2000 indicates the following:

- Every wet weather mass emission bacteria sample taken exceeded the public health criteria for indicator bacteria. All of the dry weather bacteria samples taken for the low flow diversion projects exceeded the public health criteria. Most of the dry weather mass emission bacteria samples taken exceeded the public health criteria. Wet weather flows

contained bacteria densities at much higher levels (three to four orders of magnitude) than dry weather flows.

- Except for 1996-97, densities observed during the first storm of each rainy season were not necessarily higher than during consecutive storm events, suggesting that there was no consistent "first-flush" effect in these watersheds. Peak densities were observed at different times each year. In 1995-96, the peak density at all four mass emission stations and one land use station coincided with the peak storm of the season.

- Except for somewhat lower densities at Malibu Creek, there was no seasonal or regional consistency in cell densities. There was a very wide range of densities for all stations.

- There was one storm event, January 9, 1998, that yielded extremely high counts in all stations for all bacterial strains. The available data do not provide an explanation, or suggest whether this could be a contamination artifact.

- The 1996-97 season had one event, November 21, 1996, that yielded runoff with high counts in all stations for all species.

- During the 1998-99 season, the event of March 15, 1999 was associated with high bacterial counts for most stations and the events of March 25, 1999 and April 4, 1999 were associated with unusually low counts for most stations.

The following table gives the storm date when the peak fecal coliform reading was observed for that season:

[SEE TABLE ON NEXT PAGE]

Comparison of Storm Dates to Peak Fecal Coliform Dates

		1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000
Date of First Storm > 0.1"		10/04/94	12/13/95	10/29/96	11/10/97	11/08/98	11/08/99
Date of Largest Storm		01/07/95	02/20/96	01/20/97	02/21/98	04/11/99	03/03/00
Depth of Largest Storm (inches)		6.65	4.39	3.54	5.08	1.15	2.01
MONITORING STATION	Ballona Creek	01/10/95	02/20/96	10/29/96	01/09/98	02/09/99	02/10/00
	Malibu Creek	03/03/95	02/20/96	10/29/96	01/09/98	03/15/99	02/23/00
	Los Angeles River	N/A	02/20/96	11/21/96	01/09/98	03/15/99	02/23/00
	San Gabriel River	N/A	02/20/96	11/21/96	01/09/98	03/15/99	03/08/00
	Retail/Commercial	03/21/95	12/23/95	N/A	N/A	N/A	N/A
	Vacant	N/A	12/23/95	N/A	N/A	N/A	N/A
	HDSFR	N/A	03/12/96	N/A	N/A	N/A	N/A
	Transportation	N/A	12/23/95	N/A	N/A	N/A	N/A
	Light Industrial	N/A	02/20/96	N/A	N/A	N/A	N/A

It appears from the table that in a number of instances, peak fecal coliform counts occurred at different monitoring stations in different parts of the county during the same storm. Further, in 1995-96, the highest fecal coliform readings at five stations coincided with the largest storm of the season. Also, in 1996-97, the highest fecal coliform readings at two stations coincided with the first storm of the season greater than 0.1" rainfall. These observations suggest that peak fecal coliform levels may be related to regional hydrologic conditions.

4.2.3 Stormwater Toxicity

Two studies required by the 1996 Municipal Stormwater Permit examined stormwater toxicity. The Santa Monica Bay Receiving Waters study examined water column and sediment toxicity impacts on Santa Monica Bay from stormwater from Ballona and Malibu Creeks. The Southern California Coastal Waters Research Project (SCCWRP), the University of Southern California, and the University of California Santa Barbara were the principal investigators. In addition, dry and wet weather toxicity tests were performed on the Los Angeles and San Gabriel Rivers in 1997-98 and 1998-99. This testing was performed by the Southern California Coastal Waters Research Project. Toxicity was measured as impairment to sea urchin fertilization.

An Executive Summary of the Bay Receiving Waters study is included in Appendix C. Major findings of the stormwater toxicity studies (SCCWRP, 1999) are repeated below:

- Virtually every sample of Ballona Creek stormwater tested was toxic to sea urchin fertilization.

- The first storms of the year produced the most toxic stormwater in Santa Monica Bay during the study.
- The toxic portions of the stormwater plume were variable in size, extending from 1/4 to 2 miles offshore of Ballona Creek.
- Surface water toxicity caused by unidentified sources was frequently encountered during dry weather in Santa Monica Bay.
- Zinc was the most important toxic constituent identified in stormwater in Santa Monica Bay, but zinc concentrations in the toxic portion of the discharge plume were usually below levels shown to cause toxicity in the laboratory.
- Copper and other unidentified constituents may also be responsible for some of the toxicity measured in Santa Monica Bay.
- The measured concentrations of zinc and copper in Ballona Creek stormwater were estimated to account for only 5% - 44% of the observed toxicity.
- The fate of most stormwater constituents discharged to Santa Monica Bay is unknown.
- For two years in a row, wet weather toxicity was significant in the Los Angeles River. Dry weather toxicity was significant the second year, but not the first.
- For the San Gabriel River, wet weather toxicity was significant the first year, but not the second. Dry weather toxicity was not significant either year.
- For both rivers, wet weather toxicity was higher for the first storm tested, suggesting a seasonal "fist flush" phenomenon for toxicity.

4.2.4 Contaminated Sediments and Total Suspended Solids

Sea floor habitat and sediment contamination were studied in the Santa Monica Bay Receiving Waters study and were investigated by the Southern California Coastal Waters Research Project. Major findings of the sea floor habitat and sediment contamination study (SCCWRP, 1999) are repeated below:

- The sea floor is where stormwater particles, and associated contaminants, eventually settle.
- The sediments on the sea floor can accumulate runoff inputs over an entire storm, over several storms, or over several seasons.
- Sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants, including common stormwater constituents such as lead and zinc.
- Sediments offshore of Ballona Creek showed evidence of stormwater impacts over a large area.
- Sampled biological communities offshore of Ballona Creek were similar to those offshore of Malibu Creek. Both areas had comparable abundance and similar species composition.
- Sampled biological communities offshore of Ballona and Malibu Creeks were also similar to background reference conditions established in previous studies of southern California.

The County of Los Angeles Department of Public Works has also participated on the Los Angeles Basin Contaminated Sediment Task Force. The management committee of the Task Force is comprised of the U. S. Army Corps of Engineers, the U.S. Environmental Protection Agency (Region IX), the California Water Quality Control Board (Los Angeles Region), and the California Coastal Commission. One of the goals of the Task Force is to promote and implement region-wide efforts at source reduction through watershed management. The Task Force, in its Long Term Management Strategy Action Plan (no date), states:

- Informal surveys of potential users and past projects suggest that the major sources of contaminated dredge material will continue to be Marina del Rey, the ports of Los Angeles and Long Beach, and the mouth of the Los Angeles River.
- Some of the sediments dredged from these harbors contain elevated levels of heavy metals, pesticides, and other contaminants. In most cases, the concentrations of these contaminants do not approach hazardous levels.

The Corps of Engineers, in a draft study (2000) sought to identify possible inland sources of contaminated sediments in the Ballona Creek watershed by sampling dry weather sediments in the bottom of Ballona Creek and major tributaries. The draft study found:

- Four of 21 sites were without any chemical concentration exceeding the National Oceanographic and Atmospheric Administration's "Effect Range-Low" (ERL) values: storm drain Bond Issue Project 9408, Project 425, Ballona Creek at Sawtelle Blvd., and Centinela Channel.
- Sediments on the bottoms of storm drain Bond Issue Projects 648, 51, 494, and 503 ranked by dry weight most consistently as the most contaminated sites with respect to metals and polycyclic aromatic hydrocarbons (PAHs).
- The two areas of the main Ballona Ck. channel that ranked, by dry weight, as most contaminated and exceeding ERLs were just downstream of Madison Ave. and Fairfax Ave.
- With respect to the potential for contamination from PAHs, sites in Ballona Ck. at Pickford St. and Fairfax Ave., Higuera St. drain, Projects 51 and 3867, and Culver City Acquisition and Improvement District No. 4 drain appeared most contaminated.
- Bed load sediment in the major tributary drains of Sepulveda and Centinela Channels were among the least contaminated samples.
- According to a Corps geographic information system used to model unit aerial loading, the area within the Ballona Ck. drainage area of expected highest stormwater loading of metals, oil, and grease extends from Hollywood to Culver City in a 1- to 2-mile wide, 5- to 6-mile long strip parallel and east of the San Diego (I-405) Freeway.

In an effort to analyze the presence of PAH in stormwater, Los Angeles County Public Works lowered the detection limit of semi-volatile organics in stormwater samples in the 1999-2000 season by using modified EPA method 625 (see Table 3-1). An analysis of stormwater mass emission mean concentrations (Table 4-6b) shows that two PAH compounds, phenanthrene and pyrene, exceeded the California Ocean Plan objective at the Malibu Creek station. No other PAH compound exceedences appeared through this comparison.

Given the connection between contaminated sediments and suspended solids (Stenstrom et al, 1997, in U. S. Army Corps of Engineers, 2000), we calculated suspended solids loadings at the five mass emission monitoring stations from 1994 to present (Table 4-10 and Fig. 4-5a) where data was available. The data shows that the Los Angeles River is the largest contributor of suspended solids. This finding is expected because the L. A. River drainage area is the largest monitored watershed (825 square miles at the monitoring station). However, during the El Niño season of 1997-98, suspended solid loading was disproportionately higher than Ballona Creek loading (88.8 square miles at the monitoring station). It should be noted, however, that the Ballona Ck. monitoring station was out of service during February of 1998.

Total suspended solids were high during the 1999-2000 storm season at the vacant land use site. This may have been due to modifications to the Sawpit Dam located upstream of the sampling station.

4.2.5 Comparison of Mass Emissions Concentrations to the Ocean Plan, Basin Plan, and California Toxics Rule

Table 4-6a shows the list of constituents analyzed from the stormwater mass emission monitoring sites since 1994. Both the annual mean and median of the analyses of these constituents were compared to the water quality objectives outlined in the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule. Stormwater bacteria indicators were compared to the standards in AB411. It should be noted that, except for bacteria indicators, there are no numerical water quality standards that apply to stormwater or nonpoint source pollution. Current federal and state numerical standards apply only to point source pollution, such as sanitary sewage, industrial and point source discharges to the ocean and other water bodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedence of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

Table 4-6b shows those constituents whose annual mean or median virtually exceeded the three objectives described above. For bacteria indicators, the log mean of the Most Probable Number per 100 ml was compared to the objectives of AB411. The table shows that the bacteria indicator standards were exceeded at every monitoring station where sampled for every year. The next most prominent virtual exceedences occurred with total and dissolved copper and bis (2-ethylhexyl) phthalate, followed by turbidity, total zinc, and total lead. The table also shows that 1997-98, the El Niño season, contributed the most virtual exceedences at all monitoring stations except Coyote Creek. Finally, the table shows that the Los Angeles River produced the most virtual exceedences of any other mass emission monitoring station.

4.2.6 Loading

The above discussion points to dissolved zinc and copper and total suspended solids as constituents worthy of further examination. If these are important constituents, it would be helpful to look at what watersheds are producing the greatest amounts of these constituents. A loading analysis, that is pounds of constituent per season, would make this indication. To

calculate annual loading, the annual mean concentration of the constituents of interest are multiplied by the annual volume of runoff measured at each mass emission station. Loading results are shown in Table 4-10 and Figures 4-5a through 4-12.

As expected, loading was greatest during 1997-98, the El Niño season. This analysis indicates that the Los Angeles River delivered the highest loadings of total suspended solids (approx. 220,000 tons), dissolved copper (approx. 28 tons), total copper (approx. 40 tons), dissolved zinc (approx. 170 tons), and total zinc (approx. 230 tons). Further, it appears that Los Angeles River loading for the metals is disproportionate by drainage area to the other watersheds.

Total and dissolved zinc loading is also prevalent among unmonitored watersheds. The Dominguez Channel/L. A. Harbor watershed contributed the highest loadings for dissolved zinc (approx. 2.3 tons) and dissolved copper (approx. 30 tons) and was the highest for each year.

Loading calculations from unmonitored watersheds were accomplished by a GIS model (Table 4-11 and Figures 4-16 through 4-19). Comparison of loadings between monitored and unmonitored watersheds should not be made at this time because the model is not fully calibrated.

4.2.6.1 GIS Model

To assist in implementing this requirement, the Department developed a GIS application called the Pollutant Loading Model. A brief description of the model follows:

Hardware Requirements

- IBM-compatible, running Windows NT 4.0 or Windows 95
- 8 MB hard disk space (data/project on network); 600MB hard disk space (local)
- 64 MB RAM or higher

Software Requirements

- ArcView 3.1
- Spatial Analyst 1.1 for ArcView

Data Requirements

Geographic -

- Thomas Brothers Maps® data sets, County of Los Angeles
- Southern California Association of Governments Land Use
- Watershed Management Area Boundaries
- Rain gage locations and depths
- Watershed sub-basin boundaries
- Municipal Boundaries
- Water Quality Monitoring Station locations

Tabular -

- Rain gage data for each rainfall event
- Event Mean Concentration data

The Pollutant Loading application computes total pollutant loading for selected pollutants originating in user-defined watersheds or political boundaries. It draws upon many existing data sources, such as predetermined drainage subbasins, land use, historical and event rainfall data, water quality monitoring station results, and multiple underlying geographic data including political boundaries, natural boundaries, census tracts, forest boundaries, streets, and drains.

The user is given the option of hand-digitizing a study area or graphically selecting a predetermined drainage subbasin, monitoring station watershed, city, or other municipal boundary to use as a study area. The user can also locate an area of interest by typing an address or selecting a Thomas Brothers Maps® page.

The user selects a rainfall event from historical records. Rainfall data comes in the form of a previously processed grid of the user-selected storm event or as a rain gage data file, in which case, the model will prepare a rainfall grid using the Spatial Analyst extension. There is also an option to use average annual rainfall.

The application uses the rainfall data to calculate the amount of runoff, based on the imperviousness of the land use polygons it intersects. See equations used at the end of this Section.

The user then has the ability to choose the pollutants for the study from over 257 constituents. The Water Quality data comes from over 24 monitoring stations the County has operated at some point since the 1994-95 storm season. The user can quickly select constituents from pre-classified groups such as General Minerals, Heavy Metals, Pesticides, etc. By default the model will select the 25 pollutants of concern (made up of 61 constituents) listed in the NPDES permit.

The model will then tabulate total pollutant load for the study area using previously calculated Event Mean Concentrations of the selected pollutants. A report of the results is generated in Crystal Reports. The application also produces maps as ArcView layouts showing the area of study, rainfall isohyets, landuse distribution, rain gage locations and values.

Equations Used

- Runoff Volume = (Rainfall Volume)*(Runoff Coefficient)
  Where:
  Runoff Coefficient = (0.8*Imperviousness) + 0.1
- Load = (Pollutant concentration)*(Runoff Volume)

Assumptions and Limitations

- An imperviousness value used for the calculations is associated with 104 different landuse categories.
- The 104 SCAG land use categories have been aggregated into 34 categories covering 100% of the County.

Critical Industry Land Use Types

Critical Source Industry	SCAG Land Use
Auto Dismantling (Wholesale Trade)	Heavy Industrial
Auto Repair	Retail/Commercial
Metal Fabrication	Heavy Industrial
Motor Freight	Transportation
Auto Dealerships	Retail Commercial

Table 4-15 and Figure 4-3 show the highest median value for total zinc (approx. 450 μg/l), dissolved zinc (approx. 360 μg/l), total copper (approx. 240 μg/l), and dissolved copper (approx. 110 μg/l) were produced at the fabricated metal sites (labeled "control"). This finding holds true for those critical source industries added and sampled in 1999-2000, namely motor freight and auto dealerships, which are discussed in the 1999-2000 annual monitoring report. However, levels for total and dissolved zinc did not appear to be significantly different between the industry types.

By contrast, levels for total and dissolved copper did appear significantly higher for the fabricated metals sites over the other critical industry categories. The highest median level for suspended solids was also produced at the fabricated metals sites, but no industry was significantly higher or lower than another for suspended solids.

Bacteria indicators were analyzed for the first time from the critical source sites in 1999-2000.

4.2.9 Best Management Practices for Critical Source Industries

In the 1999-2000 season, items of equipment called Best Management Practices (BMPs) were purchased by the County for installation at half of the companies from the auto dismantling, auto repair, and metal fabrication industries. These preventive-type BMPs took the form of good housekeeping and spill containment measures (Table 4-16). Each business owner agreed to be responsible for installing and using the BMPs. The County encouraged the business owners to utilize the BMPs during the storm season, but the County had no jurisdiction or control over how or when they were used.

Table 4-15 and Fig. 4-3 compare the results of those companies fitted with BMPs to those without. For total and dissolved zinc, the median concentration lowered or stayed nearly the same with the implementation of BMPs at the auto dismantling, auto repair, and fabricated metals industries. (For the auto dismantling and auto repair industries, the median actually increased slightly.) In none of the circumstances was the difference significant.

For total and dissolved copper, however, where the fabricated metal industry had displayed the highest median concentrations, levels were significantly reduced with the implementation of BMPs. The auto dismantling and auto repair businesses showed no significant difference.

- Water quality data collected from 8 different landuse monitoring stations yields Event Mean Concentration (EMC) values. The remaining landuse categories (34-8 = 26) use assumed EMC values based on their association with the 8 monitored landuse types.
- All polygons of the same landuse type are assumed to have the same EMC value regardless of their spatial location within the county.
- Annual pollutant loadings use previously calculated seasonal EMCs for their calculation.
- Rainfall grid cell sizes are 500 feet by 500 feet. Rainfall depth does not vary within the grid cell.
- The model does not account for variation over time in soil permeability which influences surface runoff in undeveloped watersheds. In other words, a given coefficient of discharge for a particular land use type will not change regardless of previous soil conditions (saturated soil versus dry soil)

The primary operations that are inherent to both observed and modeled methods are described below.

Comparison of Observed and Modeled Load Calculation Methods

ITEM	OBSERVED METHOD	MODEL CALCULATIONS
STORM RUNOFF VOLUME	Flow rate taken directly from stream gage data and integrated over duration of storm to develop runoff volume. Note that this parameter includes base flow and storm runoff. Calculations can be made to estimate a base flow and separate it from the observed runoff.	Rain gage rainfall depths are used to prepare a rainfall grid surface. Rainfall grid cells are 500' x 500'. Equations: (1) Runoff coeff. = (0.8 x Imperviousness) + 0.1 (2) Rainfall volume = (Rainfall depth) x Area (3) Runoff volume = (Rainfall vol.) x (Runoff coeff.)
POLLUTANT EVENT MEAN CONCENTRATION (EMC)	Flow composited samples obtained at the mass emission monitoring sites are analyzed by the lab. Resulting pollutant concentrations are EMCs.	(1) The entire county is comprised of 34 general land use types. Storm runoff from the 8 most significant types is flow-weight sampled by automated equipment. The monitored watersheds of the eight significant types are chosen to represent typical examples of that land use. (2) Water quality results from the 8 monitored land use stations are assigned to the remaining 26 unmonitored land use types based on similarities of land use. (3) Any given land use type is assumed to yield the same EMC anywhere in the county (i.e. a given polygon defined as Single Family Residential (SFR) is assumed to yield the same EMC as any other SFR polygon in the county).
POLLUTANT LOAD	Observed concentration (EMC) multiplied by observed runoff volume.	Observed and assigned concentrations (EMC) for each land use multiplied by the modeled runoff volume for each land use summed within the area of study.

The model does not take into account possible degradation or adsorption of the pollutant as it is transported downstream. These results therefore should not be taken as absolute; rather, they should be used for unmonitored watersheds or smaller portions of monitored watersheds for comparative purposes only.

4.2.7 Constituents of Concern

Table 4-6b includes sixteen chemical constituents that were identified from the comparison of mass emission annual concentrations to the objectives of the California Ocean Plan, the Los Angeles Basin Plan, and the California Toxics Rule. Two organophosphate pesticides, diazinon and chlorpyrifos, are also included in Table 4-6b because of their identification of stormwater toxicity in other independent studies (Lee, 1998). Indicator bacteria (total coliform and fecal coliform, streptococcus, and enterococcus) are also included due their exceedence of AB411.

As of yet, Total Maximum Daily Loads (TMDLs) are not part of the Los Angeles Municipal Stormwater Permit. However, constituents identified by the 303d list that were not already identified through the comparison process, namely nutrients, are also included in Table 4-6b. It should be noted that there were no virtual exceedences by nutrients (compounds of nitrogen and phosphorus) of the three water quality objectives. Further, a report by the Las Virgenes Municipal Water District (May, 2000) found that beneficial use impairment due to algae growth is not a problem during storm season in Malibu Creek.

4.2.8 Identification of Possible Sources

With the identification of dissolved zinc and copper as stormwater toxicants in the Santa Monica Bay receiving water study (SCCWRP, 1999), and the implication of suspended solids (U. S. Army Corps of Engineers, 2000), it is helpful to look at land use and critical source runoff quality data (Tables 4-12 and 4-15 and Figures 4-1 and 4-3) to see if any particular land uses or industries could be singled out as notable or significant for those constituents. Figures 4-22 and 4-23 also show which constituents were prevalent at which land use.

Light industrial, transportation, and retail/commercial land uses displayed the highest median values for total and dissolved zinc, with light industrial the highest at about 300 μg/l for dissolved zinc and about 360 μg/l for total zinc. Runoff concentrations from the remaining land use types (high density single family residential, education, multifamily residential, and mixed residential) were significantly less.

Light industrial and transportation land uses displayed the highest median values for total and dissolved copper, with transportation the highest at about 28 μg/l for dissolved copper and about 40 μg/l for total copper.

Median concentrations of total suspended solids were highest coming off of the light industrial land use category, at about 130 mg/l.

These land use observations, particularly from the light industrial and retail/commercial categories, can be narrowed down by looking at the stormwater zinc, copper, and suspended solids sampled under the Critical Source program. The critical source industries sampled to date fall under the following SCAG land use categories:

SECTION 5

R0012007

5.1 OBJECTIVES ACHIEVED

Since 1994, the goal of the Monitoring Program has been to develop information to support effective watershed stormwater quality management programs. The primary objectives of the Monitoring Program, as outlined in the Permit and Section 1 of this report, follow.

5.1.1 Track Water Quality Status, Pollutant Trends and Pollutant Loads, and Identify Pollutants of Concern

Water quality status and pollutant trends and loads were successfully addressed by all of the major monitoring program elements: the Santa Monica Bay receiving waters impact study, the mass emission monitoring element, the land use monitoring element, and the critical source monitoring element.

The Santa Monica Bay receiving waters impact study extended from the 1996-97 through the 1998-99 storm seasons and focused on discharge from Ballona and Malibu Creeks.

The five mass emission stations located on major tributaries to the Pacific Ocean sampled runoff from 1220 of 2086 square miles of the Los Angeles coastal basin. The only major watershed not monitored for mass emissions was the largely undeveloped Santa Clara River watershed in the northwest part of the permit area. The mass emission data was also used to identify pollutants of concern and to calculate seasonal loads. Since January 1995, 212 station events have been sampled. Generally, sampling activities were conducted according to plan, and attempts were made to capture as many storms as possible. Initial mechanical difficulties with the sampling equipment were overcome over the years of use.

The siting of these stations was dictated in large part by accessibility and the availability of public right of way. All five mass emission stations were set up in existing Department of Public Works stream gauge shelters. Two of the mass emission stations, Ballona Creek and Malibu Creek, have the longest record, sampling since January 1995, and the balance of the mass emission stations have been sampling since the 1995-96 storm season. The automated equipment also provided the collection of flow-weighted composite samples, which reflect and allow for varying constituent concentrations throughout the storm event.

The sampling of runoff from land use specific drainage areas also began in January 1995 with the installation of automated equipment in the Santa Monica Pier drain (retail/commercial). By the 1995-96 season, four more of the current land use monitoring stations were installed (high density SFR, vacant, light industrial, and transportation). When the current permit came into effect in July, 1996, two more land use stations were installed (multifamily residential and educational). The final land use monitoring station (mixed residential) was installed by the 1997-98 storm season. Similar flow-weighted compositing was accomplished through the use of automated equipment for sampling runoff from land use-specific drainage areas.

In contrast to the mass emission stations, land use monitoring stations are largely located in underground drains. Their siting was therefore more complicated, requiring the identification of locations where the drainage area was the predominant land use, where there was a manhole near available power in available right-of-way, where the drain was not surcharged in a moderate storm, and where personnel would be relatively safe. Since 1995, 396 station events have been sampled.

The land use monitoring was successful at characterizing runoff from land use specific drainage areas and developing seasonal mean concentrations. Seasonal mean concentrations (also called Event Mean Concentrations) were used for calculating loading from unmonitored watersheds. It was found that seasonal mean concentrations were below the 25% error rate in 77% of circumstances.

Monitoring at the land use stations and mass emission stations included a broad constituent suite including bacteria, metals, organics, major ions, and nutrients. The laboratory analytical efforts achieved detection limits (DL) as required by the Permit for all constituents, and achieved DLs that were lower than Permit requirements for many analytes, particularly for constituents of concern.

5.1.2 Monitor and Assess Pollutant Loads from Specific Land Uses and Watershed Areas

The mass emission and land use monitoring elements were successful at assessing loading. Loading was first reported in the 1994-95 Los Angeles County Stormwater Monitoring Report. Subsequent loading based on both observed and modeled data was also reported in the 1998-99 and 1999-2000 Reports. The County's GIS Loading Model has been recognized as an innovative solution to estimating loading in unmonitored watersheds.

5.1.3 Identify, Monitor, and Assess Significant Water Quality Problems Related to Stormwater Discharges Within the Watershed

The monitoring program was successful at identifying significant water quality problems associated with stormwater discharge. First, the Santa Monica Bay receiving waters impacts study identified zinc and copper from Ballona Creek discharge as being toxic to the fertilization rate of simple marine animals. Toxicity testing of dry and wet weather flow in the Los Angeles and San Gabriel Rivers also identified toxicity problems. The extent and severity of bacterial indicators was better understood through wet weather mass emission sampling and ad hoc dry weather sampling.

5.1.4 Identify Sources of Pollutants in Stormwater Runoff

All of the major monitoring program elements were used successfully to identify stormwater pollutant sources. The Santa Monica Bay receiving waters study identified Ballona Ck., and not Malibu Ck., as a contributor of stormwater toxicity. Further, it identified zinc and copper as two metals contributing to the toxicity. The mass emission monitoring identified the Los Angeles River as consistently contributing the most zinc, copper, and suspended solids.

The land use monitoring identified light industrial, transportation, and retail/commercial land uses as developing the highest median concentrations for total and dissolved zinc. Light industrial and transportation land uses displayed the highest median concentrations for total and dissolved copper, and light industrial produced the highest concentrations of suspended solids.

Finally, the critical source monitoring program identified fabricated metal businesses as producing the highest median concentrations for zinc, copper, and suspended solids.

5.1.5 Identify and Eliminate Illicit Discharges

Each Permittee has a program to identify and eliminate illicit connections to the storm drain system to the maximum extent practicable. One of the programs developed for the elimination of illicit connections is open channel and underground storm drain inspections.

Most Permittees perform random area surveillance during dry and wet weather to inspect for potential illegal discharges. The Permittees also conduct educational site visits at businesses. During these visits, flyers with information on Best Management Practices (BMPs) applicable to that business are distributed.

The County, maintaining the majority of the storm drains within Los Angeles County, conducts routine inspections of the storm drain system for illicit connections/illicit discharges. Maps and connection inventory reports for 1,304 storm drains have been prepared to facilitate these inspections, which have resulted in the discovery of 1,993 undocumented connections as of July of 1999. These connections are either removed or permitted.

A toll free number 1-888-CleanLA was created for the public to report observed illicit connections/illicit discharges to the storm drain system.

It is recommended that the IC/ID model program approved by the Regional Board on March 23, 1999, be continued.

5.1.6 Evaluate the Effectiveness of Management Programs including Pollutant Reductions Achieved by Implementation of Best Management Practices (BMPs)

The Critical Source element of the monitoring program was successful at examining the potential effectiveness of good housekeeping and preventive types of voluntary Best Management Practices at one critical source industry. While two of the industries showed no significant improvement as the result of implementing BMPs, the fabricated metal industry showed significant improvement for total and dissolved copper.

5.1.7 Assess the Impacts of Stormwater Runoff on Receiving Waters

The receiving waters impact study, one of the first to assess stormwater impacts on the marine environment, was very successful at assessing stormwater impacts on Santa Monica Bay. The study was performed by the Southern California Coastal Waters Research Project, the University of Southern California, and the University of California Santa Barbara. The plume study found that freshwater plumes extended for a number of miles out to sea and often persisted for a number of days after a storm. The toxicity study found that the stormwater discharge from Ballona Creek was toxic to sea urchin fertilization and that dissolved zinc and copper were contributors to the toxicity. The study also found that sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants, including common stormwater constituents such as lead and zinc.

5.2 WIDE CHANNEL PILOT STUDY

The purpose of the wide channel pilot study (Woodward-Clyde et al, 1996) was to evaluate the accuracy of a single point water quality intake in representing the water quality in wide channels. Ballona Creek, Los Angeles River, San Gabriel River, and Coyote Creek can be considered wide

channels. The pilot study found the water homogenous through the depth and the width of the channel. Thus, the single point intake produces a representative sample, and no adjustments were made to the monitoring stations. A complete report of this pilot study may be found in Appendix E.

Additional analysis was conducted in 1998 confirming that vertical mixing was achieved.

5.3 LOW FLOW PILOT STUDY

The purpose of the low flow pilot study (Woodward-Clyde et al, 1996) was to assess the feasibility of modifying the automated sampling equipment at land use stations in order to sample storms as small as 0.1 inch rainfall. The pilot study concluded that: operational effectiveness of automated equipment dropped significantly for storms as low as 0.1" rainfall, the feasibility and effectiveness of sample retrieval and transport became very difficult for such storms, and the ability to program and maintain low flow settings at other automated samplers could only be accomplished through large investments in telemetry. A complete report of this pilot study may be found in Appendix D.

Further analysis was conducted in 1998 that concluded 94 percent of total runoff volumes are monitored using the 0.25 inch threshold. Therefore, monitoring continued unaltered.

5.4 FUTURE MONITORING RECOMMENDATIONS

The following recommendations include monitoring, research, and studies that should be considered or undertaken to advance the understanding of stormwater quality science and support future TMDL development. Because of their scope, such studies should be undertaken by various entities, such as the Regional Water Quality Control Board, NPDES permittees, or by collaborative efforts between private and public organizations.

5.4.1 Mass Emission Element

Because the Pacific Ocean is a primary resource to Southern California, it is recommended that mass emission monitoring continue at the five existing sites for up to five storm events per season.

Non-Detection Test: The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station, then that constituent may qualify for removal from the analytical suite for the associated station. For mass emission stations, several constituents met this criterion (see Table 4-7). Carbonate, the majority of heavy metals (24 of the 38), and all of the pesticides met the criteria in each of the mass emission sites. All of the semi-volatile constituents that had more than 10 samples met the criteria in each mass emission site as well. (Due to the change in detection limits of many SVOCs, there were fewer than 10 samples tested under the new limit.) Cyanide, total phenols, MBAS, dissolved aluminum, dissolved nickel, and total lead had less than 25% detection in four of the five sites. It is recommended that these constituents be removed from the analytical suite for the associated stations.

5.4.2 Land Use Element

One of the goals of the land use monitoring element was to develop Event Mean Concentrations (EMCs) for constituents of concern. The EMCs are used in the County's GIS Loading Model to calculate seasonal loading from unmonitored watersheds.

EMC Test: The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived with an error rate of 25% or less. We used the mean standard error as a substitute for error rate as mutually agreed upon with the RWQCB (Swamikannu, 1999). Nitrate-Nitrogen achieved the 25% error rate at each of the land use monitoring sites. Total kjeldahl nitrogen (TKN) and total phosphorus met the criteria at seven of the eight land use sites. Dissolved copper, total zinc, dissolved zinc, ammonia-nitrogen, nitrate, and dissolved phosphorus met the criteria at six of the eight sites.

Of 115 station-constituents under investigation, 26 of them had an EMC with a mean standard error higher than 25% (Table 4-14). In other words, there were 26 station-constituents which had a standard error (standard deviation of the mean) larger than 25% of their corresponding mean concentrations. Carbonate, the majority of heavy metals (24 of the 38), and all of the pesticides met the criteria in each of the land use sites. All of the semi-volatile constituents that had more than 10 samples met the criteria in each land use site as well. (Due to the change in detection limits of many SVOCs, there were fewer than 10 samples tested under the new limit.) Flouride, MBAS, dissolved aluminum, and total lead had less than 25% detection in seven of the eight sites.

Given the findings of both the non-detect test and the EMC test, it is recommended that the following land use stations monitor the following constituents only:

Constituents for Future Land Use Monitoring

LAND USE STATION	DRAINAGE SYSTEM	FUTURE MONITORING
Retail/Commercial	Santa Monica Pier Drain	Ammonia, total and dissolved copper, nitrate, total lead, TSS, PAH, diazinon, chlorpyrifos.
Vacant	Sawpit Wash	TKN, TSS, PAH, diazinon, chlorpyrifos.
High Density Single Family Residential	Bond Issue Project 620	Total Lead, PAH, diazinon, chlorpyrifos.
Transportation	Dominguez Channel	PAH, diazinon, chlorpyrifos.
Light Industrial	Bond Issue Project 1202	Total Copper, PAH, diazinon, chlorpyrifos.
Education	Bond Issue Project 474	Total Copper, Total Zinc, TSS, PAH, diazinon, chlorpyrifos.
Multifamily Residential	Bond Issue Project 404	Ammonia, Ammonia Nitrogen, Nitrite Nitrogen, TSS, PAH, diazinon, chlorpyrifos.
Mixed Residential	Bond Issue Project 156	Ammonia, Nitrate, Total Zinc, PAH, diazinon, chlorpyrifos.

Note that the retail/commercial site was removed in 1999 for construction of the City of Santa Monica's stormwater treatment plant. Future monitoring at this site may be in jeopardy.

5.4.3 Critical Source Element

Limited success was achieved in evaluating BMP effectiveness for two of the first three industries. The reasons for no discernable differences in concentrations before and after BMP implementation at the two industries are not obvious, but may include the voluntary nature of the BMP usage. However, valuable baseline data has been collected to date, and success was seen at one critical source industry. Therefore, it is recommended that the critical source program continue as described in the 1996 Municipal Stormwater Permit until eight critical industries are studied.

5.4.4 TMDLs in Los Angeles County

By March, 2006, at least 22 impaired water bodies in Los Angeles County will come under Total Maximum Daily Load (TMDL) regulation due to the recent Consent Decree (Los Angeles Regional Water Quality Control Board et al, 1999). The pollutants claimed to be causing impairment include trash, nutrients, coliform, nitrogen, metal, PCBs, pesticides, and chlordane. It is recommended that receiving water impact studies be performed on significant impaired water bodies to identify impacts due to stormwater. Such impact studies could include assessments of bioassessment.

5.4.5 Constituents of Concern

The following recommendations are based on the observation of problems identified by the monitoring program, namely: dry and wet weather bacteria indicators, zinc and copper toxicity in Ballona Ck., suspended solids linked to contaminated sediments, and toxicity in the Los Angeles and San Gabriel Rivers. These recommendations also recognize the concerns regarding possible stormwater impairment to water bodies under the forthcoming TMDL regulations.

5.4.5.1 Bacteria

Wet weather observations suggest that peak coliform levels may be related to regional hydrologic conditions. In an effort to characterize the presence and persistence of indicator bacteria in dry and wet weather, the Southern California Coastal Waters Research Project is conducting research and calibrating water quality models. Participation in these studies is recommended. It is further recommended that similar studies be initiated for other parts of the County where indicator bacteria impair beneficial uses.

5.4.5.2 Contaminated Sediments

Because contaminated sediments can be linked to suspended solids in stormwater, participation in the Corps of Engineers' Sediment Control Management Plan and the Coastal Commission Sediment Task Force is recommended. It is further recommended that receiving water impacts due to aerial deposition studies be conducted on inland watersheds.

5.4.5.3 Stormwater Toxicity

With the identification of zinc and copper in Ballona Creek stormwater discharge, it is recommended that major tributaries to Ballona Creek be surveyed to find possible contributing areas and sources.

It is recommended that two dry weather and two wet weather Toxicity Identification Evaluations be conducted for a full range of constituents on freshwater species on the L. A. River and Dominguez Channel.

It is recommended that two wet weather Toxicity Identification Evaluations be conducted for a full range of constituents on freshwater species on the San Gabriel River.

5.4.6 Receiving Waters Impacts

It is recommended that follow-up studies be conducted in Santa Monica Bay that address the persistence of stormwater plumes following storm events, the toxicity of stormwater on species other than sea urchins, and the fate of sediments in the Bay.

It is further recommended that a study be conducted assessing the impacts due to stormwater on San Pedro Bay.

5.4.7 Other Monitoring Activities

Participation and cooperation with local and regional monitoring programs is recommended, including but not limited to the Santa Monica Bay Restoration Project, the City of Long Beach, and the developing Southern California Regional Stormwater Monitoring Coalition.

It is also recommended that Best Management Practices and impacts be formally evaluated. Examples would include the City of Santa Clarita demonstration projects, catch basin inserts and deflectors, groundwater impacts due to stormwater infiltration, the Department of Public Works' parking lot retrofit, and storm drain low flow diversions.

SECTION 6

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TABLES

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Table 2-1

Land Use Distribution of Monitored Catchments for the Monitoring Program

Station Name	Station No.	Drainage Area (sq. mi.)	HDSFR [1] (%)	Light Industrial (%)	Vacant (%)	Retail/ Commercial (%)	Multi-Fam. Residential (%)	Transportation (%)	Educational Facilities (%)	Mixed Residential (%)	Other (%)
LAND USE STATIONS											
Santa Monica Pier Drain [3] @ Appian Way, Santa Monica	S08	0.13	--	--	--	53.6	5.1	4.6	--	--	36.7
Sawpit Creek @ Monrovia Cr. Monrovia	S11	5.18	--	--	98.0	--	--	--	--	--	2.0
Project 620 @ Glenwood Rd. Glendale	S18	0.19	100.0	--	--	--	--	--	--	--	--
Dominguez Channel @ 116th St. Unincorporated L.A. County	S23	1.41	0.6	17.0	--	0.1	--	75.2	--	--	7.1
Project 1202 @ Wilmington Ave. Carson	S24	1.07	--	67.1	1.0	0.3	--	4.7	--	--	26.9
Project 474 @ Nordoff St. Los Angeles	S25	0.41	7.6	--	--	--	2.2	--	89.5	--	0.7
Project 404 @ La Cadena Ave. Arcadia	S26	0.34	6.3	--	--	13.1	74.3	1.7	--	--	4.6
Project 156 @ Concord St. Glendale	S27	0.20	3.8	--	--	4.5	4.0	--	5.1	77.2	5.4
MASS EMISSION STATIONS											
Ballona Creek @ Sawtelle Blvd. Los Angeles	S01	88.8	40.0	3.5	11.1	9.9	12.3	1.5	2.7	6.7	12.3
Malibu Creek @ Piuma Rd. Unincorporated L.A. County	S02	105.0	5.7	0.3	79.3	0.5	1.3	0.5	0.5	--	11.9
L.A. River @ Wardlow Long Beach	S10	822.5	28.8	5.1	40.4	3.6	3.5	2.4	1.9	1.8	12.5
San Gabriel River @ SGR Pkwy Pico Riveria	S14	450.6	15.2	2.3	66.7	1.5	1.4	1.0	1.6	0.1	10.2
Coyote Creek @ Spring St. [2] Long Beach	S13	148.6	38.3	8.4	14.3	5.6	6.1	1.8	4.3	0.2	21.0

Notes:

All land use percentages are rounded to the nearest whole number.
Land use percentages less than 0.1% are represented with a dash (--).
(1) HDSFR = High density single-family residential.
(2) Coyote Creek is not required under the Municipal Stormwater Permit, but is included in the Monitoring Plan.
(3) The Retail/Commercial sampling site on Pier Drain in Santa Monica (S08) was dismantled and not in use in the 1999-2000 season, with prior approval from the RWQCB, to accommodate construction by city of Santa Monica of its stormwater treatment plant.

R0012019

Table 3-1. Detection Limits

Constituent	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Units	ME	LU	CS
Conventional										
Cyanide	0.05	0.05	0.01	0.01	0.01	0.01	mg/l	G		
Total Petro. Hydrocarbons	1	1	1	1	1	1	mg/l	G		
Oil and Grease	1	1	1	1	1	1	mg/l	G		G
Total Phenols	0.1	0.1	0.1	0.1	0.1	0.1	mg/l	G		
Indicator Bacteria										
Total Coliform	20	20	20	20	20	20	MPN/100ml	G		G
Fecal Coliform	20	20	20	20	20	20	MPN/100ml	G		G
Fecal Streptococcus	20	20	20	20	20	20	MPN/100ml	G		G
Fecal Enterococcus	20	20	20	20	20	20	MPN/100ml	G		G
General										
Ammonia	0.1	0.1	0.1	0.1	0.1	0.1	mg/l	C	C	
Calcium	2	2	1	1	1	1	mg/l	C	C	
Magnesium	2	2	1	1	1	1	mg/l	C	C	
Potassium	1	1	1	1	1	1	mg/l	C	C	
Sodium	5	5	1	1	1	1	mg/l	C	C	
Bicarbonate	2	2	2	2	2	2	mg/l	C	C	
Carbonate	2	2	2	2	2	2	mg/l	C	C	
Chloride	2	2	2	2	2	2	mg/l	C	C	
Fluoride	0.1	0.1	0.1	0.1	0.1	0.1	mg/l	C	C	
Nitrate	0.1	0.1	0.1	0.1	0.1	0.1	mg/l	C	C	
Sulfate	0.1	0.1	0.1	0.1	0.1	0.1	mg/l	C	C	
Alkalinity	4	4	4	4	4	4	mg/l	C	C	
Hardness	5	5	2	2	2	2	mg/l	C	C	
Dissolved Phosphorus	0.05	0.05	0.05	0.05	0.05	0.05	mg/l	C	C	
Total Phosphorus	0.05	0.05	0.05	0.05	0.05	0.05	mg/l	C	C	
COD	50	50	5	10	10	10	mg/l	C	C	G
pH	14	14	14	14	14	14		C	C	G
NH3-N	0.1	0.1	0.1	0.1	0.1	0.1	mg/l	C	C	
Nitrate-N	0.03	0.03	0.5	0.5	0.5	0.5	mg/l	C	C	
Nitrite-N	0.03	0.03	0.03	0.03	0.03	0.03	mg/l	C	C	
Kjeldahl-N	0.03	0.03	0.1	0.1	0.1	0.1	mg/l	C	C	
Specific Conductance	1	1	1	1	1	1	umhos/cm	C	C	G
Total Dissolved Solids	5	5	2	2	2	2	mg/l	C	C	G
Turbidity	0.1	0.1	0.1	0.1	0.1	0.1	NTU	C	C	
Suspended Solids	1	1	2	2	2	2	mg/l	C	C	G
Volatile Suspended Solids	1	1	1	1	1	1	mg/l	C	C	
MBAS			20	0.05	0.05	0.05	mg/l	C	C	G
Total Organic Carbon	1	1	1	1	1	1	mg/l	C	C	G
BOD	1	1	1	1	1	1	mg/l	C	C	
Metals										
Dissolved Aluminum			100	100	100	100	µg/l	C	C	C

Table 3-1. Detection Limits

Constituent	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Units	ME	LU	CS
Total Aluminum			100	100	100	100	µg/l	C	C	C
Dissolved Antimony	10	10	10	5	5	5	µg/l	C	C	
Total Antimony	10	10	10	5	5	5	µg/l	C	C	
Dissolved Arsenic	10	10	10	5	5	5	µg/l	C	C	
Total Arsenic	10	10	10	5	5	5	µg/l	C	C	
Dissolved Barium	100	100	100	10	10	10	µg/l	C	C	
Total Barium	100	100	100	10	10	10	µg/l	C	C	
Dissolved Beryllium	5	5	5	1	1	1	µg/l	C	C	
Total Beryllium	5	5	5	1	1	1	µg/l	C	C	
Dissolved Boron	250	250	250	100	100	100	µg/l	C	C	
Total Boron	250	250	250	100	100	100	µg/l	C	C	
Dissolved Cadmium	10	10	10	1	1	1	µg/l	C	C	C
Total Cadmium	10	10	10	1	1	1	µg/l	C	C	C
Dissolved Chromium	10	10	10	5	5	5	µg/l	C	C	C
Total Chromium	10	10	10	5	5	5	µg/l	C	C	C
Dissolved Chromium +6	10	10	10	10	10	10	µg/l	C	C	
Total Chromium +6	10	10	10	10	10	10	µg/l	C	C	
Dissolved Copper	10	10	10	5	5	5	µg/l	C	C	C
Total Copper	10	10	10	5	5	5	µg/l	C	C	C
Dissolved Iron	100	100	100	100	100	100	µg/l	C	C	C
Total Iron	100	100	100	100	100	100	µg/l	C	C	C
Dissolved Lead	10	10	10	5	5	5	µg/l	C	C	C
Total Lead	10	10	10	5	5	5	µg/l	C	C	C
Dissolved Manganese	30	30	30	30	100	100	µg/l	C	C	
Total Manganese	30	30	30	30	100	100	µg/l	C	C	
Dissolved Mercury	1	1	1	1	1	1	µg/l	C	C	
Total Mercury	1	1	1	1	1	1	µg/l	C	C	
Dissolved Nickel	10	10	10	5	5	5	µg/l	C	C	C
Nickel	10	10	10	5	5	5	µg/l	C	C	C
Dissloved Selenium	5	5	5	5	5	5	µg/l	C	C	
Total Selenium	5	5	5	5	5	5	µg/l	C	C	
Dissolved Silver	10	10	10	1	1	1	µg/l	C	C	
Total Silver	10	10	10	1	1	1	µg/l	C	C	
Dissolved Thallium	10	10	10	5	5	5	µg/l	C	C	
Total Thallium	10	10	10	5	5	5	µg/l	C	C	
Dissolved Zinc	50	50	50	50	50	50	µg/l	C	C	C
Total Zinc	50	50	50	50	50	50	µg/l	C	C	C
Semi-Volatile Organics										
Acenaphthene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
Acenaphthylene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
Acetophenone	3	3	3	3	3	0.3	µg/l	C	C	G[1]
Aniline	3	3	3	3	3	3	µg/l	C	C	G

Table 3-1. Detection Limits

Constituent	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Units	ME	LU	CS
Antracene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
4-Aminobiphenyl	3	3	3	3	3	3	µg/l	C	C	G
Benzidine	3	3	3	3	3	3	µg/l	C	C	G
Benzo(a)anthracene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Benzo(b)fluoranthene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Benzo(k)fluoranthene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Benzo(a)pyrene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Benzyl butyl phthalate	3	3	3	3	3	0.3	µg/l	C	C	G[1]
Bis(2-chloroethyl)ether	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Bis(2-chloroethoxy)methane	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Bis(2-ethylhexyl)phthalate	3	3	3	3	3	1	µg/l	C	C	G[1]
Bis(2-chlorisopropyl)ether	1	1	1	1	1	1	µg/l	C	C	G
4-Bromophenyl phenyl ether	1	1	1	1	1	1	µg/l	C	C	G
4-Chloroaniline	1	1	1	1	1	1	µg/l	C	C	G
1-chloronaphthalene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
2-Chloronaphthalene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
4-Chlorophenyl phenyl ether	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Chrysene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
p-Dimethylaminozobenzene	3	3	3	3	3	3	µg/l	C	C	G
7,12-Dimethylbenz(a)-anthracene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
alpha,-alpha-Dimethylphenethylamine	3	3	3	3	3	3	µg/l	C	C	G
Dibenz(a,j)acridine	3	3	3	3	3	0.3	µg/l	C	C	G[1]
Dibenz(a,h)anthracene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
1,3-Dichlorobenzene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
1,2-Dichlorobenzene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
1,4-Dichlorobenzene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
3,3'-Dichlorobenzidine	3	3	3	3	3	3	µg/l	C	C	G
Diethyl phthalate	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	G
Dimethyl phthalate	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	G
Di-n-butylphthalate	3	3	3	3	3	1	µg/l	C	C	G[1]
2,4-Dinitrotoluene	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	G
2,6-Dinitrotoluene	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	G
Diphenylamine	3	3	3	3	3	1	µg/l	C	C	G[1]
1,2-Diphenylhydrazine	3	3	3	3	3	3	µg/l	C	C	G
Di-n-octylphthalate	3	3	3	3	3	1	µg/l	C	C	G[1]
Ethylmethanesulfonate	3	3	3	3	3	0.3	µg/l	C	C	G[1]
Endrin ketone	1	1	1	1	1	1	µg/l	C	C	G
Fluoranthene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Fluorene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Hexachlorobenzene	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	G
Hexachlorobutadiene	1	1	1	1	1	1	µg/l	C	C	G
Hexachlorocyclopentadiene	3	3	3	3	3	3	µg/l	C	C	G

Table 3-1. Detection Limits

Constituent	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Units	ME	LU	CS
Hexachloroethane	1	1	1	1	1	1	µg/l	C	C	G
Indeno (1,2,3-cd) pyrene	1	1	1	1	1	0.1	µg/l	C	C	G[1]
Isophorone	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
3-Methylcholanthrene	3	3	3	3	3	0.3	µg/l	C	C	G[1]
Methyl methanesulfonate	3	3	3	3	3	0.3	µg/l	C	C	G[1]
Naphthalene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
1-Naphthylamine	3	3	3	3	3	3	µg/l	C	C	G
2-Naphthylamine	3	3	3	3	3	3	µg/l	C	C	G
2-Nitroaniline	3	3	3	3	3	3	µg/l	C	C	G
3-Nitroaniline	3	3	3	3	3	3	µg/l	C	C	G
4-Nitroaniline	3	3	3	3	3	3	µg/l	C	C	G
Nitrobenzene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
N-Nitroso-di-n-butylamine	3	3	3	3	3	0.3	µg/l	C	C	G[1]
N-Nitrosodimethylamine	3	3	3	3	3	0.3	µg/l	C	C	G[1]
N-Nitrosodiphenylamine	3	3	3	3	3	0.3	µg/l	C	C	G[1]
N-Nitroso-di-n-propylamine	1	1	1	1	1	0.3	µg/l	C	C	G[1]
N-Nitrosopiperidine	3	3	3	3	3	1	µg/l	C	C	G[1]
Pentachlorobenzene	3	3	3	3	3	1	µg/l	C	C	G[1]
Phenacitin	3	3	3	3	3	3	µg/l	C	C	G
Phenanthrene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
2-Picoline	3	3	3	3	3	3	µg/l	C	C	G
Pronamide	5	5	5	5	5	5	µg/l	C	C	G
Pyrene	0.5	0.5	0.5	0.5	0.5	0.05	µg/l	C	C	G[1]
1,2,4,5-Tetrachlorobenzene	3	3	3	3	3	1	µg/l	C	C	G[1]
1,2,4-Trichlorobenzene	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	G
Benzoic acid	5	5	5	5	5	5	µg/l	C	C	G
Benzyl alchohol	5	5	5	5	5	5	µg/l	C	C	G
4-Chloro-3-methylphenol	3	3	3	3	3	3	µg/l	C	C	G
2-Chlorophenol	2	2	2	2	2	2	µg/l	C	C	G
2,4-Dichlorophenol	2	2	2	2	2	2	µg/l	C	C	G
2,6-Dichlorophenol	2	2	2	2	2	2	µg/l	C	C	G
2,4-Dimethylphenol	2	2	2	2	2	2	µg/l	C	C	G
2,4-Dinitrophenol	3	3	3	3	3	3	µg/l	C	C	G
2-Methyl-4,6-dinitrophenol	3	3	3	3	3	3	µg/l	C	C	G
2-Methylphenol	3	3	3	3	3	3	µg/l	C	C	G
4-Methylphenol	3	3	3	3	3	3	µg/l	C	C	G
2-Nitrophenol	3	3	3	3	3	3	µg/l	C	C	G
4-Nitrophenol	3	3	3	3	3	3	µg/l	C	C	G
Pentachlorophenol	2	2	2	2	2	2	µg/l	C	C	G
Phenol	1	1	1	1	1	1	µg/l	C	C	G
2,3,4,6-Tetrachlorophenol	1	1	1	1	1	1	µg/l	C	C	G
2,4,5-Trichlorophenol	1	1	1	1	1	1	µg/l	C	C	G

Table 3-1. Detection Limits

Constituent	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Units	ME	LU	CS
2,4,6-Trichlorophenol	1	1	1	1	1	1	µg/l	C	C	G
Pesticides										
Aldrin	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Alpha-BHC	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Beta-BHC	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Delta-BHC	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Gamma-BHC [Lindane]	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Chlordane	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
p,p' DDD	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
p,p' DDE	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
p,p' DDT	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Dieldrin	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Endosulfan I [alpha]	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Endosulfan II [beta]	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Endosulfan Sulfate	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Endrin	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Endrin aldehyde	0.1	0.1	0.1	0.1	0.1	0.1	µg/l	C	C	
Heptachlor	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Heptachlor epoxide	0.05	0.05	0.05	0.05	0.05	0.05	µg/l	C	C	
Methoxychlor	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
Toxaphene	1	1	1	1	1	1	µg/l	C	C	
PCB-1016	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
PCB-1221	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
PCB-1232	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
PCB-1242	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
PCB-1248	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
PCB-1254	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
PCB-1260	0.5	0.5	0.5	0.5	0.5	0.5	µg/l	C	C	
Diazinon			0.01	0.01	0.01	0.01	µg/l	C	C	
Chlorpyrifos			0.05	0.05	0.05	0.05	µg/l	C	C	
Diuron			1	1	1	1	µg/l	C	C	
Malathion			1	1	1	1	µg/l	C	C	
Prometryn	2	2	2	2	2	2	µg/l	C	C	
Simazine	2	2	2	2	2	2	µg/l	C	C	
Atrazine	2	2	2	2	2	2	µg/l	C	C	
Cyanazine	2	2	2	2	2	2	µg/l	C	C	
Molinate			2	2	2	2	µg/l	C	C	
Thiobencarb			1	1	1	1	µg/l	C	C	
Miscellaneous										
Dissolved Oxygen					1	1	mg/l	C	C	
Carbofuran			5	5	5	5	µg/l	C	C	
2,4-D			10	10	10	10	µg/l	C	C	

Table 3-1. Detection Limits

Constituent	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Units	ME	LU	CS
2,4,5-TP			1	1	1	1	µg/l	C	C	
Bentazon			2	2	2	2	µg/l	C	C	
Glyphosate			50	50	25	25	µg/l	C	C	
TPH as Gas					0.5	0.5	mg/l	C	C	G
TPH as Diesel					0.5	0.5	mg/l	C	C	G

ME = Constituents marked analyzed for mass emission stations

LU = Constituents marked analyzed for land use stations

CS = Constituents marked analyzed for critical source stations

C = Composite sample taken

G = Grab sample taken

1 = Critical Source semi-volatile detection limits were not lowered in 1999-2000. The 1998-99 values apply.

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Table 4-1. Seasonal Summary of Hydrologic Data for Monitored Stations

SEASON	STATION	LAND USE	TOTAL PRECIPITATION (in.)	TOTAL RUNOFF VOLUME* (acre-ft)
94-95	BALLONA CREEK (S01)	ME	14.76	47,900
	MALIBU CREEK (S02)	ME	35.41	37,700
	KENTER CANYON (S04)	ME	19.39	6,840
	TRANCAS CANYON (S03)	VAC.	29.73	3,590
	PROJECT 1105 (S05)	HDSFR	17.17	1,920
	PROJECT 558 (S06)	LDSFR	17.17	161
	PROJECT 5401 (S07)	HDSFR	17.17	197
	SANTA MONICA PIER (S08)	COMM.	19.39	272
	L.A. DRAIN 2361 (S09)	COMM.	16.61	125
96-97	BALLONA CREEK (S01)	ME	11.18	22,200
	MALIBU CREEK (S02)	ME	9.22	NA
	KENTER CANYON (S04)	ME	7.42	675
	L.A. RIVER AT WARDLOW (S10)	ME	6.17	66,700
	COYOTE CREEK (S13)	ME	6.06	NA
	SAN GABRIEL RIVER (S14)	ME	8.00	NA
	SANTA MONICA PIER (S08)	COMM.	13.82	211
	SAWPIT CREEK (S11)	VAC.	15.15	189
	PROJECT 620 (S18)	HDSFR	2.68	22
	DOMINGUEZ CHANNEL (S23)	TRAN.	13.82	446
	PROJECT 1202 (S24)	LT. IND.	12.64	463
97-98	BALLONA CREEK (S01)	ME	28.28	18,300
	MALIBU CREEK (S02)	ME	37.51	39,700
	L.A. RIVER AT WARDLOW (S10)	ME	17.80	297,000
	COYOTE CREEK (S13)	ME	23.03	60,500
	SAN GABRIEL RIVER (S14)	ME	28.80	32,800
	SANTA MONICA PIER (S08)	COMM.	28.28	215
	SAWPIT CREEK (S11)	VAC.	24.56	303
	PROJECT 620 (S18)	HDSFR	24.44	66
	DOMINGUEZ CHANNEL (S23)	TRAN.	28.28	1,250
	PROJECT 1202 (S24)	LT. IND.	30.06	906
	PROJECT 474 (S25)	EDU	33.72	161
	PROJECT 404 (S26)	MFR	24.76	176
	PROJECT 156 (S27)	MIX. RES.	24.44	144
98-99	BALLONA CREEK (S01)	ME	9.48	10,700
	MALIBU CREEK (S02)	ME	8.48	419
	L.A. RIVER AT WARDLOW (S10)	ME	6.34	NA
	COYOTE CREEK (S13)	ME	6.64	11,500
	SAN GABRIEL RIVER (S14)	ME	6.20	12,700
	SANTA MONICA PIER (S08)	COMM.	9.48	91
	SAWPIT CREEK (S11)	VAC.	10.00	47
	PROJECT 620 (S18)	HDSFR	6.11	6
	DOMINGUEZ CHANNEL (S23)	TRAN.	10.28	334
	PROJECT 1202 (S24)	LT. IND.	4.83	218
	PROJECT 474 (S25)	EDU	8.16	3
	PROJECT 404 (S26)	MFR	10.60	1,280
	PROJECT 156 (S27)	MIX. RES.	7.08	475
99-2000	BALLONA CREEK (S01)	ME	6.76	20,086
	MALIBU CREEK (S02)	ME	10.95	4,286
	L.A. RIVER AT WARDLOW (S10)	ME	5.00	18,515
	COYOTE CREEK (S13)	ME	2.96	22,937
	SAN GABRIEL RIVER (S14)	ME	11.96	3,777
	SANTA MONICA PIER (S08)	COMM.	6.76	NA
	SAWPIT CREEK (S11)	VAC.	11.96	61
	PROJECT 620 (S18)	HDSFR	9.36	33
	DOMINGUEZ CHANNEL (S23)	TRAN.	6.76	239
	PROJECT 1202 (S24)	LT. IND.	2.96	1,671
	PROJECT 474 (S25)	EDU	8.36	51
	PROJECT 404 (S26)	MFR	8.16	101
	PROJECT 156 (S27)	MIX. RES.	9.04	56

*ALL FLOWS INCLUDE BASE FLOW

Hydrologic Data_Int.xls

Table 4-2. 1994-2000 Los Angeles County Stormwater Monitoring Analytical Data Inventory.

Station No.	Station Type	No. of Events Sampled	Sample Type	Analytes: General Minerals	Heavy Metals	Miscellaneous Bacteria	Semi-Volatiles	Pesticides
S08-Santa Monica Pier	LU	11	Grab			7/11		
	Comm	50	Comp	37/50	40/50	33/50	23/50	29/50
S11-Sawpit Creek	LU	21	Grab			20/21		
	Vacant	52	Comp	45/52	45/52	43/52	34/52	39/52
S18-Project 620	LU	5	Grab			3/5		
	HDSFR	50	Comp	39/50	39/50	35/50	26/50	32/50
S23-Dominguez Channel	LU	4	Grab			X		
	Trans	72	Comp	65/72	65/72	63/72	40/72	58/72
S24-Project 1202	LU	5	Grab			X		
	Lt. Ind.	54	Comp	51/54	51/54	47/54	24/54	43/54
S25-Project 474	LU		Grab					
	Edu.	44	Comp	43/44	43/44	43/44	23/44	39/44
S26-Project 404	LU		Grab					
	Multi-Fam	45	Comp	44/45	X	44/45	30/45	37/45
S27-Project 156	LU	1	Grab			X		
	Mix. Res.	46	Comp	45/46	45/46	45/46	33/46	40/46
S01-Ballona Creek	ME	91	Grab			45/91		
		50	Comp	40/50	40/50	40/50	16/50	39/50
S02-Malibu Creek	ME	42	Grab			38/42		
		45	Comp	31/45	32/45	29/45	27/45	30/45
S10-L.A. River	ME	35	Grab			34/35		
		40	Comp	33/40	33/40	29/40	16/40	31/40

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Table 4-2. 1994-2000 Los Angeles County Stormwater Monitoring Analytical Data Inventory.

Station No.	Station Type	No. of Events Sampled	Sample Type	Analytes: General Minerals	Heavy Metals	Miscellaneous Bacteria	Semi-Volatiles	Pesticides
S13-Coyote Creek	ME	7	Grab			5/7		
		52	Comp	45/52	45/52	40/52	23/52	41/52
S14-San Gabriel River	ME	41	Grab			39/41		
		49	Comp	43/49	43/49	38/49	21/49	41/49

Notes:
Comp = flow composite sample
X = denotes analytes reported for all events.
1/6 = denotes analytes reported for 1 of the 6 events.
Blank = no analytes reported.
LU = land use station
- Comm = Commercial
- HDSFR = High Density Single Family Residential
- Trans = Transportation
- Lt. Ind. = Light Industrial
- Edu. = Educational
- Multi-Fam. = Multifamily Residential
- Mix. Res. = Mixed Residential

ME = mass emission station

Table 4-3. Comparison of 1994-2000 Mass Emissions Results with Standards

Class Constituent	Data Included Since[h]	DL	Units	Guidelines and Standards: Ocean Plan[g]	Basin Plan[g]	AB 411	California Toxics Rule (freshwater)[d]	California Toxics Rule (saltwater)[d]	Mass Emission: No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents														
Cyanide	96	0.01	mg/l	0.004[a]	0.2		0.0052	0.001	128	110	14	S.I.D.	S.I.D.	S.I.D.
TPH	94	1	mg/l						183	89	45	1.8	0.5	1.06
Oil and Grease	94	1	mg/l	25[b]					180	83	48	2.2	0.5	2.04
Total Phenols	94	0.1	mg/l						180	157	2	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria														
Total Coliform	94	20	MPN/100ml	1000[b]	70	10,000 (Instantaneous)			163	5	97	1,596,086	300,000	2.27
Fecal Coliform	94	20	MPN/100ml	200[b]	200	400 (Instantaneous)			183	3	98	962,419	50,000	3.38
Ratio Fecal Coliform/Total Coliform	94					10% (Instantaneous) if Total Coliform is between 1000 & 10,000			8	0	100	35%	28%	1.03
Fecal Streptococcus	94	20	MPN/100ml						163	5	97	524,640	160,000	2.98
Fecal Enterococcus	94	20	MPN/100ml	24[b]		104			99	2	98	252,551	30,000	1.91
General Minerals														
Ammonia	94	0.1	mg/l	2.4[a]	6.8				188	64	66	0.7	0.3	1.57
Calcium	96	1.0	mg/l						164	0	100	44	31	0.82
Magnesium	96	1.0	mg/l						164	0	100	17.5	7.8	1.29
Potassium	94	1.0	mg/l						191	0	100	4.4	4.2	0.44
Sodium	96	1.0	mg/l						175	0	100	42	29	0.96
Bicarbonate	94	2.0	mg/l						184	0	100	88	71	0.68
Carbonate	94	2.0	mg/l						184	182	1	S.I.D.	S.I.D.	S.I.D.
Chloride	94	2.0	mg/l						185	1	99	42	29	0.92
Fluoride	94	0.1	mg/l		2.4				185	40	78	0.2	0.2	0.68
Nitrate	94	0.1	mg/l						185	3	98	7.2	5.6	0.86
Sulfate	94	0.1	mg/l						185	1	99	103	48	1.33
Alkalinity	94	4.0	mg/l						184	0	100	84	68	0.68
Hardness	96	2.0	mg/l						164	0	100	179	110	1.01
COD	97	5	mg/l						159	7	96	74	55	0.96
pH	94	0-14			<6.5 & >8.5				184	0	100	7.4	7.4	0.06
Specific Conductance	94	1.0	umhos/cm						180	0	100	569	365	0.94
Total Dissolved Solids	96	2.0	mg/l		250				164	0	100	362	219	0.96
Turbidity	94	0.1	NTU	75[b]					183	0	100	109	64	1.44
Total Suspended Solids	96	2.0	mg/l						166	0	100	255	160	1.24
Volatile Suspended Solids	94	1.0	mg/l/hr						183	1	99	51	41	0.99
MBAS	97	0.05	mg/l		0.5				153	86	44	0.08	0.03	1.43
Total Organic Carbon	94	1.0	mg/l						184	0	100	10	8	0.73
BOD	94	2.0	mg/l						173	6	97	25	18	1.27
Nutrients														
Dissolved Phosphorus	94	0.05	mg/l						182	5	97	0.3	0.3	0.67
Total Phosphorus	94	0.05	mg/l						182	1	99	0.5	0.4	0.70
NH3-N	94	0.1	mg/l	2.4[a]	2.7				185	72	61	0.6	0.2	1.57
Nitrate-N	96	0.1	mg/l		10 and also must not exceed 5 when added to Nitrite-N				168	5	97	1.5	1.2	0.90
Nitrite-N	94	0.1	mg/l		1 and also must not exceed 5 when added to Nitrate-N				186	35	81	0.19	0.09	1.32

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Table 4-3. Comparison of 1994-2000 Mass Emissions Results with Standards

Class Constituent	Data Included Since[h]	DL	Units	Guidelines and Standards: Ocean Plan[a]	Basin Plan[a]	AB 411	California Toxics Rule (freshwater)[d]	California Toxics Rule (saltwater)[d]	Mass Emission: No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
TKN	96	0.1	mg/l						173	1	99	3.1	2.3	0.79
Metals														
Dissolved Aluminum	96	100	µg/l						175	97	45	567	50	2.29
Total Aluminum	96	100	µg/l		1000				175	19	89	2009	325	2.99
Dissolved Antimony	97	5	µg/l						159	157	1	S.I.D.	S.I.D.	S.I.D.
Total Antimony	97	5	µg/l	1200[b]	6				159	156	2	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	97	5	µg/l				150	36	159	157	1	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	97	5	µg/l	32[a]	50				159	147	8	S.I.D.	S.I.D.	S.I.D.
Dissolved Barium	97	10	µg/l						159	14	91	46	42	0.65
Total Barium	97	10	µg/l		1000				159	12	92	75	51	1.29
Dissolved Beryllium	97	1	µg/l						156	156	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	97	1	µg/l	0.033[b]	4				159	159	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	97	100	µg/l						159	27	83	209	185	0.60
Total Boron	97	100	µg/l		1000				159	17	89	271	257	0.56
Dissolved Cadmium	97	1	µg/l				2.2	9.3	159	142	11	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	97	1	µg/l	4[a]	5				159	131	18	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	97	5	µg/l				180		159	146	8	S.I.D.	S.I.D.	S.I.D.
Total Chromium	97	5	µg/l	190[b]	50				159	113	29	6.1	2.5	2.03
Dissolved Chromium +6	94	10	µg/l				11	50	175	175	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	94	10	µg/l	8[a]					175	175	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Copper	97	5	µg/l				9	3.1	159	67	58	13.0	5.8	2.23
Total Copper	97	5	µg/l	12[a]					159	4	97	23.1	12	1.94
Dissolved Iron	94	100	µg/l						193	89	54	756	120	2.70
Total Iron	94	100	µg/l						193	17	91	4280	670	2.60
Dissolved Lead	97	5	µg/l				2.5	8.1	159	135	15	S.I.D.	S.I.D.	S.I.D.
Total Lead	97	5	µg/l	8[a]					159	102	36	25	2.5	4.48
Dissolved Manganese	98	100	µg/l						112	112	0	S.I.D.	S.I.D.	S.I.D.
Total Manganese	98	100	µg/l						112	94	16	S.I.D.	S.I.D.	S.I.D.
Dissolved Mercury	94	1	µg/l						191	191	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	94	1	µg/l	0.16[a]	2				191	187	2	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	97	5	µg/l				52	8.2	159	120	25	5.2	2.5	1.56
Nickel	97	5	µg/l	20[a]	100				159	80	50	9.3	2.5	1.74
Dissolved Selenium	94	5	µg/l				5[e]	71	193	193	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	94	5	µg/l	60[a]	50				193	179	7	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	97	1	µg/l				3.4[f]	1.9[f]	159	158	1	S.I.D.	S.I.D.	S.I.D.
Total Silver	97	1	µg/l	2.8[a]					159	153	4	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	97	5	µg/l						159	159	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	97	5	µg/l	14[b]	2				159	159	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	94	50	µg/l				120	81	193	145	25	73	25	2.43
Total Zinc	94	50	µg/l	80[a]					193	73	62	127	64	1.83
SVOCs														
Bis(2-ethylhexyl)phthalate	99	1	µg/l	3.5[b] 0.0086[c]					10	5	50	4	0.9	1.45
PAHs														
Acenaphthene	99	0.05	µg/l						10	9	10	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	99	0.05	µg/l						10	9	10	S.I.D.	S.I.D.	S.I.D.
Antracene	99	0.05	µg/l						10	10	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	99	0.1	µg/l		2				10	10	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)pyrene	99	0.1	µg/l						10	10	0	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	99	0.1	µg/l						10	9	10	S.I.D.	S.I.D.	S.I.D.

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Table 4-3. Comparison of 1994-2000 Mass Emissions Results with Standards

Class Constituent	Data Included Since[h]	DL	Units	Guidelines and Standards					Mass Emission					
				Ocean Plan[a]	Basin Plan[a]	AB 411	California Toxics Rule (freshwater)[d]	California Toxics Rule (saltwater)[d]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Benzo(k)fluoranthene	99	0.1	µg/l						10	10	0	S.I.D.	S.I.D.	S.I.D.
Chrysene	99	0.1	µg/l						10	9	10	S.I.D.	S.I.D.	S.I.D.
Dibenz(a,h)anthracene	99	0.1	µg/l						10	10	0	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	99	0.1	µg/l	15[b]					10	7	30	0.071	0.050	0.49
Fluorene	99	0.1	µg/l						10	10	0	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	99	0.1	µg/l						10	10	0	S.I.D.	S.I.D.	S.I.D.
Naphthalene	99	0.05	µg/l						10	9	10	S.I.D.	S.I.D.	S.I.D.
Phenanthrene	99	0.05	µg/l						10	8	20	0.039	0.025	0.93
Pyrene	99	0.05	µg/l						10	6	40	0.126	0.025	1.64
All other SVOCs	94	0.05-5.0	µg/l						103	103	0	S.I.D.	S.I.D.	S.I.D.
Pesticides														
Organochlorine Pesticides & PCBs	94	0.05-1.0	µg/l	0.000019[b]	0.00007		0.014	0.03	93	93	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	96	5	µg/l		16				169	169	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	98	25	µg/l		700				111	107	4	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides														
Diazinon	96	0.01	µg/l						167	144	14	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	96	0.05	µg/l						167	167	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides														
Thiobencarb	96	1	µg/l						167	163	2	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticides	94	1.0-2.0	µg/l						182	182	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides														
2,4-D	96	10	µg/l		70				86	86	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	96	1	µg/l		50				86	86	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	96	2	µg/l		18				86	86	0	S.I.D.	S.I.D.	S.I.D.

CV = Coeffiecient of variation

DL = Detection Limit

S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

a) Criteria based on daily maximum

b) Criteria based on 30-day average

c) Criteria for the sum of acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo(k)fluoranthene, 1,12-benzoperylene, benzo(a)pyrene, chrysene, dibenzo(ah)anthracene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene and pyrene.

d) Criteria continuous concentration which equals the highest concentration of pollutant to which aquatic life can be exposed for an extended period time (4 days) without deleterious effects.

e) Criterion expressed in the total recoverable form.

f) Criteria maximum concentration which equals the highest concentration of pollutant to which aquatic life can be exposed for a short period time without deleterious effects.

g) Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

h) Detection limits have changed throughout the monitoring process. Only data matching the current detection limit is displayed in this table. The *Data Included Since* field indicates the first year of the storm season with the current detection limit.

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Table 4-4. Summary of 1994-2000 Mass Emissions Results by Year

Class Constituent	DL	Units	1994-95						1995-96						1996-97					
			No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																				
Cyanide	0.01	mg/l	9	9	0	S.I.D.	S.I.D.	S.I.D.	24	23	4	S.I.D.	S.I.D.	S.I.D.	17	15	12	S.I.D.	S.I.D.	S.I.D.
TPH	1	mg/l	9	5	44	1.8	0.5	0.96	26	10	62	2.4	1.7	0.89	17	11	35	1.9	0.5	1.20
Oil and Grease	1	mg/l	6	3	50	2.0	1.4	0.94	26	10	62	2.4	1.7	0.89	17	11	35	1.8	0.5	1.18
Total Phenols	0.1	mg/l	9	9	0	S.I.D.	S.I.D.	S.I.D.	24	23	4	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria																				
Total Coliform	20	MPN/100ml	9	0	100	423,333	240,000	1.07	26	2	92	3,997,462	1,700,000	1.26	17	0	100	1,346,894	240,000	2.83
Fecal Coliform	20	MPN/100ml	9	0	100	195,444	230,000	0.79	26	0	100	2,581,288	900,000	1.94	17	0	100	71,818	24,000	1.27
Ratio Fecal Coliform/Total Coliform			0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
Fecal Streptococcus	20	MPN/100ml	9	0	100	279,222	90,000	1.81	26	2	92	1,305,032	700,000	1.49	17	0	100	248,047	240,000	1.06
Fecal *Enterococcus*	20	MPN/100ml	9	0	100	243,788	60,000	2.12	26	2	92	867,424	270,000	1.06	4	0	100	73,050	60,000	1.02
General Minerals																				
Ammonia	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	10	41	0.7	0.1	1.44	16	4	75	0.5	0.3	1.16
Calcium	1.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	39	38	0.52	16	0	100	21	17	0.54
Magnesium	1.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	13.4	9.7	0.95	16	0	100	4.9	3.7	0.77
Potassium	1.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	4.5	4.0	0.44	16	0	100	3.5	3.3	0.58
Sodium	1.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	37	32	0.60	16	0	100	15	10	0.68
Bicarbonate	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	77	81	0.54	16	0	100	41	34	0.44
Carbonate	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Chloride	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	34	32	0.57	16	0	100	18	10	0.85
Fluoride	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	0.2	0.2	0.23	16	10	38	0.1	0.1	0.62
Nitrate	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	13.2	12.8	0.38	16	0	100	5.2	3.3	0.74
Sulfate	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	88	83	0.94	16	0	100	29	18	0.80
Alkalinity	4.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	77	81	0.54	16	0	100	41	34	0.44
Hardness	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	152	135	0.66	16	0	100	73	56	0.57
COD	5	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	10	33	20	3	1.56	16	1	94	121	108	0.80
pH	0-14		0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	7.7	7.7	0.04	16	0	100	7.3	7.2	0.04
Specific Conductance	1.0	umhos/cm	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	465	425	0.55	16	0	100	244	225	0.57
Total Dissolved Solids	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	310	280	0.58	16	0	100	163	153	0.59
Turbidity	0.1	NTU	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	75	61	0.75	16	0	100	40	26	0.97
Total Suspended Solids	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	348	360	0.60	16	0	100	205	182	0.58
Volatile Suspended Solids	1.0	mg/l/hr	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	54	56	0.48	16	0	100	47	45	0.53
MBAS	0.05	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Organic Carbon	1.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	0	100	12	10	0.49	16	0	100	12	9	0.86
BOD	2.0	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	14	0	100	34	30	0.45	16	0	100	33	31	0.42
Nutrients																				
Dissolved Phosphorus	0.05	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	0.3	0.2	0.60	16	0	100	0.3	0.2	0.49
Total Phosphorus	0.05	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	0.4	0.3	0.74	16	0	100	0.8	0.8	0.43
NH3-N	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	14	9	36	0.5	0.1	1.58	16	6	63	0.4	0.2	1.19
Nitrate-N	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	3.0	2.9	0.38	16	0	100	1.2	0.7	0.74
Nitrite-N	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	3	81	0.13	0.08	0.89	16	0	100	0.13	0.09	0.80
TKN	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	0	100	2.3	1.7	0.65	16	0	100	3.0	2.9	0.64
Metals																				
Dissolved Aluminum	100	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	14	13	S.I.D.	S.I.D.	S.I.D.
Total Aluminum	100	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	11	31	1130	50	1.91
Dissolved Antimony	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Antimony	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	15	6	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	5	µg/l	1	0	100	S.I.D.	S.I.D.	S.I.D.	17	16	6	S.I.D.	S.I.D.	S.I.D.	16	10	38	2.0	3	0.34
Dissolved Barium	10	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	7	56	10	6	0.67
Total Barium	10	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	16	6	S.I.D.	S.I.D.	S.I.D.	16	5	69	41	23	1.33
Dissolved Beryllium	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	100	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	17	16	6	S.I.D.	S.I.D.	S.I.D.	16	14	13	S.I.D.	S.I.D.	S.I.D.
Total Boron	100	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	15	12	S.I.D.	S.I.D.	S.I.D.	16	11	31	84	50	0.68
Dissolved Cadmium	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	11	31	2.4	3	0.36
Total Chromium	5	µg/l	1	0	100	S.I.D.	S.I.D.	S.I.D.	17	11	35	14.0	2.5	1.73	16	3	81	11.1	3.5	1.55
Dissolved Chromium +6	10	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	10	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.

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Table 4-4. Summary of 1994-2000 Mass Emissions Results by Year

Class Constituent	DL	Units	1994-95						1995-96						1996-97					
			No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Copper	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D	17	15	12	S.I.D.	S.I.D	S.I.D	16	9	44	3.0	2.5	0.75
Total Copper	5	µg/l	1	0	100	S.I.D	S.I.D.	S.I.D	17	3	82	27.1	24	0.84	16	1	94	24.6	13	1.26
Dissolved Iron	100	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D	17	10	41	134	50	1.23	16	8	50	217	100	1.11
Total Iron	100	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D	17	0	100	2642	1110	1.39	16	0	100	1821	790	1.44
Dissolved Lead	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D	17	15	12	S.I.D.	S.I.D	S.I.D	16	14	13	S.I.D	S.I.D	S.I.D.
Total Lead	5	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D.	17	11	35	18	2.5	2.46	16	2	88	21	9.0	1.61
Dissolved Manganese	100	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D	17	13	24	50	50	0.13	16	16	0	S.I.D	S.I.D.	S.I.D.
Total Manganese	100	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	2	88	97	65	1.01	16	11	31	94	50	1.27
Dissolved Mercury	1	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D	17	17	0	S.I.D	S.I.D	S.I.D	16	16	0	S.I.D	S.I.D.	S.I.D
Total Mercury	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	15	12	S.I.D.	S.I.D.	S.I.D.	16	15	6	S.I.D.	S.I.D	S.I.D.
Dissolved Nickel	5	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D.	17	15	12	S.I.D.	S.I.D.	S.I.D.	16	13	19	S.I.D.	S.I.D.	S.I.D.
Nickel	5	µg/l	1	0	100	S.I.D.	S.I.D.	S.I.D.	17	7	59	14.6	18.0	0.85	16	4	75	7.4	3.3	1.31
Dissolved Selenium	5	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D	17	17	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	5	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D.	17	14	18	S.I.D.	S.I.D.	S.I.D	16	13	19	S.I.D.	S.I.D.	S.I.D
Dissolved Silver	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D	17	17	0	S.I.D.	S.I.D	S.I.D	16	16	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	1	µg/l	1	1	0	S.I.D	S.I.D.	S.I.D.	17	16	6	S.I.D.	S.I.D.	S.I.D	16	15	6	S.I.D.	S.I.D.	S.I.D
Dissolved Thallium	5	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D	S.I.D	16	16	0	S.I.D.	S.I.D.	S.I.D
Total Thallium	5	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D.	17	17	0	S.I.D	S.I.D.	S.I.D	16	16	0	S.I.D.	S.I.D	S.I.D.
Dissolved Zinc	50	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D	17	13	24	37	25	0.64	16	12	25	34	25	0.52
Total Zinc	50	µg/l	1	1	0	S.I.D.	S.I.D	S.I.D.	17	7	59	91	73	0.99	16	2	88	118	71	1.19
SVOCs																				
Bis(2-ethylhexyl)phthalate	1	µg/l	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D	15	4	73	19	14.4	1.12	16	5	69	9	4.2	1.26
PAHs																				
Acenaphthene	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D.	S.I.D	16	16	0	S.I.D.	S.I.D	S.I.D.
Acenaphthylene	0.05	µg/l	0	0	S.I.D	S.I.D	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D	S.I.D	16	16	0	S.I.D.	S.I.D.	S.I.D
Anthracene	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D	S.I.D	16	16	0	S.I.D.	S.I.D	S.I.D
Benzo(a)anthracene	0.1	µg/l	0	0	S.I.D.	S.I.D	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D	S.I.D	16	16	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)pyrene	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
Benzo(b)fluoranthene	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
Benzo(k)fluoranthene	0.1	µg/l	0	0	S.I.D.	S.I.D	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D	S.I.D	S.I.D
Chrysene	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
Dibenz(a,h)anthracene	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D	16	16	0	S.I.D.	S.I.D.	S.I.D
Fluoranthene	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D	S.I.D.	15	15	0	S.I.D.	S.I.D	S.I.D	16	16	0	S.I.D.	S.I.D	S.I.D
Fluorene	0.1	µg/l	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
Indeno (1,2,3-cd)pyrene	0.1	µg/l	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D	15	15	0	S.I.D	S.I.D.	S.I.D.	16	16	0	S.I.D	S.I.D.	S.I.D.
Naphthalene	0.05	µg/l	0	0	S.I.D	S.I.D.	S.I.D	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D	S.I.D
Phenanthrene	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Pyrene	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D.	S.I.D	16	16	0	S.I.D	S.I.D	S.I.D.
All other SVOCs	0.05-5.0	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Pesticides																				
Organochlorine Pesticides & PCBs	0.05-1.0	µg/l	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D	15	15	0	S.I.D.	S.I.D.	S.I.D.	11	11	0	S.I.D.	S.I.D	S.I.D
Carbofuran	5	µg/l	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D.	13	13	0	S.I.D.	S.I.D	S.I.D
Glyphosate	25	µg/l	0	0	S.I.D.	S.I.D	S.I.D	S.I.D	0	0	S.I.D.	S.I.D.	S.I.D	S.I.D.	16	16	0	S.I.D	S.I.D.	S.I.D.
Organo-Phosphate Pesticides																				
Diazinon	0.01	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
Chlorpyrifos	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides																				
Thiobencarb	1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
All other N- and P- Pesticides	1.0-2.0	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D
Phenoxyacetic Acid Herbicides																				
2,4-D	10	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	16	16	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	2	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D	16	16	0	S.I.D.	S.I.D.	S.I.D.

R0012033

Table 4-4. Summary of 1994-2000 Mass Emissions Results by Year

Class Constituent	DL	Units	1997-98						1998-99						1999-2000					
			No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																				
Cyanide	0.01	mg/l	31	25	19	S.I.D.	S.I.D.	S.I.D.	44	34	23	0.014	0.005	2.800	36	36	0	S.I.D.	S.I.D.	S.I.D.
TPH	1	mg/l	31	23	26	0.9	0.5	1.12	44	25	43	1.3	0.5	1.2	36	15	58	1.6	1.4	0.79
Oil and Grease	1	mg/l	31	22	29	1.4	0.5	2.62	44	24	45	2.9	0.5	2.6	36	13	64	2.1	2.1	0.79
Total Phenols	0.1	mg/l	31	30	3	S.I.D.	S.I.D.	S.I.D.	44	43	2	S.I.D.	S.I.D.	S.I.D.	35	35	0	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria																				
Total Coliform	20	MPN/100ml	31	0	100	2,908,484	500,000	1.80	44	3	93	414,867	240,000	2.02	36	0	100	585,231	240,000	2.59
Fecal Coliform	20	MPN/100ml	31	0	100	2,536,806	130,000	2.12	44	3	93	53,090	9,000	1.96	36	0	100	161,347	50,000	1.85
Ratio Fecal Coliform/Total Coliform			0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	2	0	100	S.I.D.	S.I.D.	S.I.D.	3	0	100	64%	44%	0.76
Fecal Streptococcus	20	MPN/100ml	31	0	100	965,803	240,000	2.98	44	3	93	147,863	31,500	1.92	36	0	100	216,153	145,000	1.17
Fecal Enterococcus	20	MPN/100ml	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	24	0	100	67,393	22,500	1.67	36	0	100	98,494	18,500	2.14
General Minerals																				
Ammonia	0.1	mg/l	47	0	100	1.0	0.7	0.96	56	22	61	0.7	0.2	1.91	52	28	46	0.4	0.1	2.17
Calcium	1.0	mg/l	38	0	100	38	33	0.67	58	0	100	57	49	0.70	52	0	100	41	28	0.95
Magnesium	1.0	mg/l	38	0	100	14.6	8.4	1.07	58	0	100	24	15	1.06	52	0	100	15.6	6.8	1.51
Potassium	1.0	mg/l	46	0	100	4.3	4.3	0.39	58	0	100	4.6	4.4	0.38	54	0	100	4.3	4.1	0.51
Sodium	1.0	mg/l	47	0	100	36	24	0.95	58	0	100	53	41	0.86	54	0	100	44	29	1.01
Bicarbonate	2.0	mg/l	40	0	100	76	62	0.70	58	0	100	105	101	0.55	53	0	100	98	71	0.73
Carbonate	2.0	mg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	58	56	3	S.I.D.	S.I.D.	S.I.D.	53	53	0	S.I.D.	S.I.D.	S.I.D.
Chloride	2.0	mg/l	41	0	100	35	26	0.86	58	1	98	57	48	0.82	54	0	100	42	28	0.96
Fluoride	0.1	mg/l	41	14	66	0.1	0.1	0.74	58	6	90	0.3	0.3	0.58	54	10	81	0.2	0.2	0.68
Nitrate	0.1	mg/l	41	0	100	5.0	4.4	0.65	58	2	97	8	6	0.97	54	1	98	7.2	5.5	0.84
Sulfate	0.1	mg/l	41	0	100	81	42	1.19	58	1	98	125	78	1.20	54	0	100	115	47	1.43
Alkalinity	4.0	mg/l	40	0	100	76	62	0.70	58	0	100	105	101	0.55	53	0	100	82	60	0.75
Hardness	2.0	mg/l	38	0	100	151	120	0.85	58	0	100	234	177	0.86	52	0	100	172	98	1.15
COD	5	mg/l	47	0	100	119	88	0.88	58	2	97	81	51	0.65	54	5	91	50	39	0.79
pH	0-14		40	0	100	7.3	7.4	0.06	58	0	100	7.7	7.7	0.06	53	0	100	7.3	7.2	0.06
Specific Conductance	1.0	umhos/cm	38	0	100	463	360	0.83	57	0	100	757	577	0.84	53	0	100	571	321	1.03
Total Dissolved Solids	2.0	mg/l	38	0	100	291	224	0.84	57	0	100	478	360	0.83	53	0	100	348	206	1.04
Turbidity	0.1	NTU	40	0	100	212	102	1.29	57	0	100	78	54	1.03	53	0	100	98	66	1.06
Total Suspended Solids	2.0	mg/l	39	0	100	467	284	1.05	58	0	100	148	88	1.13	53	0	100	232	140	1.04
Volatile Suspended Solids	1.0	mg/Vhr	39	0	100	81	53	0.92	58	1	98	36	23	1.05	53	0	100	48	32	0.94
MBAS	0.05	mg/l	46	46	0	S.I.D.	S.I.D.	S.I.D.	56	22	61	0.11	0.07	1.31	51	18	65	0.08	0.07	1.08
Total Organic Carbon	1.0	mg/l	45	0	100	11	10	0.69	52	0	100	10	7	0.82	54	0	100	9	8	0.70
BOD	2.0	mg/l	37	0	100	25	25	0.52	52	3	94	33	19	1.53	54	3	94	13	7	1.48
Nutrients																				
Dissolved Phosphorus	0.05	mg/l	44	0	100	0.5	0.5	0.60	55	2	96	0.3	0.3	0.63	51	3	94	0.3	0.3	0.58
Total Phosphorus	0.05	mg/l	44	0	100	0.6	0.5	0.69	55	1	98	0.4	0.3	0.63	51	0	100	0.4	0.3	0.59
NH3-N	0.1	mg/l	47	0	100	0.9	0.6	0.95	56	24	57	0.6	0.2	1.90	52	33	37	0.4	0.1	2.17
Nitrate-N	0.1	mg/l	38	1	97	1.2	1.0	0.66	58	3	95	1.7	1.4	0.97	54	1	98	1.6	1.2	0.85
Nitrite-N	0.1	mg/l	42	6	86	0.18	0.06	1.14	58	15	74	0.26	0.12	1.18	54	11	80	0.19	0.10	1.61
TKN	0.1	mg/l	46	0	100	3.6	2.8	0.78	58	1	98	3.6	3.0	0.87	53	0	100	2.2	1.4	0.96
Metals																				
Dissolved Aluminum	100	µg/l	47	7	85	1813	958	1.12	58	47	19	S.I.D.	S.I.D.	S.I.D.	54	29	46	159	50	1.30
Total Aluminum	100	µg/l	47	0	100	6086	2970	1.72	58	3	95	606	199	2.11	54	5	91	336	248	0.80
Dissolved Antimony	5	µg/l	47	45	4	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Antimony	5	µg/l	47	45	4	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	53	2	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	5	µg/l	47	46	2	S.I.D.	S.I.D.	S.I.D.	58	57	2	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	5	µg/l	47	37	21	4.3	3	1.14	58	56	3	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Barium	10	µg/l	47	8	83	54	48	0.70	58	3	95	44	40	0.48	54	3	94	41	34	0.70
Total Barium	10	µg/l	47	8	83	124	83	1.27	58	3	95	58	51	0.64	54	1	98	51	42	0.72
Dissolved Beryllium	1	µg/l	44	44	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	1	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	100	µg/l	47	3	94	214	209	0.43	58	4	93	263	247	0.50	54	20	63	148	117	0.81
Total Boron	100	µg/l	47	1	98	301	276	0.38	58	2	97	325	309	0.48	54	14	74	186	147	0.77
Dissolved Cadmium	1	µg/l	47	32	32	1.4	1	1.46	58	56	3	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	1	µg/l	47	26	45	1.9	1	1.43	58	51	12	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	5	µg/l	47	36	23	5.6	3	1.26	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	52	4	S.I.D.	S.I.D.	S.I.D.
Total Chromium	5	µg/l	47	14	70	19.4	10.8	1.38	58	49	16	S.I.D.	S.I.D.	S.I.D.	54	50	7	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium +6	10	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	10	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.

R0012034

Table 4-4. Summary of 1994-2000 Mass Emissions Results by Year

Class Constituent	DL	Units	1997-98						1998-99						1999-2000					
			No of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Copper	5	µg/l	47	8	83	30.7	15.0	1.59	58	28	52	5.7	5.3	0.67	54	31	43	5.5	2.5	0.93
Total Copper	5	µg/l	47	0	100	49.1	28	1.54	58	1	98	13.3	10	0.76	54	3	94	10.9	9	0.64
Dissolved Iron	100	µg/l	47	7	85	2553	870	1.40	58	38	34	156	50	2.39	54	25	54	207	130	1.25
Total Iron	100	µg/l	47	0	100	14577	8900	1.31	58	9	84	658	248	2.21	54	7	87	529	340	0.98
Dissolved Lead	5	µg/l	47	25	47	37	2.5	2.35	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	52	4	S.I.D.	S.I.D.	S.I.D.
Total Lead	5	µg/l	47	14	70	74	15.9	2.69	58	50	14	S.I.D.	S.I.D.	S.I.D.	54	38	30	4	2.5	0.90
Dissolved Manganese	100	µg/l	47	24	49	157	50	1.03	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Manganese	100	µg/l	47	6	89	291	186	1.00	58	44	24	90	50	1.00	54	50	7	S.I.D.	S.I.D.	S.I.D.
Dissolved Mercury	1	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	1	µg/l	46	44	2	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	5	µg/l	47	21	55	10.2	6.0	1.31	58	53	9	S.I.D.	S.I.D.	S.I.D.	54	46	15	S.I.D.	S.I.D.	S.I.D.
Nickel	5	µg/l	47	14	70	18.0	9.7	1.47	58	34	41	5.4	2.5	0.84	54	32	41	5.9	2.5	1.24
Dissolved Selenium	5	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	5	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	50	14	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	1	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	57	2	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	1	µg/l	47	43	9	S.I.D.	S.I.D.	S.I.D.	58	56	3	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	5	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	5	µg/l	47	47	0	S.I.D.	S.I.D.	S.I.D.	58	58	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	50	µg/l	47	23	51	194	50	1.70	58	43	26	37	25	0.81	54	53	2	S.I.D.	S.I.D.	S.I.D.
Total Zinc	50	µg/l	47	2	96	313	211	1.27	58	23	60	70	54	1.00	54	38	30	42	25	1.03
SVOCs																				
Bis(2-ethylhexyl)phthalate	1	µg/l	43	4	91	19	13.8	0.93	22	5	77	17	13.3	1.01	10	5	50	19	0.9	1.45
PAHs																				
Acenaphthene	0.05	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	19	19	0	S.I.D.	S.I.D.	S.I.D.	10	9	10	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	0.05	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	19	19	0	S.I.D.	S.I.D.	S.I.D.	10	9	10	S.I.D.	S.I.D.	S.I.D.
Anthracene	0.05	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)pyrene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	9	10	S.I.D.	S.I.D.	S.I.D.
Benzo(k)fluoranthene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Chrysene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	9	10	S.I.D.	S.I.D.	S.I.D.
Dibenz(a,h)anthracene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	7	30	0.050	0.050	0.49
Fluorene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	0.1	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Naphthalene	0.05	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	9	10	S.I.D.	S.I.D.	S.I.D.
Phenanthrene	0.05	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	8	20	0.025	0.025	0.93
Pyrene	0.05	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	6	40	0.025	0.025	1.64
All other SVOCs	0.05-5.0	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Pesticides																				
Organochlorine Pesticides & PCBs	0.05-1.0	µg/l	42	42	0	S.I.D.	S.I.D.	S.I.D.	21	21	0	S.I.D.	S.I.D.	S.I.D.	10	10	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	5	µg/l	46	46	0	S.I.D.	S.I.D.	S.I.D.	56	56	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	25	µg/l	46	46	0	S.I.D.	S.I.D.	S.I.D.	57	54	5	S.I.D.	S.I.D.	S.I.D.	54	53	2	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides																				
Diazinon	0.01	µg/l	42	41	2	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	54	44	19	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	0.05	µg/l	42	42	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides																				
Thiobencarb	1	µg/l	42	42	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticides	1.0-2.0	µg/l	42	42	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	54	54	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides																				
2,4-D	10	µg/l	44	44	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	1	µg/l	44	44	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	2	µg/l	44	44	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.

CV = Coefficient of variation
DL = Detection Limit
S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

R0012035

Table 4-5a. Summary of 1994-2000 Mass Emissions Results by Site

Class Constituent	Data Included Since*	DL	Units	Ballona Creek						Malibu Creek						L.A. River					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																					
Cyanide	96	0.01	mg/l	34	33	3	S.I.D.	S.I.D.	S.I.D.	32	30	6	S.I.D.	S.I.D.	S.I.D.	26	24	8	S.I.D.	S.I.D.	S.I.D.
TPH	94	1	mg/l	46	12	74	2.5	1.9	0.8	40	39	3	S.I.D.	S.I.D.	S.I.D.	31	5	84	2.5	1.9	0.74
Oil and Grease	94	1	mg/l	45	15	67	3.8	2.1	1.9	38	31	18	S.I.D.	S.I.D.	S.I.D.	31	9	71	2.5	1.5	0.89
Total Phenols	94	0.1	mg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	40	38	5	S.I.D.	S.I.D.	S.I.D.	31	31	0	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria																					
Total Coliform	94	20	MPN/100ml	46	1	98	1,704,131	400,000	2.30	40	1	98	879,925	125,000	3.84	31	1	97	2,213,291	500,000	1.86
Fecal Coliform	94	20	MPN/100ml	46	1	98	917,648	100,000	3.57	40	1	98	466,269	16,000	5.41	31	0	100	1,477,645	240,000	2.67
Ratio Fecal Coliform/Total Coliform	94			0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	5	0	100	41%	36%	0.87	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fecal Streptococcus	94	20	MPN/100ml	46	1	98	531,761	240,000	1.67	40	1	98	281,658	42,500	3.13	31	1	97	767,013	240,000	2.20
Fecal Enterococcus	94	20	MPN/100ml	28	0	100	433,639	180,000	1.34	24	0	100	60,720	4,000	3.06	20	1	95	388,466	87,500	1.71
General Minerals																					
Ammonia	94	0.1	mg/l	40	11	73	0.53	0.35	1.15	28	12	57	0.18	0.17	0.81	33	12	64	0.56	0.18	1.26
Calcium	96	1.0	mg/l	37	0	100	27	20	0.77	25	0	100	111	108	0.32	26	0	100	23	16	0.75
Magnesium	96	1.0	mg/l	37	0	100	8	5	1.03	25	0	100	61.7	55.0	0.43	26	0	100	5.9	3.8	1.06
Potassium	94	1.0	mg/l	40	0	100	3.2	2.9	0.46	31	0	100	5.4	4.8	0.34	33	0	100	3.7	3.4	0.51
Sodium	96	1.0	mg/l	39	0	100	20	13	0.89	29	0	100	95	91	0.38	29	0	100	17	11	0.84
Bicarbonate	94	2.0	mg/l	39	0	100	67	47	0.87	29	0	100	184	165	0.33	30	0	100	45	37	0.55
Carbonate	94	2.0	mg/l	39	39	0	S.I.D.	S.I.D.	S.I.D.	28	27	7	S.I.D.	S.I.D.	S.I.D.	30	30	0	S.I.D.	S.I.D.	S.I.D.
Chloride	94	2.0	mg/l	38	0	100	24	11	1.32	29	1	97	88	80	0.43	32	0	100	16	9.3	1.00
Fluoride	94	0.1	mg/l	38	13	66	0.20	0.14	0.87	29	2	93	0.22	0.24	0.32	32	13	59	0.15	0.13	0.74
Nitrate	94	0.1	mg/l	38	0	100	4.1	2.9	0.68	29	1	97	12.6	9.6	0.71	32	1	97	4.5	3.0	0.91
Sulfate	94	0.1	mg/l	38	0	100	39	21	1.17	29	1	97	346	328	0.50	32	0	100	26	18	1.02
Alkalinity	94	4.0	mg/l	39	0	100	83	46	0.84	29	0	100	157	159	0.34	30	0	100	42	37	0.58
Hardness	96	2.0	mg/l	37	0	100	103	72	0.85	25	0	100	509	496	0.44	26	0	100	78	52	0.87
COD	97	5	mg/l	35	1	97	64	42	0.81	29	2	93	75	55	0.90	25	2	92	95	61	1.27
pH	94	0-14		39	0	100	7.3	7.2	0.06	29	0	100	8.0	8.1	0.04	30	0	100	7.0	7.0	0.04
Specific Conductance	94	1.0	umhos/cm	38	0	100	317	205	0.90	28	0	100	1492	1340	0.38	30	0	100	227	182	0.68
Total Dissolved Solids	96	2.0	mg/l	37	0	100	199	130	0.91	26	0	100	983	877	0.35	26	0	100	144	99	0.75
Turbidity	94	0.1	NTU	39	0	100	74	65	0.74	28	0	100	176	68	1.65	30	0	100	127	99	0.78
Total Suspended Solids	96	2.0	mg/l	38	0	100	181	138	0.89	26	0	100	288	139	1.64	26	0	100	366	298	0.72
Volatile Suspended Solids	94	1.0	mg/l/hr	39	0	100	57	48	0.78	28	1	96	45	30	1.26	30	0	100	66	58	0.84
MBAS	97	0.05	mg/l	34	11	68	0.10	0.07	1.07	25	23	8	S.I.D.	S.I.D.	S.I.D.	25	15	40	0.05	0.03	0.63
Total Organic Carbon	94	1.0	mg/l	37	0	100	10	7	0.66	30	0	100	11	7	0.96	33	0	100	10	9	0.73
BOD	94	2.0	mg/l	37	2	95	29	18	1.07	28	2	93	10	6	0.90	29	0	100	26	23	0.84
Nutrients																					
Dissolved Phosphorus	94	0.05	mg/l	38	1	97	0.25	0.20	0.62	26	1	96	0.49	0.49	0.49	33	1	97	0.42	0.36	0.74
Total Phosphorus	94	0.05	mg/l	38	0	100	0.36	0.28	0.57	26	1	96	0.56	0.52	0.52	33	0	100	0.62	0.47	0.75
NH3-N	94	0.1	mg/l	40	14	65	0.43	0.29	1.15	28	13	54	0.15	0.14	0.78	33	15	55	0.47	0.15	1.25
Nitrate-N	96	0.1	mg/l	37	0	100	0.9	0.63	0.81	26	1	96	3.0	2.1	0.71	27	3	89	0.8	0.66	0.78
Nitrite-N	94	0.1	mg/l	39	2	95	0.14	0.08	1.10	29	26	10	S.I.D.	S.I.D.	S.I.D.	32	3	91	0.15	0.09	1.18
TKN	96	0.1	mg/l	38	0	100	3.3	2.6	0.79	28	1	96	1.9	1.4	0.65	29	0	100	3.5	3.1	0.77
Metals																					
Dissolved Aluminum	96	100	µg/l	39	21	46	304	50	2.11	29	22	24	621	50	2.95	29	10	66	1122	188	1.76
Total Aluminum	96	100	µg/l	39	5	87	710	208	1.56	29	4	86	2862	237	2.88	29	3	90	4499	505	2.52
Dissolved Antimony	97	5	µg/l	35	34	3	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	24	4	S.I.D.	S.I.D.	S.I.D.
Total Antimony	97	5	µg/l	35	33	6	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	24	4	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	97	5	µg/l	35	35	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	24	4	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	97	5	µg/l	35	34	3	S.I.D.	S.I.D.	S.I.D.	29	27	7	S.I.D.	S.I.D.	S.I.D.	25	20	20	4.0	3	0.90
Dissolved Barium	97	10	µg/l	35	3	91	39	35	0.66	29	2	93	45	42	0.42	25	3	88	44	34	0.82
Total Barium	97	10	µg/l	35	3	91	54	43	0.79	29	1	97	80	59	1.67	25	2	92	106	48	1.47
Dissolved Beryllium	97	1	µg/l	34	34	0	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.	25	25	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	97	1	µg/l	35	35	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	25	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	97	100	µg/l	35	10	71	187	136	0.62	29	0	100	352	379	0.35	25	6	76	157	155	0.58
Total Boron	97	100	µg/l	35	5	86	220	204	0.53	29	0	100	427	417	0.37	25	6	76	216	231	0.55
Dissolved Cadmium	97	1	µg/l	35	33	6	S.I.D.	S.I.D.	S.I.D.	29	25	14	S.I.D.	S.I.D.	S.I.D.	25	19	24	1.6	1	1.67
Total Cadmium	97	1	µg/l	35	31	11	S.I.D.	S.I.D.	S.I.D.	29	24	17	S.I.D.	S.I.D.	S.I.D.	25	16	36	1.9	0.5	1.51
Dissolved Chromium	97	5	µg/l	35	34	3	S.I.D.	S.I.D.	S.I.D.	29	27	7	S.I.D.	S.I.D.	S.I.D.	25	20	20	5.8	3	1.30
Total Chromium	97	5	µg/l	35	27	23	3.9	2.6	0.78	29	20	31	11.3	2.5	2.24	25	14	44	15.4	2.5	1.70
Dissolved Chromium +6	94	10	µg/l	39	39	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	94	10	µg/l	39	39	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Copper	97	5	µg/l	35	3	91	13	7.2	1.07	29	21	28	5.0	2.5	1.14	25	6	76	32	7.8	2.01

R0012036

Table 4-5a. Summary of 1994-2000 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Ballona Creek						Malibu Creek						L.A. River					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Total Copper	97	5	µg/l	35	0	100	22	15	0.75	29	1	97	15.7	9	1.88	25	0	100	49	15	2.00
Dissolved Iron	94	100	µg/l	40	20	50	422	80	2.72	32	21	34	622	50	2.41	33	7	79	1514	230	2.29
Total Iron	94	100	µg/l	40	1	98	1863	480	1.94	32	7	78	7141	346	2.86	33	3	91	7052	940	1.98
Dissolved Lead	97	5	µg/l	35	32	9	S.I.D.	S.I.D.	S.I.D.	29	28	3	S.I.D.	S.I.D.	S.I.D.	25	16	36	53	2.5	2.21
Total Lead	97	5	µg/l	35	21	40	12	2.5	1.84	29	25	14	S.I.D.	S.I.D.	S.I.D.	25	5	80	109	18	2.47
Dissolved Manganese	98	100	µg/l	28	28	0	S.I.D.	S.I.D.	S.I.D.	20	20	0	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.
Total Manganese	98	100	µg/l	28	24	14	S.I.D.	S.I.D.	S.I.D.	20	15	25	98	50	1.01	15	12	20	89	50	1.32
Dissolved Mercury	94	1	µg/l	39	39	0	S.I.D.	S.I.D.	S.I.D.	31	31	0	S.I.D.	S.I.D.	S.I.D.	33	33	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	94	1	µg/l	39	37	5	S.I.D.	S.I.D.	S.I.D.	31	30	3	S.I.D.	S.I.D.	S.I.D.	33	32	3	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	97	5	µg/l	35	29	17	S.I.D.	S.I.D.	S.I.D.	29	21	28	5.7	2.5	1.64	25	14	44	9.1	2.5	1.39
Nickel	97	5	µg/l	35	15	57	6.4	6.0	0.71	29	13	55	15.1	5.5	1.94	25	10	60	14.5	7.4	1.47
Dissolved Selenium	94	5	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.	33	33	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	94	5	µg/l	40	37	8	S.I.D.	S.I.D.	S.I.D.	32	31	3	S.I.D.	S.I.D.	S.I.D.	33	31	6	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	97	1	µg/l	35	34	3	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	25	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	97	1	µg/l	35	33	6	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	22	12	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	97	5	µg/l	35	35	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	25	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	97	5	µg/l	35	35	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.	25	25	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	94	50	µg/l	40	27	33	66	25	1.34	32	29	9	S.I.D.	S.I.D.	S.I.D.	33	20	39	152	25	2.40
Total Zinc	94	50	µg/l	40	7	83	136	76	1.30	32	23	28	53	25	1.27	33	8	76	253	68	1.83
SVOCs																					
Bis(2-ethylhexyl)phthalate	99	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	3	63	5	2.3	1.28	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
PAHs																					
Acenaphthene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	7	13	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	7	13	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Anthracene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(a)pyrene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	7	13	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(k)fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Chrysene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	7	13	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Dibenz(a,h)anthracene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	5	38	0.078	0.050	0.50	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fluorene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	8	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Naphthalene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	7	13	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Phenanthrene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	6	25	0.043	0.025	0.95	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Pyrene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	8	4	50	0.151	0.058	1.60	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
All other SVOCs	94	0.05-5.0	µg/l	18	18	0	S.I.D.	S.I.D.	S.I.D.	27	27	0	S.I.D.	S.I.D.	S.I.D.	18	18	0	S.I.D.	S.I.D.	S.I.D.
Pesticides																					
Organochlorine Pesticides & PCBs	94	0.05-1.0	µg/l	13	13	0	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	96	5	µg/l	38	38	0	S.I.D.	S.I.D.	S.I.D.	26	26	0	S.I.D.	S.I.D.	S.I.D.	29	29	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	98	25	µg/l	28	28	0	S.I.D.	S.I.D.	S.I.D.	19	19	0	S.I.D.	S.I.D.	S.I.D.	15	14	7	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides																					
Diazinon	96	0.01	µg/l	38	31	18	S.I.D.	S.I.D.	S.I.D.	28	26	7	S.I.D.	S.I.D.	S.I.D.	28	26	7	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	96	0.05	µg/l	38	38	0	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides																					
Thiobencarb	96	1	µg/l	38	36	5	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticides	94	1.0-2.0	µg/l	39	39	0	S.I.D.	S.I.D.	S.I.D.	30	30	0	S.I.D.	S.I.D.	S.I.D.	31	31	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides																					
2,4-D	96	10	µg/l	14	14	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.	14	14	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	96	1	µg/l	14	14	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.	14	14	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	96	2	µg/l	14	14	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.	14	14	0	S.I.D.	S.I.D.	S.I.D.

R0012037

Table 4-5a. Summary of 1994-2000 Mass Emissions Results by Site

Class Constituent	Data Included Since*	DL	Units	Coyote Creek						San Gabriel River					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents															
Cyanide	96	0.01	mg/l	2	1	50	S.I.D.	S.I.D.	S.I.D.	34	22	35	0.022	0.005	2.39
TPH	94	1	mg/l	7	2	71	2.1	1.0	0.99	39	31	21	0.7	0.5	0.68
Oil and Grease	94	1	mg/l	7	2	71	2.5	2.1	0.85	39	26	33	1.0	0.5	0.88
Total Phenols	94	0.1	mg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	38	37	3	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria															
Total Coliform	94	20	MPN/100ml	7	1	86	4,765,716	1,600,000	1.24	39	1	97	1,348,795	300,000	2.19
Fecal Coliform	94	20	MPN/100ml	7	0	100	2,892,714	900,000	2.01	39	1	97	768,098	30,000	3.48
Ratio Fecal Coliform/Total Coliform	94			0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
Fecal Streptococcus	94	20	MPN/100ml	7	1	86	471,859	240,000	1.32	39	1	97	610,734	90,000	4.18
Fecal Enterococcus	94	20	MPN/100ml	6	1	83	396,335	175,000	1.64	21	0	100	88,380	16,000	2.30
General Minerals															
Ammonia	94	0.1	mg/l	44	11	75	0.85	0.42	1.39	43	18	58	1.1	0.49	1.44
Calcium	96	1.0	mg/l	40	0	100	33	28	0.51	38	0	100	43	38	0.42
Magnesium	96	1.0	mg/l	40	0	100	10.2	7.6	0.90	38	0	100	12.5	10.0	0.48
Potassium	94	1.0	mg/l	44	0	100	4.1	4.0	0.43	43	0	100	5.5	5.1	0.31
Sodium	96	1.0	mg/l	40	0	100	45	30	1.16	38	0	100	41	35	0.51
Bicarbonate	94	2.0	mg/l	45	0	100	83	71	0.62	41	0	100	92	77	0.45
Carbonate	94	2.0	mg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	41	41	0	S.I.D.	S.I.D.	S.I.D.
Chloride	94	2.0	mg/l	45	0	100	39	28	0.98	41	0	100	51	44	0.55
Fluoride	94	0.1	mg/l	45	10	78	0.23	0.19	0.78	41	2	95	0.21	0.18	0.44
Nitrate	94	0.1	mg/l	45	1	98	6.9	5.0	0.87	41	0	100	8.6	7.5	0.51
Sulfate	94	0.1	mg/l	45	0	100	77	47	1.11	41	0	100	77	70	0.47
Alkalinity	94	4.0	mg/l	45	0	100	78	67	0.59	41	0	100	88	77	0.47
Hardness	96	2.0	mg/l	40	0	100	126	105	0.60	38	0	100	161	133	0.43
COD	97	5	mg/l	36	1	97	61	55	0.60	34	1	97	62	56	0.73
pH	94	0-14		45	0	100	7.4	7.4	0.05	41	0	100	7.5	7.5	0.04
Specific Conductance	94	1.0	umhos/cm	44	0	100	466	352	0.87	40	0	100	528	435	0.44
Total Dissolved Solids	96	2.0	mg/l	39	0	100	288	194	0.91	38	0	100	331	279	0.47
Turbidity	94	0.1	NTU	45	0	100	97	64	1.26	41	0	100	100	41	1.61
Total Suspended Solids	96	2.0	mg/l	40	0	100	303	196	1.27	38	0	100	166	96	1.21
Volatile Suspended Solids	94	1.0	mg/l/hr	45	0	100	60	44	1.10	41	0	100	29	23	0.85
MBAS	97	0.05	mg/l	35	14	60	0.09	0.07	0.95	34	23	32	0.06	0.03	1.25
Total Organic Carbon	94	1.0	mg/l	43	0	100	12	10	0.67	41	0	100	9	7	0.59
BOD	94	2.0	mg/l	40	0	100	24	20	0.90	39	2	95	33	32	0.81
Nutrients															
Dissolved Phosphorus	94	0.05	mg/l	43	2	95	0.26	0.20	0.77	42	0	100	0.39	0.35	0.51
Total Phosphorus	94	0.05	mg/l	43	0	100	0.40	0.28	0.64	42	0	100	0.51	0.43	0.56
NH3-N	94	0.1	mg/l	43	12	72	0.70	0.33	1.40	41	18	56	1.0	0.41	1.44
Nitrate-N	96	0.1	mg/l	39	1	97	1.4	1.0	0.92	37	0	100	1.6	1.6	0.45
Nitrite-N	94	0.1	mg/l	45	2	96	0.20	0.10	1.73	41	2	95	0.37	0.30	0.76
TKN	96	0.1	mg/l	40	0	100	3.5	2.2	0.85	38	0	100	3.1	2.7	0.62
Metals															
Dissolved Aluminum	96	100	µg/l	40	24	40	456	50	1.93	38	20	47	481	50	1.87
Total Aluminum	96	100	µg/l	40	3	93	1257	419	1.50	38	4	89	1569	333	1.68
Dissolved Antimony	97	5	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Total Antimony	97	5	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	97	5	µg/l	36	35	3	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	97	5	µg/l	36	34	6	S.I.D.	S.I.D.	S.I.D.	34	32	6	S.I.D.	S.I.D.	S.I.D.
Dissolved Barium	97	10	µg/l	36	4	89	48	41	0.61	34	2	94	53	56	0.46
Total Barium	97	10	µg/l	36	4	89	72	49	1.11	34	2	94	73	71	0.60
Dissolved Beryllium	97	1	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	33	33	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	97	1	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	97	100	µg/l	36	5	86	178	162	0.56	34	6	82	200	195	0.56
Total Boron	97	100	µg/l	36	4	89	231	225	0.53	34	2	94	271	265	0.51
Dissolved Cadmium	97	1	µg/l	36	34	6	S.I.D.	S.I.D.	S.I.D.	34	31	9	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	97	1	µg/l	36	31	14	S.I.D.	S.I.D.	S.I.D.	34	29	15	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	97	5	µg/l	36	33	8	S.I.D.	S.I.D.	S.I.D.	34	32	6	S.I.D.	S.I.D.	S.I.D.
Total Chromium	97	5	µg/l	36	26	28	8.8	2.5	1.54	34	26	24	5.8	2.5	1.27
Dissolved Chromium +6	94	10	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	38	38	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	94	10	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	38	38	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Copper	97	5	µg/l	36	13	64	13	6.5	1.51	34	24	29	6.0	2.5	1.18

R0012038

Table 4-5a. Summary of 1994-2000 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Coyote Creek						San Gabriel River					
				No of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Total Copper	97	5	µg/l	36	1	97	21	14	1.18	34	2	94	12.9	8	0.87
Dissolved Iron	94	100	µg/l	45	19	58	780	188	2.63	43	22	49	561	50	2.50
Total Iron	94	100	µg/l	45	2	96	3601	830	1.92	43	4	91	2772	660	1.68
Dissolved Lead	97	5	µg/l	36	30	17	S.I.D.	S.I.D.	S.I.D.	34	29	15	S.I.D.	S.I.D.	S.I.D.
Total Lead	97	5	µg/l	36	26	28	11	2.5	2.23	34	25	26	7	2.5	1.40
Dissolved Manganese	98	100	µg/l	26	26	0	S.I.D.	S.I.D.	S.I.D.	23	23	0	S.I.D.	S.I.D.	S.I.D.
Total Manganese	98	100	µg/l	26	21	19	S.I.D.	S.I.D.	S.I.D.	23	22	4	S.I.D.	S.I.D.	S.I.D.
Dissolved Mercury	94	1	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	94	1	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	97	5	µg/l	36	28	22	4.2	2.5	0.92	34	28	18	S.I.D.	S.I.D.	S.I.D.
Nickel	97	5	µg/l	36	18	50	7.5	3.8	1.09	34	24	29	5.5	2.5	1.07
Dissolved Selenium	94	5	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	94	5	µg/l	45	40	11	S.I.D.	S.I.D.	S.I.D.	43	40	7	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	97	1	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	97	1	µg/l	36	35	3	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	97	5	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	97	5	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	94	50	µg/l	45	34	24	76	25	1.99	43	35	19	S.I.D.	S.I.D.	S.I.D.
Total Zinc	94	50	µg/l	45	15	67	125	69	1.27	43	20	53	77	51	0.97
SVOCs															
Bis(2-ethylhexyl)phthalate	99	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
PAHs															
Acenaphthene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Anthracene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(a)pyrene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(k)fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Chrysene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Dibenz(a,h)anthracene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fluorene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Naphthalene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Phenanthrene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Pyrene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
All other SVOCs	94	0.05-5.0	µg/l	23	23	0	S.I.D.	S.I.D.	S.I.D.	21	21	0	S.I.D.	S.I.D.	S.I.D.
Pesticides															
Organochlorine Pesticides & PCBs	94	0.05-1.0	µg/l	19	19	0	S.I.D.	S.I.D.	S.I.D.	18	18	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	96	5	µg/l	39	39	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	98	25	µg/l	26	25	4	S.I.D.	S.I.D.	S.I.D.	23	21	9	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides															
Diazinon	96	0.01	µg/l	36	30	17	S.I.D.	S.I.D.	S.I.D.	37	31	16	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	96	0.05	µg/l	36	36	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides															
Thiobencarb	96	1	µg/l	36	34	6	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticides	94	1.0-2.0	µg/l	41	41	0	S.I.D.	S.I.D.	S.I.D.	41	41	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides															
2,4-D	96	10	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	96	1	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	96	2	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.

CV = Coefficient of variation

DL = Detection Limit

S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

a) Detection limits have changed throughout the monitoring process. Only data matching the current detection limit is displayed in this table. The *Data Included Since* field indicates the first year of the storm season with the current detection limit.

R0012039

Table 4-5b 1994-2000 Dry Weather Bacteria Counts for Mass Emission Sites

Class Constituent	DL	Units	Guidelines and Standards					Ballona Ck. (S01)					
			Ocean Plan[c]	Basin Plan[c]	AB 411	California Toxics Rule (freshwater)[b]	California Toxics Rule (saltwater)[b]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Indicator Bacteria													
Total Coliform	20	MPN/100ml	1000[a]	70	10,000 (Instantaneous)			9	0	100	44,156	24,000	1.16
Fecal Coliform	20	MPN/100ml	200[a]	200	400 (Instantaneous)			9	0	100	2,426	1,300	1.66
Fecal Streptococcus	20	MPN/100ml						9	0	100	4,518	700	2.53
Fecal Enterococcus	20	MPN/100ml	24[a]		104			8	0	100	2,581	280	2.27

Class Constituent	DL	Units	Guidelines and Standards					Malibu Ck. (S02)					
			Ocean Plan[c]	Basin Plan[c]	AB 411	California Toxics Rule (freshwater)[b]	California Toxics Rule (saltwater)[b]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Indicator Bacteria													
Total Coliform	20	MPN/100ml	1000[a]	70	10,000 (Instantaneous)			6	0	100	16,633	10,000	1.12
Fecal Coliform	20	MPN/100ml	200[a]	200	400 (Instantaneous)			6	0	100	265	100	1.56
Fecal Streptococcus	20	MPN/100ml						6	0	100	278	265	0.46
Fecal Enterococcus	20	MPN/100ml	24[a]		104			5	0	100	250	300	0.73

Class Constituent	DL	Units	Guidelines and Standards					LA River (S10)					
			Ocean Plan[c]	Basin Plan[c]	AB 411	California Toxics Rule (freshwater)[b]	California Toxics Rule (saltwater)[b]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Indicator Bacteria													
Total Coliform	20	MPN/100ml	1000[a]	70	10,000 (Instantaneous)			7	0	100	67,443	1,300	1.24
Fecal Coliform	20	MPN/100ml	200[a]	200	400 (Instantaneous)			7	1	86	24,296	400	2.47
Fecal Streptococcus	20	MPN/100ml						7	0	100	2,673	300	1.50
Fecal Enterococcus	20	MPN/100ml	24[a]		104			7	0	100	2,647	300	1.52

a) Criteria based on 30-day average

b) Criteria continuous concentration which equals the highest concentration of pollutant to which aquatic life can be exposed for an extended period time (4 days) without deleterious effects.

c) Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

R0012040

Table 4-5b 1994-2000 Dry Weather Bacteria Counts for Mass Emission Sites

Class Constituent	DL	Units	Guidelines and Standards					Coyote Ck. (S13)					
			Ocean Plan[c]	Basin Plan[c]	AB 411	California Toxics Rule (freshwater)[b]	California Toxics Rule (saltwater)[b]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Indicator Bacteria													
Total Coliform	20	MPN/100ml	1000[a]	70	10,000 (Instantaneous)			8	0	100	42,000	20,500	1.40
Fecal Coliform	20	MPN/100ml	200[a]	200	400 (Instantaneous)			8	0	100	5,850	3,350	0.92
Fecal Streptococcus	20	MPN/100ml						8	0	100	2,942	1,100	1.85
Fecal Enterococcus	20	MPN/100m	24[a]		104			8	0	100	758	1,000	0.72

Class Constituent	DL	Units	Guidelines and Standards					SG River (S14)					
			Ocean Plan[c]	Basin Plan[c]	AB 411	California Toxics Rule (freshwater)[b]	California Toxics Rule (saltwater)[b]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Indicator Bacteria													
Total Coliform	20	MPN/100ml	1000[a]	70	10,000 (Instantaneous)			8	0	100	10,275	9,000	0.81
Fecal Coliform	20	MPN/100ml	200[a]	200	400 (Instantaneous)			8	0	100	1,171	285	1.13
Fecal Streptococcus	20	MPN/100ml						8	0	100	486	400	0.69
Fecal Enterococcus	20	MPN/100ml	24[a]		104			7	0	100	384	170	1.27

a) Criteria based on 30-day average

b) Criteria continuous concentration which equals the highest concentration of pollutant to which aquatic life can be exposed for an extended period time (4 days) without deleterious effects.

c) Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

R0012041

Table 4-5c **Dry Weather Bacteria Counts for Low-Flow Diversion Projects**

Class Constituent	DL	Units	Guidelines and Standards			Alamitos Bay 12/31/97	Alamitos Bay 02/10/98	Herondo 05/28/98	Herondo 06/02/98	Pershing 05/28/98	Brooks 06/10/98	Brooks 06/19/98	Ashland 06/10/98	Ashland 06/11/98
			Ocean Plan[b]	Basin Plan[b]	AB 411									
Indicator Bacteria														
Total Coliform	20	MPN/100ml	1000[a]	70	10,000 (Instantaneous)	240,000	160,000	22,000	160,000	3,000,000	110,000	280,000	900,000	16,000,000
Fecal Coliform	20	MPN/100ml	200[a]	200	400 (Instantaneous)	90,000	14,000	230	2,800	30,000	300	2,200	900,000	90,000
Fecal Streptococcus	20	MPN/100ml				9,000	50,000	1,300	17,000	300,000	1,700	1,300	900,000	900,000
Fecal Enterococcus	20	MPN/100ml	24[a]		104	7,000	30,000	1,300	17,000	300,000	1,700	1,300	900,000	900,000

a) Criteria based on 30-day average

b) Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

R0012042

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

Ballona Creek

Class Constituent	DL	Units	1994-95						1995-96						1996-97						1997-98						1998-99						1999-2000					
			No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																																						
Cyanide	0.01	mg/l	6	6	0	BID	BID	BID	6	6	0	BID	BID	BID	6	5	17	BID	BID	BID	6	6	0	BID	BID	BID	13	13	0	BID	BID	BID	9	9	0	BID	BID	BID
MBAS	1	mg/l	6	2	67	36	28	87	6	0	100	38	38	05	6	3	50	27	13	11	6	5	17	BID	BID	BID	13	1	92	27	18	079	9	1	89	23	28	064
Oil and Grease	1	mg/l	5	2	60	22	22	08	6	0	100	30	28	05	6	3	50	25	13	10	4	5	17	BID	BID	BID	13	4	69	71	28	185	9	1	89	35	36	054
Total Phenols	01	mg/l	6	6	0	BID	BID	BID	6	6	0	BID	BID	BID	6	6	0	BID	BID	BID	6	6	0	BID	BID	BID	13	13	0	BID	BID	BID	6	6	0	BID	BID	BID
Indicator Bacteria																																						
Total Coliform	20	MPN/100ml	6	0	100	536,333	200,000	191	6	0	100	4,833,333	2,350,000	125	6	0	100	2,891,667	270,000	272	6	0	100	2,466,667	1,900,000	177	13	1	92	441,538	240,000	0.66	9	0	100	328,889	300,000	0.67
Fecal Coliform	20	MPN/100ml	6	0	100	208,500	160,000	0.64	6	0	100	3,301,667	850,000	180	6	0	100	73,000	57,500	0.64	6	0	100	2,100,333	700,000	2.04	13	1	92	83,293	30,000	1.26	9	0	100	137,556	130,000	0.78
Ratio Fecal Coliform/Total Coliform			6	6	BID	BID	BID	BID	0	0	BID	BID	BID	BID	0	0	BID	BID	BID	BID	0	0	BID	BID	BID	BID	0	0	BID	BID	BID	BID	6	6	BID	BID	BID	BID
Fecal Streptococcus	20	MPN/100ml	6	0	100	491,667	166,000	1.46	6	0	100	1,853,333	1,650,000	0.89	6	0	100	291,667	240,000	1.08	6	0	100	433,000	170,000	1.45	13	1	92	266,693	170,000	0.92	9	0	100	346,222	220,000	0.93
Fecal Enterococcus	20	MPN/100ml	6	0	100	366,263	93,000	1.74	6	0	100	1,203,333	1,360,000	0.49	1	0	100	BID	BID	BID	6	0	BID	BID	BID	BID	6	0	100	196,667	140,000	0.82	9	0	100	588,611	33,000	1.70
General Minerals																																						
Ammonia	0.1	mg/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	1	75	0.23	0.16	0.84	7	0	100	0.76	0.72	0.63	16	4	75	0.45	0.40	0.66	12	5	58	0.63	0.17	1.45
Calcium	1.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	10	11	0.07	8	0	100	31	18	1.08	16	0	100	32	26	0.55	12	0	100	26	16	0.66
Magnesium	1.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	2.0	2.3	0.57	5	0	100	12	8.1	1.20	16	0	100	10	8.1	0.64	12	0	100	7.8	4.9	1.05
Potassium	1.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	1.8	1.8	0.41	7	0	100	3.5	3.0	0.40	16	0	100	3.5	3.0	0.36	12	0	100	3.4	2.8	0.53
Sodium	1.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	5.4	5.4	0.27	7	0	100	18	12	1.06	16	0	100	23	16	0.73	12	0	100	21	13	0.84
Bicarbonate	2.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	27	26	0.14	6	0	100	88	36	1.17	16	0	100	66	53	0.81	12	0	100	80	60	0.94
Carbonate	2.0	mg/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	6	6	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Chloride	2.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	5.8	6.0	0.14	5	0	100	29	10	1.48	16	0	100	24	17	0.68	12	0	100	26	11	1.53
Fluoride	0.1	mg/l	0	0	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	4	0	BID	BID	BID	5	2	60	0.14	0.10	0.92	16	3	81	0.23	0.17	0.76	12	4	67	0.24	0.20	0.85
Nitrate	0.1	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	2.1	2.2	0.12	5	0	100	4	3	0.64	16	0	100	3.6	2.7	0.48	12	0	100	5.2	4.3	0.73
Sulfate	0.1	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	6.8	9.2	0.18	5	0	100	53	20	1.51	16	0	100	43	25	0.96	12	0	100	36	21	1.04
Alkalinity	4.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	27	26	0.14	6	0	100	89	36	1.17	16	0	100	68	53	0.81	12	0	100	87	49	0.93
Hardness	2.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	34	36	0.13	5	0	100	124	72	1.11	16	0	100	116	85	0.84	12	0	100	87	64	0.92
COD	5	mg/l	6	6	BID	BID	BID	BID	0	0	BID	BID	BID	BID	4	0	100	118	135	0.46	7	0	100	103	141	0.65	16	0	100	64	40	0.78	12	1	92	42	36	0.75
pH	0-14		0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	7.1	7.1	0.02	8	0	100	7.1	6.9	0.08	16	0	100	7.4	7.4	0.05	12	0	100	7.2	7.2	0.05
Specific Conductance	1.0	umhos/cm	6	0	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	113	114	0.13	5	0	100	357	200	1.17	16	0	100	346	274	0.83	12	0	100	342	210	1.06
Total Dissolved Solids	2.0	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	70	69	0.10	5	0	100	222	126	1.18	16	0	100	218	161	0.85	12	0	100	207	125	1.07
Turbidity	0.1	NTU	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	30	26	0.32	6	0	100	81	66	0.49	16	0	100	61	66	0.79	12	0	100	66	63	0.51
Total Suspended Solids	2.0	mg/l	0	0	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	108	90	0.45	6	0	100	266	241	0.57	16	0	100	201	147	1.05	12	0	100	170	125	0.80
Volatile Suspended Solids	1.0	mg/l/ml	0	0	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	42	36	0.34	6	0	100	76	61	0.67	16	0	100	62	60	0.64	12	0	100	46	37	0.86
MBAS	0.05	mg/l	6	6	BID	BID	BID	BID	0	0	BID	BID	BID	BID	4	4	0	BID	BID	BID	6	6	0	BID	BID	BID	16	3	81	0.12	0.10	0.64	12	2	83	0.11	0.07	1.18
Total Organic Carbon	1.0	mg/l	0	0	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	5.1	5.7	0.55	6	0	100	9	8	0.31	14	0	100	12	8	0.85	12	0	100	9.2	7.4	0.67
BOD	2.0	mg/l	6	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	29	29	0.41	6	0	100	20	17	0.52	14	1	93	46	24	1.04	12	1	92	12	8.4	1.09
Nutrients																																						
Dissolved Phosphorus	0.05	mg/l	6	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	0.17	0.17	0.07	6	0	100	0.31	0.31	0.64	15	0	100	0.24	0.21	0.36	12	1	92	0.27	0.25	0.43
Total Phosphorus	0.05	mg/l	6	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	0.42	0.42	0.22	6	0	100	0.34	0.32	0.53	15	0	100	0.35	0.26	0.72	12	0	100	0.36	0.31	0.56
NH3-N	0.1	mg/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	2	50	0.16	0.11	1.02	7	0	100	0.62	0.58	0.82	16	5	69	0.37	0.33	0.66	12	6	50	0.52	0.12	1.44
Nitrate-N	0.1	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	0.46	0.50	0.12	5	0	100	0.81	0.86	0.64	16	0	100	0.62	0.60	0.48	12	0	100	1.3	1.0	0.92
Nitrite-N	0.1	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	0.06	0.05	0.34	6	0	100	0.10	0.06	0.64	16	1	94	0.10	0.08	1.03	12	1	92	0.14	0.09	1.23
TKN	0.1	mg/l	0	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	1.7	1.7	0.28	6	0	100	2.4	2.4	0.54	16	0	100	4.5	3.7	0.80	12	0	100	2.8	1.4	1.07
Metals																																						
Dissolved Aluminum	100	ug/l	0	0	BID	BID	BID	BID	0	0	BID	BID	BID	BID	4	4	0	BID	BID	BID	7	1	86	1264	800	0.96	16	12	25	77	50	0.79	12	4	67	119	113	0.50
Total Aluminum	100	ug/l	0	0	BID	BID	BID	BID	0	0	BID	BID	BID	BID	4	4	0	BID	BID	BID	7	0	100	2333	2578	0.68	16	1	94	446	182	1.66	12	0	100	341	270	0.68
Dissolved Antimony	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	6	14	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Antimony	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	6	14	BID	BID	BID	16	16	0	BID	BID	BID	12	11	8	BID	BID	BID
Dissolved Arsenic	5	ug/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Arsenic	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	1	75	1.4	1.0	0.56	7	6	14	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Dissolved Barium	10	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	1	75	8.0	5.5	0.76	7	1	86	47	47	0.48	16	1	94	36	36	0.45	12	1	92	36	28	0.94
Total Barium	10	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	1	75	25	15	1.03	7	1	86	72	69	0.61	16	1	94	46	45	0.66	12	1	92	51	37	1.08
Dissolved Beryllium	1	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	8	8	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Beryllium	1	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Dissolved Boron	100	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	2	71	184	142	0.88	16	3	81	184	166	0.54	12	5	58	133	118	0.71
Total Boron	100	ug/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	1	86	237	229	0.61	16	1	94	245	244	0.45	12	3	75	176	188	0.58
Dissolved Cadmium	1	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	6	14	BID	BID	BID	16	15	6	BID	BID	BID	12	12	0	BID	BID	BID
Total Cadmium	1	ug/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	5	29	0.29	0.5	0.72	16	14	13	BID	BID	BID	12	12	0	BID	BID	BID
Dissolved Chromium	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	2	50	2.8	2.5	0.60	7	6	14	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Chromium	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	0	100	5.8	4.6	0.74	7	3	57	6.4	6.5	0.67	16	14	13	BID	BID	BID	12	10	17	BID	BID	BID
Dissolved Chromium +6	10	ug/l	6	6	BID	BID	BID	BID	0	0	BID	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Chromium +6	10	ug/l	6	6	BID	BID	BID	BID	0	6	BID	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Dissolved Copper	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	0	100	3.3	2.8	0.56	7	0	100	30	36	0.80	16	0	100	8.3	6.6	0.39	12	3	75	8.8	6.6	0.93
Total Copper	5	ug/l	6	6	BID	BID	BID	BID	1	0	100	BID	BID	BID	4	0	100	12	10	0.47	7	0	100	38	43	0.65	16	0	100	16	16	0.44	12	0	100	16	13	0.71
Dissolved Iron	100	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	2	50	118	100	0.71	7	2	71	1480	566	1.47	16	11	31	103	50	0.95	12	4	67	247	160	1.13
Total Iron	100	ug/l	6	6	BID	BID	BID	BID	1	0	100	404	413	0.12	7	0	100	7365	4600	0.79	16	1	94	587	313	1.33	12	0	100	433	520	0.93
Dissolved Lead	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	4	43	19	26	1.47	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Lead	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	0	100	6.6	6.5	0.65	7	2	71	36	9.0	1.10	16	11	31	6.5	2.5	1.80	12	6	33	4.9	2.5	0.89
Dissolved Manganese	100	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	4	43	85	50	0.54	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Manganese	100	ug/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	1	86	126	133	0.41	16	13	19	BID	BID	BID	12	11	8	BID	BID	BID
Dissolved Mercury	1	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	6	6	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Mercury	1	ug/l	6	6	BID	BID	BID	BID	0	0	BID	BID	BID	BID	4	3	75	0.0	0.00	1.95	6	6	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Dissolved Nickel	5	ug/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	3	25	2.8	2.5	0.26	7	4	43	11.3	2.5	1.72	16	14	13	BID	BID	BID	12	11	8	BID	BID	BID
Nickel	5	ug/l	0	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	0	100	4.0	4.0	0.65	7	2	71	6.6	6.0	0.46	16	7	56	6.6	5.7	0.63	12	6	50	5.7	4.3	0.67
Dissolved Selenium	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	16	0	BID	BID	BID	12	12	0	BID	BID	BID
Total Selenium	5	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	3	25	2.8	2.5	0.06	7	7	0	BID	BID	BID	16	14	13	BID	BID	BID	12	12	0	BID	BID	BID
Dissolved Silver	1	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	15	6	BID	BID	BID	12	12	0	BID	BID	BID
Total Silver	1	ug/l	6	6	BID	BID	BID	BID	1	1	0	BID	BID	BID	4	4	0	BID	BID	BID	7	7	0	BID	BID	BID	16	14	13	BID	BID	BID	12	12	0	BID	BID	BID

R0012043

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

Ballona Creek

Class Constituent	DL	Units	1994-95						1995-96						1996-97						1997-98						1998-99						1999-2000					
			No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Thallium	5	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	16	16	0	SID	SID	SID	12	12	0	SID	SID	SID
Total Thallium	5	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	16	16	0	SID	SID	SID	12	12	0	SID	SID	SID
Dissolved Zinc	50	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	2	50	46	34	861	7	4	43	156	25	1.06	16	9	44	50	25	883	12	11	8	SID	SID	SID
Total Zinc	50	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	0	100	80	81	821	7	0	100	342	347	0.81	16	2	88	96	83	882	12	4	67	73	54	1.10
SVOCs																																						
Bis(2-ethylhexyl)phthalate	1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	1	75	7	58	1.00	6	1	83	12	12	0.85	4	1	75	11	7.2	1.56	1	1	0	SID	SID	SID
PAHs																																						
Acenaphthene	0.05	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Acenaphthylene	0.05	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Anthracene	0.05	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(a)anthracene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(a)pyrene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(b)fluoranthene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(k)fluoranthene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Chrysene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Dibenz(a,h)anthracene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Fluoranthene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Fluorene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Indeno(1,2,3-cd)pyrene	0.1	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Naphthalene	0.05	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Phenanthrene	0.05	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Pyrene	0.05	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
All other SVOCs	0.05-5.0	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Pesticides																																						
Organochlorine Pesticides & PCBs	0.05-1.0	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	2	2	0	SID	SID	SID	7	7	0	SID	SID	SID	3	3	0	SID	SID	SID	0	0	SID	SID	SID	SID
Carbofuran	5	ug/l	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	3	3	0	SID	SID	SID	7	7	0	SID	SID	SID	16	16	0	SID	SID	SID	12	12	0	SID	SID	SID
Glyphosate	25	ug/l	8	8	SID	SID	SID	SID	8	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	16	16	0	SID	SID	SID	12	12	0	SID	SID	SID
Organo-Phosphate Pesticides																																						
Diazinon	0.01	ug/l	8	8	SID	SID	SID	SID	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	15	9	40	0.005	0.005	1.64	12	11	8	SID	SID	SID
Chlorpyrifos	0.05	ug/l	8	8	SID	SID	SID	SID	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	15	15	0	SID	SID	SID	12	12	0	SID	SID	SID
N- and P-Containing Pesticides																																						
Thiobencarb	1	ug/l	8	8	SID	SID	SID	SID	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	15	13	13	SID	SID	SID	12	12	8	SID	SID	SID
All other N- and P- Pesticides	1.0-2.0	ug/l	8	8	SID	SID	SID	SID	1	1	0	SID	SID	SID	4	4	0	SID	SID	SID	7	7	0	SID	SID	SID	15	15	0	SID	SID	SID	12	12	0	SID	SID	SID
Phenoxyacetic Acid Herbicides																																						
2,4-D	10	ug/l	8	8	SID	SID	SID	SID	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	0	0	SID	SID	SID	SID
2,4,5-TP	1	ug/l	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	0	0	SID	SID	SID	SID
Bentazon	2	ug/l	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	4	4	0	SID	SID	SID	6	6	0	SID	SID	SID	4	4	0	SID	SID	SID	0	0	SID	SID	SID	SID

CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data, not enough data above detection limit collected
See Table 4-3 for water quality objectives

R0012044

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

Malibu Creek

Class Constituent	DL	Units	1994-95 No. of Samples	1994-95 No. of Non-detects	1994-95 Percent Detects	1994-95 Mean	1994-95 Median	1994-95 CV	1995-96 No. of Samples	1995-96 No. of Non-detects	1995-96 Percent Detects	1995-96 Mean	1995-96 Median	1995-96 CV	1996-97 No. of Samples	1996-97 No. of Non-detects	1996-97 Percent Detects	1996-97 Mean	1996-97 Median	1996-97 CV	1997-98 No. of Samples	1997-98 No. of Non-detects	1997-98 Percent Detects	1997-98 Mean	1997-98 Median	1997-98 CV	1998-99 No. of Samples	1998-99 No. of Non-detects	1998-99 Percent Detects	1998-99 Mean	1998-99 Median	1998-99 CV	1999-2000 No. of Samples	1999-2000 No. of Non-detects	1999-2000 Percent Detects	1999-2000 Mean	1999-2000 Median	1999-2000 CV
Miscellaneous Constituents																																						
Cyanide	0.01	mg/L	3	3	0	ND	ND	ND	5	5	0	ND	ND	ND	3	3	0	ND	ND	ND	6	6	25	0.008	0.008	0.867	12	12	0	ND	ND	ND	9	9	0	ND	ND	ND
TPH	1	mg/L	3	3	0	ND	ND	ND	5	5	0	ND	ND	ND	3	3	0	ND	ND	ND	8	8	0	ND	ND	ND	12	11	8	ND	ND	ND	9	9	0	ND	ND	ND
Oil and Grease	1	mg/L	1	1	0	ND	ND	ND	5	5	0	ND	ND	ND	3	3	0	ND	ND	ND	8	8	38	2.8	0.50	2.39	12	9	25	1.0	0.50	1.21	9	8	11	ND	ND	ND
Total Phenols	0.1	mg/L	3	3	0	ND	ND	ND	5	4	20	0.44	0.05	1.58	3	3	0	ND	ND	ND	8	7	13	ND	ND	ND	12	12	0	ND	ND	ND	9	9	0	ND	ND	ND
Indicator Bacteria																																						
Total Coliform	20	MPN/100ml	3	0	100	213,330	240,000	0.27	5	0	100	406,800	170,000	1.65	3	0	100	200,733	300,000	0.86	8	0	100	2,164,250	170,000	2.56	12	1	92	474,674	26,000	3.01	9	0	100	100,922	80,000	1.10
Fecal Coliform	20	MPN/100ml	3	0	100	167,330	240,000	0.75	5	0	100	166,700	11,000	2.11	3	0	100	22,600	17,000	1.11	8	0	100	2,644,100	33,500	2.78	12	1	92	34,982	6,000	2.45	9	0	100	40,967	8,000	1.56
Ratio Fecal Coliform/Total Coliform			0	0	ND	ND	ND	ND	5	5	ND	ND	ND	ND	1	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	1	0	100	ND	ND	ND	3	0	100	84%	44%	0.76
Fecal Streptococcus	20	MPN/100ml	3	0	100	34,333	50,000	0.79	5	0	100	60,140	16,000	1.68	3	0	100	163,000	240,000	0.92	6	0	100	791,615	166,000	2.25	12	1	92	156,410	8,500	2.86	9	0	100	175,288	60,000	1.64
Fecal Enterococcus	20	MPN/100ml	3	0	100	28,800	30,000	0.27	5	0	100	14,200	16,000	0.98	1	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	6	0	100	9,588	1,150	2.67	9	0	100	137,366	5,000	2.18
General Minerals																																						
Ammonia	0.1	mg/L	6	6	ND	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	100	0.29	0.28	0.41	9	4	56	0.18	0.11	0.89	6	6	25	0.08	0.05	0.80
Calcium	1.0	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	2	0	100	78	80	0.26	10	0	100	132	133	0.14	8	0	100	115	106	0.37
Magnesium	1.0	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	6	100	42	44	0.28	10	0	100	73	77	0.26	8	0	100	85	56	0.54
Potassium	1.0	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	4.8	4.5	0.34	10	0	100	5.4	5.1	0.27	10	0	100	6.3	6.1	0.33
Sodium	1.0	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	86	76	0.48	10	0	100	108	104	0.18	10	0	100	100	80	0.45
Bicarbonate	2.0	mg/L	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	144	151	0.27	10	0	100	178	176	0.23	9	0	100	188	175	0.30
Carbonate	2.0	mg/L	6	6	ND	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	0	ND	ND	ND	10	8	20	3.6	1.0	1.57	9	9	0	ND	ND	ND
Chloride	2.0	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	6	100	73	79	0.36	10	1	90	102	113	0.46	10	0	100	88	72	0.40
Fluoride	0.1	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	1	86	0.15	0.17	0.26	10	1	90	0.24	0.26	0.31	10	0	100	0.26	0.25	0.14
Nitrate	0.1	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	2.6	6.4	0.55	10	1	90	15	9.6	0.83	10	0	100	14	13	0.56
Sulfate	0.1	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	294	285	0.29	10	1	90	331	405	0.66	10	0	100	410	342	0.42
Alkalinity	4.0	mg/L	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	100	144	151	0.27	10	0	100	178	172	0.23	9	0	100	182	143	0.36
Hardness	2.0	mg/L	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	362	380	0.27	10	0	100	567	650	0.37	8	0	100	536	488	0.50
COD	5	mg/L	6	6	ND	ND	ND	ND	1	1	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	0	100	111	79	0.84	10	2	80	46	51	0.66	10	0	100	89	69	0.96
pH	0.10		6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	7.8	7.8	0.04	10	0	100	8.2	8.3	0.03	9	0	100	7.9	7.7	0.04
Specific Conductance	1.0	umhos/cm	6	6	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	1084	1156	0.26	10	0	100	1803	1743	0.23	9	0	100	1588	1350	0.41
Total Dissolved Solids	2.0	mg/L	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	672	696	0.30	10	0	100	1157	1180	0.20	9	0	100	974	832	0.39
Turbidity	0.1	NTU	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	3.9	1.63	1.50	8	0	100	8.0	2.3	1.53	9	0	100	1.55	7.4	1.37
Total Suspended Solids	2.0	mg/L	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	604	394	1.21	10	0	100	106	26	1.48	9	0	100	244	182	1.08
Volatile Suspended Solids	1.0	mg/L	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	7	0	100	87	57	1.11	10	1	90	20	9	1.16	9	0	100	30	26	0.56
MBAS	0.05	mg/L	6	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	6	6	ND	ND	ND	ND	6	6	0	ND	ND	ND	8	7	22	0.15	0.03	2.00	7	7	0	ND	ND	ND
Total Organic Carbon	1.0	mg/L	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	6	6	100	15	11	0.73	10	0	100	11	6.3	1.31	10	0	100	7.5	7.8	0.18
BOD	2.0	mg/L	6	6	0.18	0.18	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	6	6	100	1.8	1.9	0.36	10	0	100	7.1	5.7	0.55	10	2	80	3.4	3.5	0.53
Nutrients																																						
Dissolved Phosphorus	0.05	mg/L	6	6	0.18	0.18	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	6	0	100	0.57	0.61	0.54	8	1	88	0.45	0.43	0.52	7	0	100	0.50	0.48	0.25
Total Phosphorus	0.05	mg/L	6	6	0.18	0.18	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	6	0	100	0.71	0.60	0.54	8	1	88	0.48	0.48	0.51	7	0	100	0.56	0.54	0.28
NH3-H	0.1	mg/L	6	6	0.18	0.18	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	0	100	0.24	0.23	0.42	9	5	44	0.14	0.05	0.80	8	6	25	0.08	0.05	0.89
Nitrate-N	0.1	mg/L	6	6	0.18	0.18	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	6	0	100	1.9	1.7	0.54	10	1	90	3.3	2.2	0.82	10	0	100	3.3	3.0	0.56
Nitrite-N	0.1	mg/L	6	6	0.18	0.18	ND	ND	2	1	50	ND	ND	ND	6	6	ND	ND	ND	ND	7	6	14	ND	ND	ND	10	10	0	ND	ND	ND	10	9	10	ND	ND	ND
TKN	0.1	mg/L	6	6	0.18	0.18	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	9	8	100	2.4	2.2	0.43	10	1	90	2.0	1.6	0.64	9	0	100	1.3	1.4	0.36
Metals																																						
Dissolved Aluminum	100	ug/L	6	6	ND	ND	ND	ND	0	0	ND	ND	ND	ND	6	6	ND	ND	ND	ND	9	2	78	1660	404	1.60	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Aluminum	100	ug/L	6	6	ND	ND	ND	ND	0	0	ND	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	5778	3660	1.55	10	1	90	292	144	0.98	10	3	70	186	152	0.84
Dissolved Antimony	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Antimony	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Arsenic	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Arsenic	5	ug/L	1	0	100	ND	ND	ND	2	1	50	ND	ND	ND	6	6	ND	ND	ND	ND	8	7	22	5.8	2.5	1.67	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Barium	10	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	1	88	38	43	0.45	10	0	100	48	46	0.35	10	1	90	46	42	0.49
Total Barium	10	ug/L	1	1	0	ND	ND	ND	2	1	50	ND	ND	ND	6	6	ND	ND	ND	ND	8	1	88	120	61	1.82	10	0	100	57	57	0.40	10	0	100	56	48	0.52
Dissolved Beryllium	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Beryllium	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Boron	100	ug/L	0	0	ND	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Boron	100	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	0	100	325	360	0.33	10	0	100	425	404	0.21	10	0	100	302	344	0.46
Dissolved Cadmium	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	0	100	417	360	0.36	10	0	100	496	472	0.23	10	0	100	366	367	0.50
Total Cadmium	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	5	44	1.1	0.50	0.73	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Chromium	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	4	56	2.2	1.4	1.43	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Chromium	5	ug/L	1	0	100	ND	ND	ND	2	1	50	ND	ND	ND	6	6	ND	ND	ND	ND	9	7	22	6.7	2.5	1.44	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Chromium +6	10	ug/L	0	0	ND	ND	ND	ND	6	0	ND	ND	ND	ND	6	6	ND	ND	ND	ND	9	2	78	3.0	1.4	1.34	10	6	20	3.0	2.5	0.38	10	10	0	ND	ND	ND
Total Chromium +6	10	ug/L	0	0	ND	ND	ND	ND	6	0	ND	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Copper	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Copper	5	ug/L	1	0	100	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	9	4	56	9.1	5.0	0.96	10	9	10	ND	ND	ND	10	8	20	3.4	2.5	0.56
Dissolved Iron	100	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	0	100	37	20	1.45	10	0	100	64	76	0.34	10	1	90	71	70	0.33
Total Iron	100	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	4	56	1972	410	1.27	10	7	30	64	50	0.77	10	7	30	161	50	1.68
Dissolved Lead	5	ug/L	1	1	0	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	100	23,161	14,500	1.48	10	4	60	410	154	1.36	10	2	80	351	235	1.03
Total Lead	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	8	11	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Manganese	100	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	5	44	24	2.5	2.44	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Manganese	100	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	8	33	180	50	1.12	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Mercury	1	ug/L	1	1	0	ND	ND	ND	2	0	100	ND	ND	ND	6	6	ND	ND	ND	ND	9	2	78	452	448	1.04	10	6	40	140	50	0.91	10	9	10	ND	ND	ND
Total Mercury	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	8	8	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Nickel	5	ug/L	1	1	0	ND	ND	ND	2	1	50	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Nickel	5	ug/L	1	0	100	ND	ND	ND	2	1	50	ND	ND	ND	6	6	ND	ND	ND	ND	9	5	44	11	2.5	1.45	10	8	20	3.4	2.5	0.56	10	8	20	3.3	2.5	0.54
Dissolved Selenium	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Selenium	5	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	8	0	ND	ND	ND	10	9	10	ND	ND	ND	10	10	0	ND	ND	ND
Dissolved Silver	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND
Total Silver	1	ug/L	1	1	0	ND	ND	ND	2	2	0	ND	ND	ND	6	6	ND	ND	ND	ND	9	9	0	ND	ND	ND	10	10	0	ND	ND	ND	10	10	0	ND	ND	ND

R0012045

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

Malibu Creek

Class Constituent	DL	Units	1994-95						1995-96						1996-97						1997-98						1998-99						1999-2000					
			No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Thallium	5	µg/l	1	1	0	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	9	9	0	SID	SID	SID	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Thallium	5	µg/l	1	1	0	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	9	9	0	SID	SID	SID	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Zinc	20	µg/l	1	1	0	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	9	6	33	46	25	073	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Zinc	20	µg/l	1	1	0	SID	SID	SID	2	1	50	SID	SID	SID	8	8	SID	SID	SID	SID	9	2	78	114	73	093	10	9	10	SID	SID	SID	10	10	0	SID	SID	SID
SVOCs																																						
Bis(2-ethylhexyl)phthalate	1	µg/l	9	8	SID	SID	SID	SID	2	1	50	SID	SID	SID	8	0	SID	SID	SID	SID	8	1	88	22	128	104	9	5	44	26	05	217	8	3	63	48	23	138
PAHs																																						
Acenaphthene	005	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	7	13	SID	SID	SID
Acenaphthylene	005	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	7	13	SID	SID	SID
Anthracene	005	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Benz(a)anthracene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Benzo(a)pyrene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Benzo(b)fluoranthene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	7	13	SID	SID	SID
Benzo(k)fluoranthene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Chrysene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	7	13	SID	SID	SID
Dibenzo(a,h)anthracene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Fluoranthene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	5	38	0078	0050	050
Fluorene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Indeno (1,2,3-cd)pyrene	01	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Naphthalene	005	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	7	13	SID	SID	SID
Phenanthrene	005	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	25	0043	0025	085
Pyrene	005	µg/l	9	8	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	4	50	0151	0058	150
All other SVOCs	005-50	µg/l	9	9	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	9	9	0	SID	SID	SID	8	8	0	SID	SID	SID
Pesticides																																						
Organochlorine Pesticides & PCBs	005-10	µg/l	9	9	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID	10	10	0	SID	SID	SID
Carbofuran	5	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID	10	10	0	SID	SID	SID
Glyphosate	25	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID	10	10	0	SID	SID	SID
Organo-Phosphate Pesticides																																						
Diazinon	001	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	10	9	10	SID	SID	SID	10	9	10	SID	SID	SID
Chlorpyrifos	005	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
N- and P-Containing Pesticides																																						
Diuron	1	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
All other N- and P- Pesticides	1-0.2	µg/l	9	9	SID	SID	SID	SID	2	2	0	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Pharmaceutic Acid Herbicides																																						
2,4-D	10	µg/l	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID
2,4,5-TP	1	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID
Bentazon	2	µg/l	9	9	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	SID	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID

CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data, not enough data above detection limit collected
See Table 4-3 for water quality objectives

R0012046

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

			L.A. River																									
			1995-96						1996-97						1997-98						1998-99						1999-2000			
Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																														
Cyanide	0.01	mg/l	5	5	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	8	7	13	BLD	BLD	BLD	5	4	20	0.010	0.005	1.161	9	8	0	BLD	BLD	BLD
TPH	1	mg/l	5	0	100	4.9	5.4	0.36	4	2	50	2.9	2.2	1.00	8	1	88	1.5	1.2	0.74	5	1	80	1.3	1.0	0.75	9	1	89	2.5	2.0	0.41
Oil and Grease	1	mg/l	5	0	100	4.9	5.4	0.36	4	2	50	2.5	1.8	1.08	8	5	38	1.4	0.50	1.82	5	1	80	1.8	1.2	1.02	9	1	89	2.4	2.1	0.52
Total Phenols	0.1	mg/l	5	5	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	8	8	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD
Indicator Bacteria																														
Total Coliform	20	MPN/100ml	5	1	80	6,000,000	2,400,000	1.29	4	0	100	826,000	765,000	0.92	8	0	100	3,081,250	1,250,000	1.74	5	0	100	260,400	240,000	0.66	9	0	100	1,808,889	300,000	1.79
Fecal Coliform	20	MPN/100ml	5	0	100	3,880,000	1,400,000	1.77	4	0	100	102,250	80,900	1.07	8	0	100	2,751,125	270,000	1.99	5	0	100	110,540	17,000	1.97	9	0	100	392,972	240,000	1.34
Ratio Fecal Coliform/Total Coliform			0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Fecal Streptococcus	20	MPN/100ml	5	1	80	3,980,000	1,700,000	1.14	4	0	100	272,500	270,000	0.66	8	0	100	930,000	370,000	1.03	5	0	100	94,800	36,000	1.06	9	0	100	242,600	280,000	0.80
Fecal Enterococcus	20	MPN/100ml	5	1	80	1,220,000	1,600,000	0.60	1	0	100	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	5	0	100	51,600	35,000	1.19	9	0	100	71,240	17,000	1.23
General Minerals																														
Ammonia	0.1	mg/l	4	2	50	0.85	0.51	1.12	4	3	25	0.58	0.05	1.82	10	0	100	1.1	0.88	0.73	5	3	40	0.23	0.05	1.33	10	4	80	0.18	0.11	1.42
Calcium	1.0	mg/l	4	0	100	20	17	0.28	4	0	100	15	14	0.40	7	0	100	17	12	0.82	5	0	100	46	32	0.54	10	0	100	18	15	0.53
Magnesium	1.0	mg/l	4	0	100	3.8	4.2	0.48	4	0	100	3.2	2.8	0.68	7	0	100	3.5	2.9	0.44	5	0	100	14	9.7	0.71	10	0	100	4.4	4.2	0.58
Potassium	1.0	mg/l	4	0	100	3.8	3.6	0.56	4	0	100	3.8	3.4	0.73	10	0	100	3.8	2.6	0.52	5	0	100	4.4	4.1	0.30	10	0	100	3.2	2.4	0.56
Sodium	1.0	mg/l	4	0	100	14	12	0.69	4	0	100	11	9.1	0.61	10	0	100	11	10	0.45	5	0	100	34	31	0.58	10	0	100	15	10	0.81
Bicarbonate	2.0	mg/l	4	0	100	43	40	0.39	4	0	100	32	34	0.21	7	0	100	30	26	0.38	5	0	100	73	53	0.50	10	0	100	48	44	0.50
Carbonate	2.0	mg/l	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	7	7	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Chloride	2.0	mg/l	4	0	100	14	11	0.70	4	0	100	11	8.3	0.70	8	0	100	9	6	0.71	5	0	100	36	21	0.79	10	0	100	14	8.4	0.88
Fluoride	0.1	mg/l	4	0	100	0.23	0.22	0.27	4	2	50	0.11	0.08	0.67	8	0	100	0.10	0.05	0.91	5	0	100	0.21	0.15	0.50	10	5	50	0.17	0.08	0.67
Nitrate	0.1	mg/l	4	0	100	1.2	1.1	0.42	4	0	100	5.5	3.2	1.02	8	0	100	3.0	2.4	0.46	5	1	80	2.4	2.6	0.86	10	0	100	3.5	2.7	0.54
Sulfate	0.1	mg/l	4	0	100	2.0	2.6	0.56	4	0	100	1.8	1.4	0.86	8	0	100	1.7	1.2	0.55	5	0	100	6.4	5.7	0.67	10	0	100	2.3	1.5	0.74
Alkalinity	4.0	mg/l	4	0	100	43	40	0.29	4	0	100	32	34	0.21	7	0	100	30	28	0.38	5	0	100	73	53	0.50	10	0	100	48	44	0.50
Hardness	2.0	mg/l	4	0	100	66	60	0.27	4	0	100	52	43	0.44	7	0	100	51	42	0.75	5	0	100	113	110	0.58	10	0	100	63	52	0.52
COD	5	mg/l	4	3	25	19	3	1.74	4	0	100	108	108	0.31	10	0	100	175	126	0.83	5	0	100	56	43	0.42	10	2	80	36	34	0.71
pH	0-14		4	0	100	7.3	7.3	0.03	4	0	100	7.0	7.0	0.03	7	0	100	6.8	6.8	0.02	5	0	100	7.4	7.3	0.04	10	0	100	6.9	6.8	0.04
Specific Conductance	1.0	umhos/cm	4	0	100	248	191	0.35	4	0	100	173	143	0.44	7	0	100	154	118	0.57	5	0	100	429	351	0.54	10	0	100	202	155	0.58
Total Dissolved Solids	2.0	mg/l	4	0	100	144	131	0.29	4	0	100	121	103	0.48	7	0	100	95	74	0.80	5	0	100	278	218	0.57	10	0	100	131	86	0.58
Turbidity	0.1	NTU	4	0	100	505	198	0.60	4	0	100	34	25	1.01	7	0	100	160	144	0.89	5	0	100	107	54	1.08	10	0	100	139	124	0.42
Total Suspended Solids	3.0	mg/l	4	0	100	488	458	0.27	4	0	100	266	282	0.42	7	0	100	650	408	0.67	5	0	100	230	181	0.58	10	0	100	333	249	0.54
Volatile Suspended Solids	1.0	mg/l(fix)	4	0	100	58	58	0.20	4	0	100	88	58	0.57	7	0	100	81	75	0.66	5	0	100	44	47	0.44	10	0	100	81	56	0.55
MBAS	0.05	mg/l	0	0	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	4	20	0.04	0.03	0.87	10	1	90	0.07	0.08	0.33
Total Organic Carbon	1.0	mg/l	4	0	100	12	11	0.55	4	0	100	30	18	0.78	10	0	100	9.5	10	0.64	5	0	100	7.5	6.4	0.30	10	0	100	8.9	8.8	0.46
BOD	2.0	mg/l	3	0	100	37	38	0.37	4	0	100	45	42	0.30	7	0	100	23	25	0.56	5	0	100	43	26	0.86	10	0	100	9.2	7.5	0.53
Nutrients																														
Dissolved Phosphorus	0.05	mg/l	4	0	100	0.29	0.26	0.63	4	0	100	0.30	0.24	0.79	10	0	100	0.66	0.66	0.64	5	0	100	0.36	0.27	0.58	10	1	90	0.30	0.32	0.50
Total Phosphorus	0.05	mg/l	4	0	100	0.34	0.37	0.57	4	0	100	1.0	1.0	0.42	10	0	100	0.85	0.78	0.78	5	0	100	0.46	0.43	0.47	10	0	100	0.41	0.41	0.42
NH3-N	0.1	mg/l	4	2	50	0.54	0.43	1.10	4	3	25	0.47	0.05	1.78	10	0	100	0.81	0.73	0.71	5	3	40	0.18	0.05	1.27	10	7	30	0.14	0.05	1.54
Nitrate-N	0.1	mg/l	4	0	100	2.7	2.5	0.42	4	0	100	1.2	0.71	1.02	8	1	88	0.88	0.56	0.57	5	2	60	0.55	0.60	0.83	10	0	100	0.78	0.61	0.54
Nitrite-N	0.1	mg/l	4	1	75	0.14	0.06	1.02	4	0	100	0.10	0.10	0.32	8	0	100	0.11	0.07	1.05	5	1	80	0.30	0.18	1.25	10	1	90	0.13	0.10	0.64
TKN	0.1	mg/l	4	0	100	2.2	2.2	0.57	4	0	100	4.1	3.3	0.79	10	0	100	4.4	3.2	0.83	5	0	100	3.2	3.1	0.34	10	0	100	2.4	2.1	0.59
Metals																														
Dissolved Aluminum	100	ppb	5	5	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	1	90	2958	1775	0.82	5	4	20	74	50	0.72	10	1	90	339	212	1.08
Total Aluminum	100	ppb	0	0	BLD	BLD	BLD	BLD	4	3	25	1993	50	1.85	10	0	100	11,004	7176	1.62	5	0	100	1463	202	1.96	10	0	100	503	381	0.86
Dissolved Antimony	5	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	9	10	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Antimony	5	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	9	10	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Dissolved Arsenic	5	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	9	10	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Arsenic	5	ppb	4	4	0	BLD	BLD	BLD	4	3	25	2.1	2.5	0.35	10	6	40	5.7	2.5	0.80	5	4	20	3.7	2.5	0.72	10	10	0	BLD	BLD	BLD
Dissolved Barium	10	ppb	4	4	0	BLD	BLD	BLD	4	2	50	7.8	6.5	0.49	10	2	80	58	56	0.85	5	0	100	48	27	0.45	10	1	90	27	27	0.43
Total Barium	10	ppb	4	4	0	BLD	BLD	BLD	4	1	75	58	24	1.45	10	2	80	164	126	1.21	5	0	100	84	49	0.84	10	0	100	34	30	0.36
Dissolved Beryllium	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Beryllium	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Dissolved Boron	100	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	0	100	164	164	0.26	5	1	80	236	231	0.56	10	5	50	90	79	0.50
Total Boron	100	ppb	4	4	0	BLD	BLD	BLD	4	2	25	88	50	0.95	10	0	100	271	261	0.30	5	1	80	291	278	0.57	10	5	50	176	86	0.75
Dissolved Cadmium	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	4	60	3.3	2.5	1.15	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Cadmium	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	3	70	3.8	3.1	1.04	5	3	40	1.0	0.50	0.73	10	10	0	BLD	BLD	BLD
Dissolved Chromium	5	ppb	4	4	0	BLD	BLD	BLD	4	3	25	2.4	2.5	0.11	10	6	40	6.9	2.6	1.67	5	5	0	BLD	BLD	BLD	10	9	10	BLD	BLD	BLD
Total Chromium	5	ppb	4	2	50	37.0	25.5	1.18	4	1	75	16	4.5	1.27	10	1	90	31	23	1.18	5	4	20	8.4	2.5	1.57	10	9	10	BLD	BLD	BLD
Dissolved Chromium +6	10	ppb	0	0	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Chromium +6	10	ppb	0	0	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Dissolved Copper	5	ppb	4	3	25	10	2.5	1.51	4	3	25	4.8	2.5	0.92	10	0	100	88	44	1.30	5	1	80	8.0	7.4	0.48	10	5	50	6.8	4.2	0.71
Total Copper	5	ppb	4	0	100	49	36	0.71	4	0	100	44	19	1.21	10	0	100	100	62	1.44	5	0	100	26	10	1.37	10	0	100	13.5	12	0.31
Dissolved Iron	100	ppb	4	0	100	193	145	0.64	4	2	50	156	145	0.78	10	0	100	4330	1540	1.25	5	2	60	654	108	1.83	10	3	70	151	175	0.76
Total Iron	100	ppb	4	0	100	3713	1375	1.44	4	0	100	2700	886	1.58	10	0	100	10,142	11,600	1.08	5	1	80	2164	361	1.96	10	2	80	443	275	0.76
Dissolved Lead	5	ppb	4	2	50	6.0	5.3	1.73	4	3	25	2.8	2.8	0.10	10	3	70	7.0	4.5	1.26	5	5	0	BLD	BLD	BLD	10	8	20	3.2	2.5	0.46
Total Lead	5	ppb	4	1	75	8.2	3.8	1.37	4	0	100	46	19	1.39	10	0	100	28.6	9.43	1.50	5	4	20	6.3	2.5	1.56	10	1	90	6.1	6.8	0.64
Dissolved Manganese	100	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	4	60	23.2	17.5	0.96	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Manganese	100	ppb	4	0	100	87	73	0.81	4	2	50	141	50	1.52	10	0	100	356	237	0.92	5	3	40	155	50	1.79	10	8	10	BLD	BLD	BLD
Dissolved Mercury	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Mercury	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	9	10	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Dissolved Nickel	5	ppb	4	3	25	4.8	2.5	0.92	4	3	25	2.1	2.5	0.35	10	3	70	11	11	1.05	5	4	20	3.0	2.5	0.38	10	7	30	4.5	2.5	0.81
Nickel	5	ppb	4	1	75	22.1	21.5	0.78	4	1	75	13	4.5	1.40	10	1	90	27	15	1.08	5	4	20	6.8	2.5	1.30	10	5	50	6.0	4.1	0.82
Dissolved Selenium	5	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Selenium	5	ppb	4	3	25	3.4	2.5	0.52	4	3	25	2.4	2.5	0.13	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Dissolved Silver	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Silver	1	ppb	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	7	30	0.81	0.50	1.02	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD

R0012047

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

			L.A. River																									
			1995-96						1996-97						1997-98						1998-99						1999-2000					
Class Constituent	DL	Units	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Thallium	5	µg/L	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Total Thallium	5	µg/L	4	4	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Dissolved Zinc	20	µg/L	4	2	50	56	53	0.67	4	2	50	40	36	0.64	10	3	70	417	224	1.44	5	3	40	43	25	0.98	10	10	0	BLD	BLD	BLD
Total Zinc	20	µg/L	4	1	75	141	108	0.82	4	0	100	208	83	1.24	10	0	100	573	323	1.28	5	2	60	126	51	1.41	10	5	50	44	42	0.47
SVOCs																																
Bis(2-ethylhexyl)phthalate	1	µg/L	5	0	100	17	15	0.32	4	2	50	17	1.9	1.41	9	0	100	17	20	0.83	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
PAHs																																
Acenaphthene	0.05	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Acenaphthylene	0.05	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Anthracene	0.05	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Benzo(a)anthracene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Benzo(a)pyrene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	8	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Benzo(b)fluoranthene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Benzo(k)fluoranthene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Chrysene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Dibenz(a,h)anthracene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Fluoranthene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Fluorene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Indeno (1,2,3-cd)pyrene	0.1	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Naphthalene	0.05	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Phenanthrene	0.05	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Pyrene	0.05	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
All other SVOCs	0.05-5.0	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Pesticides																																
Organochlorine Pesticides & PCBs	0.05-1.0	µg/L	3	3	0	BLD	BLD	BLD	3	3	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Carbofuran	5	µg/L	8	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Glyphosate	25	µg/L	8	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	5	4	20	13	13	0.84	10	10	0	BLD	BLD	BLD
Organo-Phosphate Pesticides																																
Diazinon	0.01	µg/L	0	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	8	11	BLD	BLD	BLD	5	4	20	0.014	0.005	2.15	10	10	0	BLD	BLD	BLD
Chlorpyrifos	0.05	µg/L	0	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
N- and P-Containing Pesticides																																
Thiobencarb	1	µg/L	8	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
All other N- and P- Pesticides	1.0-2.0	µg/L	3	3	0	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	9	9	0	BLD	BLD	BLD	5	5	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD
Pharmaceuticals And Herbicides																																
2,4-D	10	µg/L	8	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
2,4,5-TP	1	µg/L	8	8	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD
Bentazon	2	µg/L	8	0	BLD	BLD	BLD	BLD	4	4	0	BLD	BLD	BLD	10	10	0	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD	0	0	BLD	BLD	BLD	BLD

CV = Coefficient of variation
DL = Detection Limit
BLD = Blank/erroneously low/old Data, not enough data above detection limit collected
See Table 4-3 for water quality objectives

R0012048

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

			Coyote Creek																									
			1994-95						1995-96						1996-97						1997-98						1998-99					
Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																														
Cyanide	0.01	mg/l	4	4	0	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	1	50	ND	ND	ND
TPH	1	mg/l	5	1	80	2.6	2.1	0.67	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	1	50	ND	ND	ND
Oil and Grease	1	mg/l	5	1	80	2.6	2.1	0.67	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	1	50	ND	ND	ND
Total Phenols	0.1	mg/l	4	4	0	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	2	0	ND	ND	ND
Indicator Bacteria																														
Total Coliform	20	MPN/100ml	5	1	80	8,338,002	5,600,000	1.62	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND
Fecal Coliform	20	MPN/100ml	5	0	100	4,044,808	1,600,000	1.66	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND
Ratio Fecal Coliform/Total Coliform			0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND
Fecal Streptococcus	20	MPN/100ml	5	1	80	634,002	300,000	1.09	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	2	0	100	ND	ND	ND
Fecal Enterococcus	20	MPN/100ml	5	1	80	476,002	240,000	1.48	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	0	0	ND	ND	ND	ND	1	0	100	ND	ND	ND
General Minerals																														
Ammonia	0.1	mg/l	5	2	60	0.60	0.05	1.02	4	0	100	0.52	0.43	0.83	10	0	100	1.0	0.56	1.24	13	5	62	0.75	0.28	1.37	12	4	67	1.0	0.79	1.60
Calcium	1.0	mg/l	5	0	100	35	35	0.14	4	0	100	23	20	0.45	10	0	100	33	34	0.51	14	0	100	38	40	0.43	12	0	100	30	27	0.61
Magnesium	1.0	mg/l	5	0	100	12	8.7	0.05	4	0	100	4.6	3.7	0.16	10	0	100	9.2	8.3	0.61	14	0	100	14	8.7	0.96	12	0	100	8.9	6.1	0.52
Potassium	1.0	mg/l	5	0	100	4.0	3.6	0.25	4	0	100	3.4	3.6	0.41	9	0	100	4.5	4.5	0.41	14	0	100	3.8	4.2	0.26	12	0	100	4.2	3.1	0.60
Sodium	1.0	mg/l	5	0	100	48	32	0.51	4	0	100	15	15	0.44	10	0	100	34	26	0.82	14	0	100	60	41	1.18	12	0	100	47	34	1.05
Bicarbonate	2.0	mg/l	5	0	100	83	86	0.27	4	0	100	50	46	0.38	10	0	100	63	64	0.56	14	0	100	80	73	0.56	12	0	100	99	76	0.74
Carbonate	2.0	mg/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Chloride	2.0	mg/l	5	0	100	38	36	0.46	4	0	100	14	13	0.36	10	0	100	31	24	0.67	14	0	100	54	44	0.97	12	0	100	36	33	0.66
Fluoride	0.1	mg/l	5	0	100	0.23	0.25	0.23	4	0	100	0.25	0.07	0.05	10	4	60	0.17	0.11	0.91	14	2	86	0.26	0.26	0.70	12	1	92	0.27	0.19	0.78
Nitrate	0.1	mg/l	5	0	100	1.4	1.3	0.36	4	0	100	4.8	3.4	0.68	10	0	100	3.6	3.2	0.63	14	0	100	7.9	6.5	0.93	12	1	92	6.1	4.8	0.90
Sulfate	0.1	mg/l	5	0	100	65	57	0.56	4	0	100	27	27	0.29	10	0	100	64	48	0.89	14	0	100	111	88	1.11	12	0	100	82	46	1.10
Alkalinity	4.0	mg/l	5	0	100	83	86	0.27	4	0	100	50	46	0.38	10	0	100	63	64	0.56	14	0	100	80	73	0.56	12	0	100	81	63	0.74
Hardness	2.0	mg/l	5	0	100	126	135	0.31	4	0	100	75	68	0.34	10	0	100	121	130	0.56	14	0	100	156	140	0.56	12	0	100	112	87	0.56
COD	5	mg/l	5	3	40	20	25	1.00	4	0	100	198	184	0.62	10	0	100	123	110	0.69	14	0	100	68	57	0.61	12	1	92	61	43	0.92
pH	0.14		5	0	100	7.8	7.8	0.02	4	0	100	7.5	7.6	0.03	10	0	100	7.3	7.4	0.03	14	0	100	7.7	7.8	0.05	12	0	100	7.2	7.2	0.05
Specific Conductance	1.0	umhos/cm	5	0	100	524	553	0.34	4	0	100	257	261	0.16	10	0	100	372	298	0.76	13	0	100	618	474	1.00	12	0	100	433	350	0.72
Total Dissolved Solids	2.0	mg/l	5	0	100	348	342	0.34	4	0	100	172	174	0.13	10	0	100	233	180	0.75	13	0	100	388	302	0.84	12	0	100	288	203	0.82
Turbidity	0.1	NTU	5	0	100	37	88	0.83	4	0	100	42	36	0.73	10	0	100	198	108	1.14	14	0	100	77	66	0.71	12	0	100	63	56	0.80
Total Suspended Solids	2.0	mg/l	5	0	100	310	380	0.34	4	0	100	248	254	0.18	10	0	100	588	267	1.02	14	0	100	147	103	0.81	12	0	100	284	138	1.33
Volatile Suspended Solids	1.0	mg/l	5	0	100	60	58	0.41	4	0	100	48	54	0.23	10	0	100	104	48	1.00	14	0	100	31	24	0.72	12	0	100	61	37	1.18
MBAS	0.05	mg/l	0	0	ND	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	13	2	85	0.12	0.09	0.70	12	2	83	0.12	0.10	0.65
Total Organic Carbon	1.0	mg/l	5	0	100	15	14	0.24	4	0	100	8	10	0.40	10	0	100	13	10	0.80	12	0	100	11	8	0.56	12	0	100	10	10	0.76
BOD	2.0	mg/l	3	0	100	22	21	0.11	4	0	100	24	27	0.20	9	0	100	26	19	0.72	12	0	100	23	22	0.55	12	0	100	24	8	1.46
Nutrients																														
Dissolved Phosphorus	0.05	mg/l	5	0	100	0.14	0.13	0.30	4	0	100	0.23	0.22	0.24	9	0	100	0.48	0.38	0.64	13	1	92	0.16	0.17	0.54	12	1	92	0.26	0.22	0.72
Total Phosphorus	0.05	mg/l	5	0	100	0.21	0.22	0.48	4	0	100	0.65	0.60	0.26	9	0	100	0.56	0.42	0.73	13	0	100	0.31	0.18	0.46	12	0	100	0.40	0.31	0.85
NH3-N	0.1	mg/l	4	2	50	0.07	0.09	1.20	4	1	75	0.38	0.31	0.88	10	0	100	0.84	0.50	1.21	13	5	62	0.62	0.22	1.36	12	4	67	0.84	0.24	1.58
Nitrate-N	0.1	mg/l	5	0	100	3.1	2.8	0.36	4	0	100	1.0	0.77	0.68	9	0	100	0.80	0.89	0.62	14	0	100	1.8	1.5	0.93	12	1	92	1.4	1.1	0.89
Nitrite-N	0.1	mg/l	5	0	100	0.08	0.05	0.63	4	0	100	0.06	0.09	0.44	10	0	100	0.18	0.07	1.46	14	2	86	0.18	0.12	1.02	12	0	100	0.32	0.11	1.02
TKN	0.1	mg/l	5	0	100	2.7	1.8	0.58	4	0	100	2.9	3.1	0.54	10	0	100	4.4	2.9	0.83	14	0	100	3.6	2.5	0.69	12	0	100	2.7	1.6	1.04
Metals																														
Dissolved Aluminum	100	ug/l	0	0	ND	ND	ND	ND	4	3	25	71	50	0.80	10	2	80	1542	1180	0.86	14	10	29	146	50	1.46	12	9	25	106	50	1.02
Total Aluminum	100	ug/l	0	0	ND	ND	ND	ND	4	1	75	1960	1330	0.98	10	0	100	3147	2705	0.83	14	0	100	630	298	1.74	12	2	83	276	237	0.66
Dissolved Antimony	5	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Antimony	5	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Arsenic	5	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	13	7	ND	ND	ND	12	12	0	ND	ND	ND
Total Arsenic	5	ug/l	5	5	0	ND	ND	ND	4	3	25	2.2	2.5	0.25	10	8	10	ND	ND	ND	14	13	7	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Barium	10	ug/l	5	5	0	ND	ND	ND	4	2	50	11	11	0.64	10	3	70	63	53	0.68	14	1	93	42	38	0.50	12	0	100	43	35	0.88
Total Barium	10	ug/l	5	5	0	ND	ND	ND	4	1	75	80	36	1.20	10	3	70	118	62	1.13	14	1	93	66	52	0.89	12	0	100	56	41	0.87
Dissolved Beryllium	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Beryllium	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Boron	100	ug/l	5	5	0	ND	ND	ND	4	3	25	89	50	0.87	10	0	100	205	204	0.24	14	0	100	214	180	0.46	12	5	58	117	104	0.60
Total Boron	100	ug/l	5	5	0	ND	ND	ND	4	2	50	104	78	0.72	10	0	100	298	298	0.26	14	0	100	295	226	0.43	12	4	67	137	112	0.62
Dissolved Cadmium	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	8	20	1.2	0.50	1.22	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Cadmium	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	7	30	1.3	0.50	1.18	14	12	14	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Chromium	5	ug/l	5	5	0	ND	ND	ND	4	3	25	2.4	2.5	0.11	10	8	20	4.7	2.5	0.89	14	14	0	ND	ND	ND	12	11	8	ND	ND	ND
Total Chromium	5	ug/l	5	3	40	7.1	2.5	0.91	4	1	75	23	9.8	1.34	10	4	60	15	11	1.16	14	11	21	4.0	2.5	0.89	12	11	8	ND	ND	ND
Dissolved Chromium +6	10	ug/l	0	0	ND	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Chromium +6	10	ug/l	0	0	ND	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Copper	5	ug/l	5	4	20	4.8	2.5	1.02	4	3	25	2.4	2.5	0.13	10	1	90	31	20	0.93	14	6	57	8.2	5.6	0.81	12	8	50	5.8	3.8	0.80
Total Copper	5	ug/l	5	1	80	25	24	0.63	4	0	100	24	23	0.20	10	0	100	43	28	0.88	14	0	100	14	12	0.63	12	1	92	10	8	0.48
Dissolved Iron	100	ug/l	5	3	40	196	80	1.40	4	2	50	370	258	1.12	10	1	90	2631	880	1.34	14	7	50	172	74	1.11	12	6	50	161	106	0.90
Total Iron	100	ug/l	5	0	100	2324	1240	0.86	4	0	100	2466	1245	1.08	10	0	100	12 370	8140	0.82	14	0	100	764	343	1.59	12	2	83	400	370	0.78
Dissolved Lead	5	ug/l	5	5	0	ND	ND	ND	4	3	25	2.4	2.5	0.11	10	4	60	30	13	1.30	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Lead	5	ug/l	5	2	60	8.6	2.5	1.79	4	1	75	19	16	0.96	10	4	60	29	17	1.41	14	12	14	ND	ND	ND	12	10	17	ND	ND	ND
Dissolved Manganese	100	ug/l	5	3	40	47	50	0.16	4	4	0	ND	ND	ND	10	4	60	164	126	0.90	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Manganese	100	ug/l	5	1	80	73	68	0.60	4	3	25	113	50	1.11	10	1	90	335	278	0.63	14	10	29	63	50	0.77	12	11	8	ND	ND	ND
Dissolved Mercury	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Mercury	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Nickel	5	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	4	60	7.7	6.8	0.76	14	14	0	ND	ND	ND	12	10	17	ND	ND	ND
Nickel	5	ug/l	5	2	60	14	10	0.86	4	2	50	7.3	3.7	1.11	10	3	70	13	10	0.86	14	7	50	5.7	3.8	0.73	12	6	33	4.6	2.5	0.75
Dissolved Selenium	5	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Selenium	5	ug/l	5	5	0	ND	ND	ND	4	3	25	2.4	2.5	0.06	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Dissolved Silver	1	ug/l	5	5	0	ND	ND	ND	4	4	0	ND	ND	ND	10	10	0	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND
Total Silver	1	ug/l	5	4	20	0.80	0.80	0.37	4	4	0	ND	ND	ND	10	9	10	ND	ND	ND	14	14	0	ND	ND	ND	12	12	0	ND	ND	ND

R0012049

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

			Coyote Creek																									
			1994-95						1995-96						1996-97						1997-98						1998-99					
Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Thallium	5	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	14	14	0	SID	SID	SID	12	12	0	SID	SID	SID
Total Thallium	5	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	14	14	0	SID	SID	SID	12	12	0	SID	SID	SID
Dissolved Zinc	50	ppb	5	3	40	39	25	0.48	4	4	0	SID	SID	SID	10	4	60	234	145	1.16	14	11	21	34	25	0.57	12	12	0	SID	SID	SID
Total Zinc	50	ppb	5	1	80	83	80	0.56	4	0	100	83	83	0.06	10	0	100	344	288	0.62	14	5	64	67	62	0.62	12	9	25	36	25	0.66
SVOCs																																
Bis(2-ethylhexyl)phthalate	1	ppb	5	1	80	17	27	1.04	4	1	75	17	7.7	0.96	9	1	89	17	11	1.02	4	2	50	17	2.9	0.93	1	1	0	SID	SID	SID
PAHs																																
Acenaphthene	0.05	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Acenaphthylene	0.05	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Anthracene	0.05	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benz(a)anthracene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(a)pyrene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(b)fluoranthene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Benzo(k)fluoranthene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Chrysene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Dibenz(a,h)anthracene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Fluoranthene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Fluorene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Indeno(1,2,3-cd)pyrene	0.1	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Naphthalene	0.05	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Phenanthrene	0.05	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Pyrene	0.05	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
All other SVOCs	0.05-5.0	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	1	1	0	SID	SID	SID
Pesticides																																
Organochlorine Pesticides & PCBs	0.05-1.0	ppb	5	5	0	SID	SID	SID	3	3	0	SID	SID	SID	8	8	0	SID	SID	SID	3	3	0	SID	SID	SID	0	0	SID	SID	SID	SID
Carbofuran	5	ppb	0	0	SID	SID	SID	SID	3	3	0	SID	SID	SID	10	10	0	SID	SID	SID	14	14	0	SID	SID	SID	12	12	0	SID	SID	SID
Glyphosate	25	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	14	14	0	SID	SID	SID	12	11	8	SID	SID	SID
Organo-Phosphate Pesticides																																
Diazinon	0.01	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	8	8	0	SID	SID	SID	12	10	17	SID	SID	SID	12	8	33	0.018	0.006	1.52
Chlorpyrifos	0.05	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	8	8	0	SID	SID	SID	12	12	0	SID	SID	SID	12	12	0	SID	SID	SID
N- and P-Containing Pesticides																																
Resmethrin	1	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	8	8	0	SID	SID	SID	12	10	17	SID	SID	SID	12	12	0	SID	SID	SID
All other N- and P- Pesticides	1.0-2.5	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	8	8	0	SID	SID	SID	12	12	0	SID	SID	SID	12	12	0	SID	SID	SID
Phenoxyacetic Acid Herbicides																																
2,4-D	10	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	0	0	SID	SID	SID	SID
2,4,5-TP	1	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	0	0	SID	SID	SID	SID
Bentazon	2	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	4	4	0	SID	SID	SID	0	0	SID	SID	SID	SID

CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data, not enough data above detection limit collected
See Table 4-3 for water quality objectives

R0012050

Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

Class Constituent	DL	Units	San Gabriel River 1995-96 No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	1996-97 No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	1997-98 No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	1998-99 No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	1999-2000 No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																																
Cyanide	0.01	mg/l	4	3	25	0.010	0.006	1.47	4	3	25	0.010	0.008	0.85	9	6	33	0.025	0.005	2.11	12	4	67	0.038	0.010	2.08	9	9	0	SID	SID	SID
TPH	1	mg/l	5	4	20	0.60	0.50	0.50	4	3	25	0.88	0.50	0.86	9	9	0	SID	SID	SID	12	11	8	SID	SID	SID	9	4	56	1.2	1.3	0.80
Oil and Grease	1	mg/l	5	4	20	0.60	0.50	0.50	4	3	25	1.0	0.50	0.87	9	7	22	0.64	0.50	0.50	12	9	25	0.81	0.50	0.85	9	3	67	1.7	1.8	0.75
Total Phenols	0.1	mg/l	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	12	11	8	SID	SID	SID	9	9	0	SID	SID	SID
Indicator Bacteria																																
Total Coliform	20	MPN/100ml	5	0	100	3,800,000	2,400,000	0.88	4	0	100	401,250	136,000	1.51	9	0	100	3,062,222	800,000	1.68	12	1	92	313,568	200,000	1.83	9	0	100	252,222	280,000	0.51
Fecal Coliform	20	MPN/100ml	5	0	100	1,388,000	1,600,000	0.74	4	0	100	74,860	2,300	1.93	9	0	100	2,408,889	110,000	2.22	12	1	92	40,783	1,250	2.17	9	0	100	73,844	30,000	1.36
Ratio Fecal Coliform/Total Coliform			0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID	1	0	100	SID	SID	SID	0	0	SID	SID	SID	SID
Fecal Streptococcus	20	MPN/100ml	5	0	100	644,000	500,000	0.80	4	0	100	221,900	42,500	1.74	9	0	100	1,982,889	240,000	2.08	12	1	92	42,104	4,000	1.56	9	0	100	78,500	80,000	0.74
Fecal Enterococcus	20	MPN/100ml	5	0	100	322,400	230,000	1.08	1	0	100	SID	SID	SID	0	0	SID	SID	SID	SID	4	0	100	13,670	1,080	2.32	9	0	100	14,418	10,000	0.84
General Minerals																																
Ammonia	0.1	mg/l	5	3	40	1.1	0.080	1.36	4	0	100	0.74	0.54	0.74	11	0	100	1.8	1.6	0.81	13	6	54	1.5	0.12	1.59	10	9	10	SID	SID	SID
Calcium	1.0	mg/l	5	0	100	48	48	0.38	4	0	100	33	32	0.24	9	0	100	36	34	0.25	13	0	100	58	61	0.37	10	0	100	37	34	0.36
Magnesium	1.0	mg/l	5	0	100	13	8.8	0.50	4	0	100	10.4	10.7	0.27	9	0	100	8.2	8.8	0.23	13	0	100	17	18	0.38	10	0	100	10	7.5	0.44
Potassium	1.0	mg/l	5	0	100	8.4	7.4	0.27	4	0	100	5.0	5.1	0.34	11	0	100	4.8	4.7	0.18	13	0	100	8.2	6.1	0.32	10	0	100	4.9	4.9	0.32
Sodium	1.0	mg/l	5	0	100	40	38	0.28	4	0	100	29	27	0.19	11	0	100	30	28	0.24	13	0	100	58	53	0.44	10	0	100	38	34	0.50
Bicarbonate	2.0	mg/l	5	0	100	98	82	0.47	4	0	100	97	62	0.38	9	0	100	88	72	0.17	13	0	100	122	144	0.38	10	0	100	87	80	0.34
Carbonate	2.0	mg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	9	9	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Chloride	2.0	mg/l	4	0	100	42	42	0.14	4	0	100	40	40	0.30	10	0	100	38	39	0.31	13	0	100	73	78	0.48	10	0	100	43	35	0.54
Fluoride	0.1	mg/l	4	0	100	0.19	0.17	0.38	4	1	75	0.13	0.15	0.43	10	1	90	0.16	0.16	0.50	13	0	100	0.27	0.29	0.33	10	0	100	0.21	0.21	0.41
Nitrate	0.1	mg/l	4	0	100	17	16	0.26	4	0	100	8.8	7.8	0.25	10	0	100	6.7	5.8	0.47	13	0	100	9.3	8.8	0.48	10	0	100	7.2	6.5	0.58
Sulfate	0.1	mg/l	4	0	100	73	72	0.08	4	0	100	62	61	0.79	10	0	100	61	60	0.31	13	0	100	108	125	0.46	10	0	100	64	58	0.36
Alkalinity	4.0	mg/l	5	0	100	98	82	0.47	4	0	100	97	62	0.38	9	0	100	90	72	0.17	13	0	100	122	144	0.39	10	0	100	72	66	0.34
Hardness	2.8	mg/l	5	0	100	173	141	0.41	4	0	100	130	124	0.14	9	0	100	116	120	0.44	13	0	100	215	230	0.34	10	0	100	147	144	0.35
COD	5	mg/l	5	3	40	23	3	1.31	4	1	75	63	47	1.08	11	0	100	79	74	0.75	13	0	100	65	48	0.56	10	1	90	40	32	0.77
pH	0-14		5	0	100	7.7	7.8	0.04	4	0	100	7.5	7.4	0.04	9	0	100	7.5	7.5	0.02	13	0	100	7.7	7.8	0.08	10	0	100	7.3	7.3	0.03
Specific Conductance	1.0	umhos/cm	4	0	100	480	463	0.12	4	0	100	436	420	0.25	9	0	100	394	377	0.25	13	0	100	724	758	0.36	10	0	100	456	398	0.38
Total Dissolved Solids	2.0	mg/l	4	0	100	351	386	0.08	4	0	100	290	284	0.29	9	0	100	248	242	0.25	13	0	100	450	458	0.40	10	0	100	287	231	0.40
Turbidity	0.1	NTU	5	0	100	43	22	1.72	4	0	100	56	24	1.27	9	0	100	246	128	1.18	13	0	100	42	27	0.88	10	0	100	88	56	0.80
Total Suspended Solids	2.0	mg/l	5	0	100	287	134	1.21	4	0	100	170	116	0.90	9	0	100	372	148	0.87	13	0	100	81	48	1.28	10	0	100	134	100	0.82
Volatile Suspended Solids	1.0	mg/l	5	0	100	31	30	0.83	4	0	100	31	30	0.52	9	0	100	48	45	0.75	13	0	100	18	11	1.10	10	0	100	25	25	0.41
MBAS	0.05	mg/l	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	6	54	0.10	0.08	1.06	10	6	40	0.04	0.03	0.52
Total Organic Carbon	1.0	mg/l	5	0	100	11	9	0.60	4	0	100	16	11	0.61	11	0	100	11	8	0.56	11	0	100	6.8	6.4	0.48	10	0	100	7.0	6.8	0.72
BOD	2.0	mg/l	5	0	100	43	33	0.48	4	0	100	33	32	0.52	9	0	100	33	33	0.19	11	2	82	48	34	0.86	10	0	100	12	10	0.67
Nutrients																																
Dissolved Phosphorus	0.05	mg/l	4	0	100	0.36	0.38	0.26	4	0	100	0.37	0.36	0.21	11	0	100	0.48	0.48	0.46	13	0	100	0.46	0.42	0.50	10	0	100	0.22	0.21	0.48
Total Phosphorus	0.05	mg/l	4	0	100	0.58	0.47	0.08	4	0	100	0.80	0.61	0.32	11	0	100	0.58	0.56	0.44	13	0	100	0.51	0.45	0.50	10	0	100	0.26	0.24	0.33
NH3-N	0.1	mg/l	3	2	33	1.0	0.08	1.84	4	0	100	0.42	0.46	0.74	11	0	100	1.6	1.3	0.58	13	6	54	1.3	0.18	1.58	10	10	0	SID	SID	SID
Nitrate-N	0.1	mg/l	4	0	100	3.8	3.7	0.28	4	0	100	1.9	1.8	0.24	10	0	100	1.5	1.3	0.47	13	0	100	3.1	2.0	0.48	10	0	100	1.6	1.5	0.38
Nitrite-N	0.1	mg/l	4	1	75	0.21	0.20	0.83	4	0	100	0.29	0.29	0.32	10	0	100	0.30	0.25	0.88	13	1	92	0.57	0.40	0.63	10	0	100	0.26	0.22	0.58
TKN	0.1	mg/l	4	0	100	3.0	2.9	0.80	4	0	100	3.3	3.1	0.34	11	0	100	3.5	3.6	0.37	13	0	100	3.8	3.8	0.63	10	0	100	1.5	1.3	0.45
Metals																																
Dissolved Aluminum	100	µg/l	0	0	SID	SID	SID	SID	4	3	25	74	50	0.64	11	1	91	1382	956	0.94	13	11	15	SID	SID	SID	10	5	50	197	87	1.10
Total Aluminum	100	µg/l	0	0	SID	SID	SID	SID	4	3	25	815	50	1.88	11	0	100	4481	3820	0.78	13	1	92	236	204	0.54	10	0	100	401	339	0.54
Dissolved Antimony	5	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Antimony	5	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Arsenic	5	µg/l	5	5	0	SID	SID	SID	4	3	25	3.3	2.5	0.15	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Arsenic	5	µg/l	5	5	0	SID	SID	SID	4	3	25	2.3	2.5	0.15	11	9	18	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Barium	10	µg/l	5	5	0	SID	SID	SID	4	2	50	14	13	0.74	11	1	91	50	50	0.45	13	1	92	50	58	0.53	10	0	100	51	48	0.41
Total Barium	10	µg/l	5	5	0	SID	SID	SID	4	2	50	27	15	1.21	11	1	91	106	98	0.50	13	1	92	57	58	0.57	10	0	100	57	57	0.40
Dissolved Beryllium	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Beryllium	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Boron	100	µg/l	5	4	20	108	80	1.18	4	3	25	78	50	0.71	11	1	91	182	214	0.31	13	0	100	288	263	0.40	10	5	50	98	85	0.57
Total Boron	100	µg/l	5	3	40	152	50	0.82	4	2	50	115	108	0.88	11	0	100	275	298	0.27	13	0	100	325	354	0.35	10	2	80	133	137	0.39
Dissolved Cadmium	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	9	18	SID	SID	SID	13	12	8	SID	SID	SID	10	10	0	SID	SID	SID
Total Cadmium	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	7	36	0.67	0.50	0.72	13	12	8	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Chromium	5	µg/l	5	5	0	SID	SID	SID	4	3	25	2.1	2.5	0.35	11	9	18	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Chromium	5	µg/l	5	4	20	4.2	2.5	0.81	4	1	75	5.3	3.3	0.86	11	4	64	12	11	0.82	13	12	8	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Chromium +6	10	µg/l	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Chromium +6	10	µg/l	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Copper	5	µg/l	5	5	0	SID	SID	SID	4	3	25	2.7	3.5	0.15	11	3	73	15	13	0.77	13	12	8	SID	SID	SID	10	9	10	SID	SID	SID
Total Copper	5	µg/l	5	2	60	11	16	0.75	4	1	75	18	13	1.02	11	0	100	24	22	0.55	13	1	92	7.3	6.7	0.36	10	1	90	7.4	7.5	0.36
Dissolved Iron	100	µg/l	5	4	20	74	50	0.73	4	2	50	225	180	0.93	11	0	100	1749	430	1.40	13	11	15	SID	SID	SID	10	5	50	279	108	1.46
Total Iron	100	µg/l	5	0	100	1130	778	0.73	4	0	100	1587	810	1.01	11	0	100	8865	7700	0.84	13	3	77	211	174	0.76	10	1	90	581	380	0.93
Dissolved Lead	5	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	6	45	10	2.5	1.07	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Lead	5	µg/l	5	5	0	SID	SID	SID	4	1	75	10	8.4	1.03	11	3	73	15	16	0.87	13	13	0	SID	SID	SID	10	9	10	SID	SID	SID
Dissolved Manganese	100	µg/l	5	3	40	33	50	0.17	4	4	0	SID	SID	SID	11	6	45	81	50	0.56	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Manganese	100	µg/l	5	0	100	70	65	0.20	4	2	50	73	50	0.82	11	1	91	166	156	0.56	13	12	8	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Mercury	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Mercury	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Nickel	5	µg/l	5	5	0	SID	SID	SID	4	3	25	2.4	2.5	0.04	11	5	55	5.0	6.0	0.52	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Nickel	5	µg/l	5	3	40	12	13	0.78	4	1	75	8.8	3.1	1.08	11	5	55	6.6	6.5	0.88	13	11	15	SID	SID	SID	10	8	20	4.7	2.5	1.20
Dissolved Selenium	5	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Selenium	5	µg/l	5	3	40	3.5	2.5	0.38	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	12	8	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Silver	1	µg/l	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Silver	1	µg/l	5	5	0	SID	SID	SID	4	3	25	0.85	0.50	0.17	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID	10	10	0	SID	SID	SID

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Table 4-6a. Summary of 1994-2000 Mass Emissions Results by Site and Year

			San Gabriel River																							
			1995-96						1996-97						1997-98						1998-99					
Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Thallium	5	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID
Total Thallium	5	ppb	5	5	0	SID	SID	SID	4	1	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID
Dissolved Zinc	50	ppb	5	5	0	SID	SID	SID	4	4	0	SID	SID	SID	11	6	45	98	25	0.95	13	10	23	32	25	0.40
Total Zinc	50	ppb	5	3	40	44	75	0.80	4	2	50	98	40	1.79	11	0	100	166	173	0.44	13	5	62	50	51	0.46
SVOCs																										
Bis(2-ethylhexyl)phthalate	1	ppb	4	1	75	17	20	1.62	4	1	75	17	5.0	1.44	11	1	91	17	15	0.83	2	1	50	SID	SID	SID
PAHs																										
Acenaphthene	0.05	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Acenaphthylene	0.05	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Anthracene	0.05	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Benz(a)anthracene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Benzo(a)pyrene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Benzo(b)fluoranthene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Benzo(g,h,i)perylene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Chrysene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Dibenz(a,h)anthracene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Fluoranthene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Fluorene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Indeno (1,2,3-cd)pyrene	0.1	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Naphthalene	0.05	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Phenanthrene	0.05	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Pyrene	0.05	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
All other SVOCs	0.05-5.0	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Pesticides																										
Organochlorine Pesticides & PCBs	0.05-1.0	ppb	4	4	0	SID	SID	SID	3	3	0	SID	SID	SID	10	10	0	SID	SID	SID	1	1	0	SID	SID	SID
Carbofuran	5	ppb	0	0	SID	SID	SID	SID	3	3	0	SID	SID	SID	11	11	0	SID	SID	SID	13	13	0	SID	SID	SID
Glyphosate	25	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	13	11	15	SID	SID	SID
Organo-Phosphate Pesticides																										
Diazinon	0.01	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	13	11	15	SID	SID	SID
Chlorpyrifos	0.05	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	13	13	0	SID	SID	SID
N- and P-Containing Pesticides																										
Thiobencarb	1	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	13	13	0	SID	SID	SID
All other N- and P- Pesticides	1.0-2.0	ppb	4	4	0	SID	SID	SID	4	4	0	SID	SID	SID	10	10	0	SID	SID	SID	13	13	0	SID	SID	SID
Phenoxyacetic Acid Herbicides																										
2,4-D	10	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
2,4,5-TP	1	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID
Bentazon	2	ppb	0	0	SID	SID	SID	SID	4	4	0	SID	SID	SID	11	11	0	SID	SID	SID	2	2	0	SID	SID	SID

			1999-2000					
Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Thallium	5	ppb	10	10	0	SID	SID	SID
Total Thallium	5	ppb	10	10	0	SID	SID	SID
Dissolved Zinc	50	ppb	10	10	0	SID	SID	SID
Total Zinc	50	ppb	10	10	0	SID	SID	SID
SVOCs								
Bis(2-ethylhexyl)phthalate	1	ppb	0	0	SID	SID	SID	SID
PAHs								
Acenaphthene	0.05	ppb	0	0	SID	SID	SID	SID
Acenaphthylene	0.05	ppb	0	0	SID	SID	SID	SID
Anthracene	0.05	ppb	0	0	SID	SID	SID	SID
Benz(a)anthracene	0.1	ppb	0	0	SID	SID	SID	SID
Benzo(a)pyrene	0.1	ppb	0	0	SID	SID	SID	SID
Benzo(b)fluoranthene	0.1	ppb	0	0	SID	SID	SID	SID
Benzo(g,h,i)perylene	0.1	ppb	0	0	SID	SID	SID	SID
Chrysene	0.1	ppb	0	0	SID	SID	SID	SID
Dibenz(a,h)anthracene	0.1	ppb	0	0	SID	SID	SID	SID
Fluoranthene	0.1	ppb	0	0	SID	SID	SID	SID
Fluorene	0.1	ppb	0	0	SID	SID	SID	SID
Indeno (1,2,3-cd)pyrene	0.1	ppb	0	0	SID	SID	SID	SID
Naphthalene	0.05	ppb	0	0	SID	SID	SID	SID
Phenanthrene	0.05	ppb	0	0	SID	SID	SID	SID
Pyrene	0.05	ppb	0	0	SID	SID	SID	SID
All other SVOCs	0.05-5.0	ppb	0	0	SID	SID	SID	SID
Pesticides								
Organochlorine Pesticides & PCBs	0.05-1.0	ppb	0	0	SID	SID	SID	SID
Carbofuran	5	ppb	10	10	0	SID	SID	SID
Glyphosate	25	ppb	10	10	0	SID	SID	SID
Organo-Phosphate Pesticides								
Diazinon	0.01	ppb	10	6	40	0.016	0.025	1.26
Chlorpyrifos	0.05	ppb	10	10	0	SID	SID	SID
N- and P-Containing Pesticides								
Thiobencarb	1	ppb	10	10	0	SID	SID	SID
All other N- and P- Pesticides	1.0-2.0	ppb	10	10	0	SID	SID	SID
Phenoxyacetic Acid Herbicides								
2,4-D	10	ppb	0	0	SID	SID	SID	SID
2,4,5-TP	1	ppb	0	0	SID	SID	SID	SID
Bentazon	2	ppb	0	0	SID	SID	SID	SID

CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data, not enough data above detection limit collected
See Table 4-3 for water quality objectives.

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Table 4-6b. 1994-2000 Comparison of Mass Emissions Annual Mean Concentrations to Objectives by Site

Class Constituent	Ballona Creek *							Malibu Creek *							Los Angeles River *						Coyote Creek						San Gabriel River *						Grand Total
	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Total	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	Total	1995-96	1996-97	1997-98	1998-99	1999-2000	Total	1995-96	1996-97	1997-98	1998-99	1999-2000	Total	1995-96	1996-97	1997-98	1998-99	1999-2000	Total	
Total Rainfall (in.)	14.76	^	11.18	28.28	9.48	10.59		35.41	17.9	9.22	37.51	8.48	17.24		10.5	6.17	17.8	6.34	7.98		^	6.06	23.03	6.64	5.29		13.11	8	28.8	8.2	12.41		
Cyanide	~	~	~	~	~	~		~	~	~	X	~	~	1	~	~	~	X	~	1	~	~	~	~	~		X	X	X	X	~	4	6
Total Coliform	X	X	X	X	X	X	6	X	X	X	X	X	X	6	X	X	X	X	X	5	X	NS	NS	NS	NS	1	X	X	X	X	X	5	23
Fecal Coliform	X	X	X	X	X	X	6	X	X	X	X	X	X	6	X	X	X	X	X	5	X	NS	NS	NS	NS	1	X	X	X	X	X	5	23
Fecal Streptococcus																						NS	NS	NS	NS								
Fecal Enterococcus	X	X	~	~	X	X	4	X	X	~	~	X	X	4	X	~	~	X	X	3	X	~	~	~	~	1	X	~	~	X	X	3	15
Total Dissolved Solids	~	~						~	~	~	X	X	X	3				X		1	X			X	X	3	X	X		X	X	4	11
Turbidity	~	~		X	X		2	~	~	~	X	X	X	3	X		X	X	X	4	X		X	X		3			X		X	2	14
Total Suspended Solids	~	~						~	~	~																							
Dissolved Phosphorus	~	~						~	~	~																							
Total Phosphorus	~	~						~	~	~																							
NH3-N	~	~						~	~	~																						~	
Nitrate-N	~	~						~	~	~																							
Nitrite-N	~	~						~	~	~	~	~	~																				
TKN	~	~						~	~	~																							
Total Aluminum	~	~	~	X			1	~	~	~	X			1	~	X	X	X		3	~	X	X			2	~		X			1	8
Dissolved Cadmium	~	~	~	~	~	~		~	~	~		~	~		~	~	X	~	~	1	~	~		~	~		~	~	~	~	~		1
Dissolved Copper	~	~		X	X	X	3	~	~	~	X	~	X	2	X	X	X	X	X	5	X		X	X	X	4	~		X	~	~	1	15
Total Copper	~	~		X	X	X	3	~	~	~	X			1	X	X	X	X	X	5	X	X	X	X		4	X	X	X			3	16
Dissolved Lead	~	~	~	X	~	~	1	~	~	~	~	~	~		X	X	X	~	X	4	~		X	~	~	1	~	~	X	~	~	1	7
Total Lead	~	~	X	X			2	~	~	~	X	~	~	1	X	X	X	X	X	5	X	X	X	~	~	3	~	X	X	~	~	2	13
Total Mercury	~	~	X	~	~	~	1	~	~	~	~	~	~		~	~	~	~	~		~	~	~	~	~		~	~	~	~	~		1
Dissolved Nickel	~	~		X	~	~	1	~	~	~	X			1			X			1	~	~		~	~		~			~	~		3
Nickel	~	~						~	~	~	X			1	X		X			2										~			3
Dissolved Zinc	~	~		X		~	1	~	~	~		~	~				X		~	1		~	X		~	1	~	~	X		~	1	4
Total Zinc	~	~	X	X	X		3	~	~	~	X	~	~	1	X	X	X	X		4	X	X	X			3		X	X		~	2	13
Bis(2-ethylhexyl)phthalate	~	~	X	X	X	~	3	~	~	~	X	X	X	3	X	X	X	~	~	3	X	X	X	X	~	4	X	X	X	~	~	3	16
Phenanthrene	~	~	~	~	~	~		~	~	~	~	~	X	1	~	~	~	~	~		~	~	~	~	~		~	~	~	~	~		1
Pyrene	~	~	~	~	~	~		~	~	~	~	~	X	1	~	~	~	~	~		~	~	~	~	~		~	~	~	~	~		1
Diazinon	~	~	~	~		~		~	~	~	~	~	~		~	~	~		~		~	~	~	~			~	~	~	~			
Chlorpyrifos	~	~	~	~	~	~		~	~	~	~	~	~		~	~	~	~	~		~	~	~	~	~		~	~	~	~	~		
Total	3	3	6	12	8	5	37	3	3	2	13	6	10	37	11	9	14	11	8	53	10	5	9	5	2	31	7	8	12	5	5	37	195

X = Greater than objective[1]. Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

* Required by Permit

^ = Rain gage not active

~ = Statistically invalid data, not enough samples or data above detection limit collected

NS = Not Sampled

Blank = No Exceedance

1 = Objectives are presented in Table 4-3.

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Table 4-7. 1994-2000 Mass Emission Constituent Detection Rates

	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Miscellaneous Constituents					
Cyanide*	X	X	X	&	X
TPH	X	X	-	&	X
Oil and Grease	X	X	-	&	X
Total Phenols	X	X	X	&	X
Indicator Bacteria*	-	-	-	&	-
General Minerals					
Ammonia	-	X	-	-	X
Calcium	-	-	-	-	-
Magnesium	-	-	-	-	-
Potassium	-	-	-	-	-
Sodium	-	-	-	-	-
Bicarbonate	-	-	-	-	-
Carbonate	X	X	X	X	X
Chloride	-	-	-	-	-
Flouride	-	-	-	-	-
Nitrate	-	-	-	-	-
Sulfate	-	-	-	-	-
Alkalinity	-	-	-	-	-
Hardness	-	-	-	-	-
COD	-	-	-	-	-
pH	-	-	-	-	-
Specific Conductance	-	-	-	-	-
Total Dissolved Solids*	-	-	-	-	-
Turbidity*	-	-	-	-	-
Total Suspended Solids*	-	-	-	-	-
Volatile Suspended Solids	-	-	-	-	-
MBAS	-	X	X	X	X
Total Organic Carbon	-	-	-	-	-
BOD	-	-	-	-	-
Nutrients					
Dissolved Phosphorus*	-	-	-	-	-
Total Phosphorus*	-	-	-	-	-
NH3-N*	-	X	X	-	X
Nitrate-N*	-	-	-	-	-
Nitrite-N*	-	X	-	-	-
TKN*	-	-	-	-	-
Metals					
Dissolved Aluminum	X	X	-	X	X
Total Aluminum*	-	-	-	-	-
Dissolved Antimony	X	X	X	X	X
Total Antimony	X	X	X	X	X
Dissolved Arsenic	X	X	X	X	X
Total Arsenic	X	X	X	X	X
Dissolved Barium	-	-	-	-	-
Total Barium	-	-	-	-	-
Dissolved Beryllium	X	X	X	X	X
Total Beryllium	X	X	X	X	X
Dissolved Boron	-	-	-	-	-
Total Boron	-	-	-	-	-
Dissolved Cadmium*	X	X	X	X	X
Total Cadmium	X	X	X	X	X
Dissolved Chromium	X	X	X	X	X

Table 4-7. 1994-2000 Mass Emission Constituent Detection Rates

	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Total Chromium	X	X	X	X	X
Dissolved Chromium +6	X	X	X	X	X
Total Chromium +6	X	X	X	X	X
Dissolved Copper*	-	X	-	-	X
Total Copper*	-	-	-	-	-
Dissolved Iron	X	X	-	-	X
Total Iron	-	-	-	-	-
Dissolved Lead*	X	X	X	X	X
Total Lead*	X	X	-	X	X
Dissolved Manganese	X	X	X	X	X
Total Manganese	X	X	X	X	X
Dissolved Mercury	X	X	X	X	X
Total Mercury*	X	X	X	X	- X
Dissolved Nickel*	X	X	-	X	X
Total Nickel*	-	-	-	-	X
Dissolved Selenium	X	X	X	X	X
Total Selenium	X	X	X	X	X
Dissolved Silver	X	X	X	X	X
Total Silver	X	X	X	X	X
Dissolved Thallium	X	X	X	X	X
Total Thallium	X	X	X	X	X
Dissolved Zinc*	X	X	X	X	X
Total Zinc*	-	X	-	X	X
SVOCs					
Bis(2-ethylhexyl)phthalate*	&	&	&	&	&
PAHs					
Phenanthrene*	&	&	&	&	&
Pyrene*	&	&	&	&	&
All other PAHs	&	&	&	&	&
All other SVOCs	X	X	X	X	X
Pesticides					
Organochlorine Pesticides & PCBs	X	X	X	X	X
Carbofuran	X	X	X	X	X
Glyphosate	X	X	X	X	X
Organo-Phosphate Pesticides					
Diazinon*	X	X	X	X	X
Chlorpyrifos*	X	X	X	X	X
N- and P-Containing Pesticides					
Thiobencarb	X	X	X	X	X
All other N- and P- Pesticieds	X	X	X	X	X
Phenoxyacetic Acid Herbicides					
2,4-D	X	X	X	X	X
2,4,5-TP	X	X	X	X	X
Bentazon	X	X	X	X	X

X = less than 25% detection in ten consecutive samples

- = more than 25% detection in ten consecutive samples

& = less than 10 samples tested

* Constituent of concern

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Table 4-8. YEARLY LOG MEAN STORMWATER BACTERIA COUNTS

Parameters	Site Name	1994-95 Log Mean (MPN/100ml)	1995-96 Log Mean (MPN/100ml)	1996-97 Log Mean (MPN/100ml)	1997-98 Log Mean (MPN/100ml)	1998-99 Log Mean (MPN/100ml)	1999-2000 Log Mean (MPN/100ml)
Total Coliform	Ballona Ck (S01)	518,004	2,623,967	667,467	1,120,085	326,580	280,332
	Malibu Ck (S02)	160,000	120,240	58,285	239,022	35,502	34,594
	L.A. River (S10)		826,002	724,824	988,604	68,786	486,365
	S.G. River (S14)		2,774,828	131,521	1,050,695	84,375	207,753
Fecal Coliform	Ballona Ck (S01)	198,738	684,899	67,466	522,415	30,930	87,737
	Malibu Ck (S02)	22,000	13,221	8,794	53,312	3,866	10,792
	L.A. River (S10)		876,085	66,884	359,825	20,677	128,606
	S.G. River (S14)		900,265	11,817	168,789	2,350	22,780
Fecal Streptococcus	Ballona Ck (S01)	203,885	1,288,572	228,438	253,300	142,141	228,154
	Malibu Ck (S02)	3,000	15,745	80,332	189,244	6,243	26,247
	L.A. River (S10)		626,164	195,743	310,288	23,163	110,557
	S.G. River (S14)		503,179	68,399	217,081	4,900	47,068
Fecal Enterococcus	Ballona Ck (S01)	151,008	1,001,181	90,000		137,594	43,877
	Malibu Ck (S02)	2,400	6,996	30,000		4,538	5,386
	L.A. River (S10)		379,895	170,000		49,137	13,272
	S.G. River (S14)		185,922	2,200		8,846	9,912

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Table 4-9. Cumulative Event Mean Concentrations 1994-2000 Storm Season

GROUP	Constituent	Unit	High Density Single Family Residential	Light Industrial	Vacant	Retail/ Commercial	Multi-family Residential	Transportation	Education	Mixed Residential
GENERAL MINERALS	Dissolved Phosphorus	mg/ℓ	0.29	0.28	0.06	0.30	0.16	0.36	0.27	0.20
	Kjeldahl-N	mg/ℓ	2.80	3.07	0.81	3.37	1.86	1.81	1.62	2.70
	NH3-N	mg/ℓ	0.36	0.48	0.08	0.91	0.38	0.23	0.26	0.58
	Nitrate-N	mg/ℓ	1.04	0.86	1.11	0.58	1.73	0.75	0.63	0.71
	Nitrite-N	mg/ℓ	0.09	0.09	0.05	0.14	0.08	0.09	0.08	0.10
	Suspended Solids	mg/ℓ	104.65	229.37	164.68	67.40	46.35	75.35	103.02	69.06
	Total Phosphorus	mg/ℓ	0.39	0.44	0.11	0.41	0.19	0.44	0.31	0.26
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Chromium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Copper	µg/ℓ	8.44	20.22	n/m	14.60	6.75	32.68	12.80	11.52
	Dissolved Lead	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Mercury	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Nickel	µg/ℓ	n/m	4.85	n/m	n/m	n/m	3.73	n/m	n/m
	Dissolved Selenium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Silver	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Dissolved Zinc	µg/ℓ	39.11	460.19	n/m	164.12	75.36	203.89	65.97	125.83
HEAVY METALS (TOTAL)	Total Cadmium	µg/ℓ	n/m	n/m	n/m	0.71	n/m	1.05	n/m	n/m
	Total Chromium +6	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Copper	µg/ℓ	15.30	31.04	9.12	34.77	12.23	51.86	21.49	17.33
	Total Lead	µg/ℓ	9.59	14.87	n/m	11.53	5.13	9.08	4.53	8.70
	Total Mercury	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Nickel	µg/ℓ	n/m	8.92	n/m	6.71	n/m	5.76	4.65	n/m
	Total Selenium	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Silver	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Total Zinc	µg/ℓ	80.35	565.60	38.81	238.53	134.88	279.45	123.69	184.85
MISCELLANEOUS	Cyanide	mg/ℓ			n/m					n/m
	Oil and Grease	mg/ℓ	1.36	1.87	n/m	3.65		3.19		n/m
	Total Petroleum Hydrocarbons	mg/ℓ	1.36	1.87	n/m	3.65		3.19		n/m
	Total Phenols	mg/ℓ	n/m	n/m	n/m	n/m		n/m		n/m

Notes:

n/m : Not meaningful, not enough data above detection limit

Blank cells: No data available

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Table 4-9. Cumulative Event Mean Concentrations 1994-2000 Storm Season (cont'd)

GROUP	Constituent	Unit	High Density Single Family Residential	Light Industrial	Vacant	Retail/ Commercial	Multi-family Residential	Transportation	Education	Mixed Residential
BACTERIA	Fecal Coliform	MPN/100mℓ	1085353.71	653070.36	2174.82	1071656.51		1340166.71		n/m
	Fecal Enterococcus	MPN/100mℓ	904554.87	128807.20	1043.87	105085.69		34660.95		
	Fecal Streptococcus	MPN/100mℓ	1360392.59	356792.16	3618.32	279561.99		300525.54		n/m
	Total Coliform	MPN/100mℓ	1395690.90	508710.38	21288.48	1733009.14		806939.80		n/m
PESTICIDES	Chlordane	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Chlorpyrifos	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Diazinon	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Malathion	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	p,p' DDT	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1016	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1221	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1232	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1242	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1248	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1254	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	PCB-1260	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
	Simazine	µg/ℓ	n/m	n/m	n/m	n/m	n/m	n/m	n/m	n/m
SEMIVOLATILES	Acenaphthene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Acenaphthylene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Antracene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Benzo(a)anthracene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		0.39
	Benzo(a)pyrene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Benzo(b)fluorant	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Benzo(k)fluorant	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Chrysene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		0.79
	Dibenz(a,h)anthrecene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Fluoranthene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		0.33
	Fluorene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Indeno (1,2,3-cd) pyrene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Naphthalene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		n/m
	Phenanthrene	µg/ℓ	n/m	n/m	n/m		n/m	n/m		0.73
	Pyrene	µg/ℓ	1.50	n/m	n/m		n/m	n/m		0.53

Notes:
n/m : Not meaningful, not enough data above detection limit
Blank cells: No data available

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Table 4-10a. ESTIMATED MASS POLLUTANT LOADING
BALLONA CREEK
MONITORED WATERSHED

LANDUSE
HDSFR..... 40.0%
Light Ind..... 3.5%
Vacant..... 11.1%
Retail/Comm..... 9.9%
Multi-Fam.Res.... 12.3%
Transportation..... 1.5%
Education..... 2.7%
Mixed Residential. 6.7%
All Other..... 12.3%

Total Area: 88.8 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98*	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	n/a	6,550,000	13,200,000	5,840,000	9,290,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/m	n/m	n/m	n/m
	Dissolved Copper	n/a	n/a	136	1,510	271	483
	Dissolved Lead	n/a	n/a	n/m	967	n/m	n/m
	Dissolved Zinc	n/a	n/a	n/m	7,710	1,460	n/m
HEAVY METALS (TOTAL)	Total Copper	n/a	n/a	724	1,960	533	878
	Total Lead	n/a	n/a	528	1,750	189	269
	Total Mercury	n/a	n/a	n/m	24.9	n/m	n/m
	Total Zinc	n/a	n/a	4,840	19,000	2,790	3,990
PESTICIDES	Chlorpyrifos	n/a	n/a	n/m	n/m	n/m	n/m
	Diazinon	n/a	n/a	n/m	n/m	3.06	n/m
MISCELLANEOUS	Cyanide	n/m	n/a	n/m	n/m	n/m	n/m
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	460	774	679	n/m
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/m	n/a	4,200,000	11,030,000	6,340,000	11,300,000
HEAVY METALS	Total Aluminum	n/m	n/a	n/m	115,000	13,000	18,600
	Dissolved Nickel	n/m	n/a	174	562	n/m	n/m
	Nickel	n/m	n/a	241	343	198	310
PAHs	Phenanthrene	n/m	n/a	n/m	n/m	n/m	n/m
	Pyrene	n/m	n/a	n/m	n/m	n/m	n/m
NUTRIENTS	Dissolved Phosphorus	n/m	n/a	10,000	15,500	6,850	14,700
	Total Phosphorus	n/m	n/a	25,400	17,100	10,200	19,500
	NH3-N	n/m	n/a	10,800	31,400	10,800	28,400
	Nitrate-N	n/m	n/a	29,200	45,400	23,900	70,000
	Nitrite-N	n/m	n/a	3,650	5,180	5,300	7,700
	TKN	n/m	n/a	101,000	119,000	130,000	154,000

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.
* = The automated sampler was out of service the month of February, 1998.

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R0012059

Table 4-10b. ESTIMATED MASS POLLUTANT LOADING
MALIBU CREEK
MONITORED WATERSHED

LANDUSE
HDSFR..... 5.7%
Light Ind..... 0.3%
Vacant..... 79.3%
Retail/Comm..... 0.5%
Multi-Fam.Res.... 1.3%
Transportation..... 0.5%
Education..... 0.5%
Mixed Residential. 0%
All Other..... 11.9%

Total Area: 105 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	n/a	n/a	88,400,000	122,000	2,840,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/m	n/a	n/a	124	n/m	n/m
	Dissolved Copper	n/m	n/a	n/a	984	n/m	39.9
	Dissolved Lead	n/m	n/a	n/a	n/m	n/m	n/m
	Dissolved Zinc	n/m	n/a	n/a	5,190	n/m	n/m
HEAVY METALS (TOTAL)	Total Copper	n/m	n/a	n/a	3950	9.59	82.6
	Total Lead	n/m	n/a	n/a	2550	n/m	n/m
	Total Mercury	n/m	n/a	n/a	n/m	n/m	n/m
	Total Zinc	n/m	n/a	n/a	12,300	n/m	n/m
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/m	n/m	n/m
	Diazinon	n/a	n/a	n/a	n/m	n/m	n/m
MISCELLANEOUS	Cyanide	n/m	n/a	n/a	n/m	n/m	n/m
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	2,340	32.7	56.2
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/m	n/a	n/a	72,500,000	1,320,000	11,300,000
HEAVY METALS	Total Aluminum	n/m	n/a	n/a	948,000	332	1,930
	Dissolved Nickel	n/m	n/a	n/a	1,190	3.82	38.7
	Nickel	n/m	n/a	n/a	3,520	6.12	105
PAHs	Phenanthrene	n/m	n/a	n/a	n/m	n/m	0.495
	Pyrene	n/m	n/a	n/a	n/m	n/m	1.76
NUTRIENTS	Dissolved Phosphorus	n/m	n/a	n/a	61,400	512	5,850
	Total Phosphorus	n/m	n/a	n/a	76,400	543	6,750
	NH3-N	n/m	n/a	n/a	26,200	165	927
	Nitrate-N	n/m	n/a	n/a	207,000	3,750	38,100
	Nitrite-N	n/m	n/a	n/a	n/m	n/m	n/m
	TKN	n/m	n/a	n/a	259,000	2,300	15,600

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

R0012060

Table 4-10c. ESTIMATED MASS POLLUTANT LOADING
LOS ANGELES RIVER
MONITORED WATERSHED

LANDUSE
HDSFR..... 28.8%
Light Ind..... 5.1%
Vacant..... 40.4%
Retail/Comm..... 3.6%
Multi-Fam.Res.... 3.5%
Transportation..... 2.4%
Education..... 1.9%
Mixed Residential. 1.8%
All Other..... 12.5%

Total Area: 825 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	n/a	53,500,000	444,000,000	34,400,000	16,800,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/m	2,670	n/m	n/m
	Dissolved Copper	n/a	n/a	n/m	56,100	991	290
	Dissolved Lead	n/a	n/a	n/m	103,000	n/m	161
	Dissolved Zinc	n/a	n/a	n/m	336,000	n/m	n/m
HEAVY METALS (TOTAL)	Total Copper	n/a	n/a	8,000	81,000	2,370	631
	Total Lead	n/a	n/a	8,290	208,000	n/m	457
	Total Mercury	n/a	n/a	n/m	n/m	n/m	n/m
	Total Zinc	n/a	n/a	36,800	463,000	13,400	2,230
PESTICIDES	Chlorpyrifos	n/a	n/a	n/m	n/m	n/m	n/m
	Diazinon	n/a	n/a	n/m	n/m	n/m	n/m
MISCELLANEOUS	Cyanide	n/a	n/a	n/m	n/m	n/m	n/m
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/m	20,600	n/a	n/m
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	21,900,000	76,400,000	34,200,000	6,090,000
HEAVY METALS	Total Aluminum	n/a	n/a	361,000	8,890,000	183,000	25,300
	Dissolved Nickel	n/a	n/a	385	13,400	373	226
	Nickel	n/a	n/a	2,280	22,000	737	302
PAHs	Phenanthrene	n/a	n/a	n/m	n/m	n/m	n/m
	Pyrene	n/a	n/a	n/m	n/m	n/m	n/m
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	54,200	530,000	46,400	15,100
	Total Phosphorus	n/a	n/a	180,000	683,000	58,800	20,800
	NH3-N	n/a	n/a	84,800	732,000	23,700	6,860
	Nitrate-N	n/a	n/a	224,000	533,000	67,300	39,300
	Nitrite-N	n/a	n/a	17,600	91,400	37,300	6,430
	TKN	n/a	n/a	747,000	3,540,000	399,000	119,000

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

R0012061

Table 4-10d. ESTIMATED MASS POLLUTANT LOADING
SAWPIT CREEK
MONITORED WATERSHED

LANDUSE

HDSFR.....	0%
Light Ind.....	0%
Vacant.....	98.0%
Retail/Comm.....	0%
Multi-Fam.Res....	0%
Transportation.....	0%
Education.....	0%
Mixed Residential.	0%
All Other.....	2.0%

Total Area: 5.18 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	n/a	15,900	16,200	1,580	53,200
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/m	n/m	n/m	n/m
	Dissolved Copper	n/a	n/a	n/m	n/m	n/m	n/m
	Dissolved Lead	n/a	n/a	n/m	n/m	n/m	n/m
	Dissolved Zinc	n/a	n/a	n/m	n/m	n/m	n/m
HEAVY METALS (TOTAL)	Total Copper	n/a	n/a	3.73	18.6	n/m	1,090
	Total Lead	n/a	n/a	n/m	n/m	n/m	n/m
	Total Mercury	n/a	n/a	n/m	n/m	n/m	n/m
	Total Zinc	n/a	n/a	13.2	53.8	n/m	n/m
PESTICIDES	Chlorpyrifos	n/a	n/a	n/m	n/m	n/m	n/m
	Diazinon	n/a	n/a	n/m	n/m	n/m	n/m
MISCELLANEOUS	Cyanide	n/a	n/a	n/m	n/m	n/m	n/m
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	4.51	14.9	5.60	979
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	76,500	169,000	23,100	40,000
HEAVY METALS	Total Aluminum	n/a	n/a	n/m	3,270,000	15,500	103,000
	Dissolved Nickel	n/a	n/a	n/m	n/m	n/m	n/m
	Nickel	n/a	n/a	1,290	n/m	n/m	796
PAHs	Phenanthrene	n/a	n/a	n/m	n/m	n/m	n/m
	Pyrene	n/a	n/a	n/m	n/m	n/m	n/m
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	30.0	145	n/m	7.46
	Total Phosphorus	n/a	n/a	54.8	170	n/m	18.2
	NH3-N	n/a	n/a	n/m	75.3	n/m	n/m
	Nitrate-N	n/a	n/a	512	642	67.3	282
	Nitrite-N	n/a	n/a	19.0	n/m	n/m	4.15
	TKN	n/a	n/a	339	554	70.7	182

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

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R0012062

Table 4-10e. ESTIMATED MASS POLLUTANT LOADING
COYOTE CREEK
MONITORED WATERSHED

LANDUSE

HDSFR.....	38.3%
Light Ind.....	8.4%
Vacant.....	14.3%
Retail/Comm.....	5.6%
Multi-Fam.Res....	6.1%
Transportation.....	1.8%
Education.....	4.3%
Mixed Residential.	0.2%
All Other.....	21.0%

Total Area: 150 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	n/a	n/a	93,100,000	4,610,000	17,700,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/a	191	n/m	n/m
	Dissolved Copper	n/a	n/a	n/a	5,180	162	364
	Dissolved Lead	n/a	n/a	n/a	3,230	n/m	n/m
	Dissolved Zinc	n/a	n/a	n/a	38,500	1,060	n/m
HEAVY METALS (TOTAL)	Total Copper	n/a	n/a	n/a	7,110	445	645
	Total Lead	n/a	n/a	n/a	4,770	n/m	n/m
	Total Mercury	n/a	n/a	n/a	n/m	n/m	n/m
	Total Zinc	n/a	n/a	n/a	56,600	2,090	2,260
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/m	n/m	n/m
	Diazinon	n/a	n/a	n/a	n/m	n/m	1.11
MISCELLANEOUS	Cyanide	n/a	n/a	n/a		n/m	n/m
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	2,970	n/m	n/m
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	n/a	38,300,000	12,100,000	16,700,000
HEAVY METALS	Total Aluminum	n/a	n/a	n/a	518,000	19,700	17,300
	Dissolved Nickel	n/a	n/a	n/a	1,270	n/m	n/m
	Nickel	n/a	n/a	n/a	2,220	178	284
PAHs	Phenanthrene	n/a	n/a	n/a	n/m	n/m	n/m
	Pyrene	n/a	n/a	n/a	n/m	n/m	n/m
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	n/a	75,100	5,620	16,500
	Total Phosphorus	n/a	n/a	n/a	97,100	6,700	25,000
	NH3-N	n/a	n/a	n/a	141,000	19,500	52,500
	Nitrate-N	n/a	n/a	n/a	147,000	55,800	85,400
	Nitrite-N	n/a	n/a	n/a	29,300	5,540	19,800
	TKN	n/a	n/a	n/a	725,000	112,000	169,000

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

R0012063

Table 4-10f. ESTIMATED MASS POLLUTANT LOADING
SAN GABRIEL RIVER
MONITORED WATERSHED

LANDUSE
HDSFR..... 15.2%
Light Ind..... 2.3%
Vacant..... 66.7%
Retail/Comm..... 1.5%
Multi-Fam.Res.... 1.4%
Transportation..... 1.0%
Education..... 1.6%
Mixed Residential. 0.1%
All Other..... 10.2%

Total Area: 450 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	n/a	n/a	28,700,000	2,810,000	1,380,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/a	n/m	n/m	n/m
	Dissolved Copper	n/a	n/a	n/a	1,120	n/m	n/m
	Dissolved Lead	n/a	n/a	n/a	901	n/m	n/m
	Dissolved Zinc	n/a	n/a	n/a	8,840	1,090	n/m
HEAVY METALS (TOTAL)	Total Copper	n/a	n/a	n/a	2,180	252	75.8
	Total Lead	n/a	n/a	n/a	1,340	n/m	n/m
	Total Mercury	n/a	n/a	n/a	n/m	n/m	n/m
	Total Zinc	n/a	n/a	n/a	14,800	1,730	n/m
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/m	n/m	n/m
	Diazinon	n/a	n/a	n/a	n/m	n/m	0.183
MISCELLANEOUS	Cyanide	n/a	n/a	n/a	2,230	1,240	n/m
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	1,390	n/m	n/m
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	n/a	22,200,000	15,500,000	2,740,000
HEAVY METALS	Total Aluminum	n/a	n/a	n/a	400,000	8,140	4,120
	Dissolved Nickel	n/a	n/a	n/a	449	n/m	n/m
	Nickel	n/a	n/a	n/a	791	n/m	48.0
PAHs	Phenanthrene	n/a	n/a	n/a	n/m	n/m	n/m
	Pyrene	n/a	n/a	n/a	n/m	n/m	n/m
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	n/a	42,500	15,500	2,310
	Total Phosphorus	n/a	n/a	n/a	52,100	17,700	2,710
	NH3-N	n/a	n/a	n/a	136,000	43,900	n/m
	Nitrate-N	n/a	n/a	n/a	135,000	72,200	16,700
	Nitrite-N	n/a	n/a	n/a	26,700	19,800	2,870
	TKN	n/a	n/a	n/a	310,000	134,000	15,000

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

R0012064

Table 4-11a. ESTIMATED MASS POLLUTANT LOADING
UNMONITORED SMBRP BASINS
UNMONITORED WATERSHED

LANDUSE
HDSFR..... 15.5%
Light Ind..... 0.6%
Vacant..... 63.4%
Retail/Comm..... 1.6%
Multi-Fam.Res..... 3.4%
Transportation..... 2.1%
Education..... 1.8%
Mixed Residential... 0.9%
All Other..... 11.2%

Total Area: 174 mi.^{2}
Overall Imperviousness: 0.18

GROUP	CONSTITUENTS	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	306,000,000	3,560,000	21,800,000	2,560,000	16,600,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/a	19.6	n/a	n/a
	Dissolved Copper	1,670	341	574	1,910	392	561
	Dissolved Lead	n/a	n/a	n/a	559	n/a	n/a
	Dissolved Zinc	2,340	1,910	5,780	19,000	4,610	3,980
HEAVY METALS (TOTAL)	Total Copper	3,990	6,340	2,520	4,790	615	1,140
	Total Lead	276	2,330	1,260	2,120	86.9	115
	Total Mercury	n/a	n/a	n/a	n/a	n/a	n/a
	Total Zinc	26,000	7,910	10,200	36,900	5,770	5,100
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/a	n/a	n/a
	Diazinon	n/a	n/a	n/a	n/a	16.9	n/a
MISCELLANEOUS	Cyanide	n/a	n/a	n/a	n/a	n/a	n/a
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	n/a	n/a	n/a	12,000,000
HEAVY METALS	Total Aluminum	n/a	n/a	n/a	n/a	n/a	36,700
	Dissolved Nickel	n/a	n/a	18.6	79.0	31.4	53.3
	Nickel	817	403	308	562	119	335
PAHs	Phenantrene	n/a	n/a	n/a	n/a	n/a	1.09
	Pyrene	n/a	n/a	n/a	n/a	n/a	32.2
NUTRIENTS	Dissolved Phosphorus	n/a	22,920	19,600	46,600	9,300	14,800
	Total Phosphorus	n/a	1,380,000	37,000	53,200	10,800	23,400
	NH3-N	n/a	25,400	8,310	52,700	28,200	22,300
	Nitrate-N	n/a	172,000	127,000	127,000	39,900	111,000
	Nitrite-N	n/a	3,590,000	6,930	13,500	3,020	7,480
	TKN	n/a	4,440,000	182,000	332,000	104,000	180,000

n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

R0012065

Table 4-11b. ESTIMATED MASS POLLUTANT LOADING
SANTA CLARA RIVER
UNMONITORED WATERSHED

LANDUSE
HDSFR..... 1.8%
Light Ind..... 0.3%
Vacant.....88.2%
Retail/Comm..... 0.2%
Multi-Fam.Res.... 0.3%
Transportation..... 0.4%
Education..... 0.2%
Mixed Residential. 0%
All Other.....8.6%

Total Area: 653 mi.^{2}
Overall Imperviousness: 0.07

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	900,000,000	10,300,000	71,900,000	5,300,000	41,200,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/a	13.0	n/a	n/a
	Dissolved Copper	697	414	465	3,320	440	521
	Dissolved Lead	n/a	n/a	n/a	1,650	n/a	n/a
	Dissolved Zinc	1,140	4,800	15,800	46,800	9,310	10,300
HEAVY METALS (TOTAL)	Total Copper	1,660	16,100	3,740	10,400	737	1,570
	Total Lead	135	9,000	740	3,710	159	179
	Total Mercury	n/a	n/a	n/a	n/a	n/a	n/a
	Total Zinc	10,900	12,300	18,900	104,000	10,300	13,000
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/a	n/a	n/a
	Diazinon	n/a	n/a	n/a	n/a	1.33	n/a
MISCELLANEOUS	Cyanide	n/a	n/a	n/a	n/a	n/a	n/a
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	n/a	n/a	n/a	29,000,000
HEAVY METALS	Total Aluminum	n/a	n/a	n/a	n/a	n/a	93,400
	Dissolved Nickel	n/a	n/a	81.0	482	75.8	138
	Nickel	327	410	301	1,080	152	809
PAHs	Phenantrene	n/a	n/a	n/a	n/a	n/a	n/a
	Pyrene	n/a	n/a	n/a	n/a	n/a	15.0
NUTRIENTS	Dissolved Phosphorus	n/a	8,780	25,400	94,100	9,260	15,500
	Total Phosphorus	n/a	3,560,000	52,600	108,000	10,900	27,100
	NH3-N	n/a	28,400	20,900	90,500	22,800	21,100
	Nitrate-N	n/a	319,000	215,000	403,000	67,200	226,000
	Nitrite-N	n/a	8,200,000	9,550	13,100	2,970	9,130
	TKN	n/a	28,400	222,000	630,000	155,000	232,000

n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available

Table 4-11b.xls

R0012066

Table 4-11c. ESTIMATED MASS POLLUTANT LOADING
DOMINGUEZ CHANNEL / L.A. HARBOR
UNMONITORED WATERSHED

LANDUSE
HDSFR.....34.2%
Light Ind.....13.2%
Vacant..... 2.5%
Retail/Comm..... 6.2%
Multi-Fam.Res..... 5.8%
Transportation..... 4.7%
Education..... 3.7%
Mixed Residential. 4.3%
All Other..... 25.4%

Total Area: 110 $mi.^2$
Overall Imperviousness: 0.62

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
GENERAL MINERALS	Suspended Solids	n/a	33,000,000	8,740,000	41,500,000	6,320,000	12,600,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	n/a	n/a	n/a	41.9	n/a	n/a
	Dissolved Copper	2,210	993	1,040	4,480	783	915
	Dissolved Lead	n/a	n/a	n/a	2,040	n/a	n/a
	Dissolved Zinc	4,960	8,040	25,400	57,900	13,400	13,600
HEAVY METALS (TOTAL)	Total Copper	5,220	4,110	5,230	8,090	1,300	1,520
	Total Lead	586	12,900	1,940	5,180	251	260
	Total Mercury	n/a	n/a	n/a	n/a	n/a	n/a
	Total Zinc	35,600	22,900	26,200	93,100	15,500	17,200
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/a	n/a	n/a
	Diazinon	n/a	n/a	n/a	n/a	42.0	n/a
MISCELLANEOUS	Cyanide	n/a	n/a	n/a	n/a	n/a	n/a
1999-2000 Additional Constituents of Concern							
GENERAL MINERALS	Total Dissolved Solids	n/a	n/a	n/a	n/a	n/a	7,350,000
HEAVY METALS	Total Aluminum	n/a	n/a	n/a	n/a	n/a	40,600
	Dissolved Nickel	n/a	n/a	117	487	93.5	176
	Nickel	926	839	630	1,600	241	446
PAHs	Phenantrene	n/a	n/a	n/a	n/a	n/a	2.72
	Pyrene	n/a	n/a	n/a	n/a	n/a	37.1
NUTRIENTS	Dissolved Phosphorus	n/a	32,400	27,900	74,000	17,400	19,500
	Total Phosphorus	n/a	695,000	56,400	87,700	20,600	29,600
	NH3-N	n/a	71,600	34,800	79,700	59,400	38,300
	Nitrate-N	n/a	167,000	127,000	89,500	48,100	92,000
	Nitrite-N	n/a	1,650,000	9,720	25,800	5,890	9,570
	TKN	n/a	1,450,000	283,000	537,000	201,000	225,000

n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

Table 4-11c.xls

R0012067

Table 4-12. Summary of 1994-2000 Land Use Results by Site

	Data Included Since[a]	DL	Units	Commercial						Vacant						High Density Single Family Residential					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																					
Cyanide	96	0.01	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	15	15	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
TPH	94	1	mg/l	8	2	75	3.1	2.9	0.63	21	19	10	S.I.D.	S.I.D.	S.I.D.	3	0	100	1.3	1.2	0.23
Oil and Grease	94	1	mg/l	8	1	88	3.3	2.9	0.51	21	17	19	S.I.D.	S.I.D.	S.I.D.	3	0	100	1.3	1.2	0.23
Total Phenols	94	0.1	mg/l	8	8	0	S.I.D.	S.I.D.	S.I.D.	21	21	0	S.I.D.	S.I.D.	S.I.D.	3	3	0	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria																					
Total Coliform	94	20	MPN/100ml	8	0	100	1,140,000	1,250,000	0.71	21	1	95	9,187	2,200	1.25	3	0	100	1,366,667	1,600,000	0.30
Fecal Coliform	94	20	MPN/100ml	8	0	100	528,750	90,000	1.35	21	2	90	1,397	500	2.60	3	0	100	933,333	900,000	0.70
Ratio Fecal Coliform/Total Coliform	94			0	0	S.I.D.	S.I.D	S.I.D.	S.I.D.	7	0	100	52%	64%	0.79	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fecal Streptococcus	94	20	MPN/100ml	8	0	100	212,875	150,000	1.37	21	1	95	2,254	800	1.57	3	0	100	1,233,333	1,600,000	0.51
Fecal Enterococcus	94	20	MPN/100ml	8	0	100	86,250	40,000	1.18	21	1	95	679	500	0.88	3	0	100	610,000	140,000	1.41
General Minerals																					
Ammonia	94	0.1	mg/l	33	7	79	1.26	0.30	2.11	41	27	34	0.13	0.05	2.48	34	6	82	0.41	0.30	1.05
Calcium	96	1.0	mg/l	30	0	100	19	11	0.86	39	0	100	50	50	0.09	32	1	97	6.7	5.8	0.55
Magnesium	96	1.0	mg/l	30	0	100	6.8	3.9	0.92	39	0	100	15	16	0.26	32	8	75	1.5	1.2	0.66
Potassium	94	1.0	mg/l	36	0	100	4.0	2.8	0.81	45	0	100	2.4	2.4	0.22	38	0	100	3.8	2.9	0.66
Sodium	96	1.0	mg/l	33	0	100	37	19	1.03	45	0	100	13	14	0.20	36	0	100	6.2	5.0	0.81
Bicarbonate	94	2.0	mg/l	33	0	100	48	21	0.93	42	0	100	175	176	0.15	35	0	100	21	13	1.04
Carbonate	94	2.0	mg/l	33	33	0	S.I.D.	S.I.D.	S.I.D.	42	36	14	S.I.D.	S.I.D.	S.I.D.	35	35	0	S.I.D.	S.I.D.	S.I.D.
Chloride	94	2.0	mg/l	33	0	100	50	15.8	1.28	43	0	100	6.6	6.5	0.26	33	2	94	5.0	4.2	0.69
Fluoride	94	0.1	mg/l	33	18	45	0.13	0.05	0.81	43	0	100	0.37	0.36	0.21	33	27	18	S.I.D.	S.I.D.	S.I.D.
Nitrate	94	0.1	mg/l	33	1	97	2.6	2.0	0.63	43	0	100	5.2	4.6	0.56	33	1	97	3.9	2.1	1.38
Sulfate	94	0.1	mg/l	33	0	100	35	11	1.18	43	0	100	17	15	0.40	33	0	100	6.9	3.8	1.05
Alkalinity	94	4.0	mg/l	33	0	100	48	21	0.93	42	0	100	169	174	0.13	35	0	100	20	13	0.91
Hardness	96	2.0	mg/l	30	0	100	76	42	0.87	39	0	100	185	190	0.11	31	0	100	23	20	0.53
COD	97	5	mg/l	24	0	100	98	89	0.80	34	15	56	17	11	1.35	32	5	84	69	39	1.87
pH	94	0-14		33	0	100	7.0	6.9	0.07	42	0	100	8.1	8.1	0.03	35	0	100	6.5	6.5	0.06
Specific Conductance	94	1.0	umhos/cm	31	0	100	356	167	0.99	38	0	100	386	390	0.11	33	0	100	90	61	0.77
Total Dissolved Solids	96	2.0	mg/l	29	0	100	226	106	0.93	36	0	100	237	240	0.09	32	0	100	58	38	0.80
Turbidity	94	0.1	NTU	33	0	100	31	24	0.67	41	0	100	69	5.6	2.30	34	0	100	34	19	1.17
Total Suspended Solids	96	2.0	mg/l	29	0	100	66	53	0.65	39	1	97	186	18	3.27	30	0	100	95	61	1.16
Volatile Suspended Solids	94	1.0	mg/l	31	0	100	32	29	0.54	41	7	83	36	12	2.48	31	0	100	46	31	0.91
MBAS	97	0.05	mg/l	22	11	50	0.18	0.04	1.52	30	30	0	S.I.D.	S.I.D.	S.I.D.	29	26	10	S.I.D.	S.I.D.	S.I.D.
Total Organic Carbon	94	1.0	mg/l	35	0	100	10	7.3	0.74	43	0	100	5.3	3.6	0.84	36	0	100	9.8	7.1	0.76
BOD	94	2.0	mg/l	26	1	96	27	24	0.58	39	4	90	12	5.0	1.01	27	0	100	16	15	0.68
Nutrients																					
Dissolved Phosphorus	94	0.05	mg/l	33	1	97	0.30	0.19	0.86	37	21	43	0.11	0.03	3.38	32	0	100	0.29	0.25	0.57
Total Phosphorus	94	0.05	mg/l	32	1	97	0.39	0.28	0.77	39	16	59	0.16	0.05	2.63	32	0	100	0.39	0.32	0.77
NH3-N	94	0.1	mg/l	33	8	76	1.04	0.25	2.11	41	30	27	0.11	0.05	2.41	34	7	79	0.34	0.25	1.04
Nitrate-N	96	0.1	mg/l	31	7	77	0.48	0.43	0.82	40	1	98	1.05	0.94	0.53	32	11	66	0.86	0.46	1.51
Nitrite-N	94	0.1	mg/l	34	7	79	0.16	0.07	1.74	43	30	30	0.05	0.05	0.20	33	12	64	0.10	0.05	1.01
TKN	96	0.1	mg/l	32	0	100	3.4	2.2	0.94	40	0	100	0.79	0.68	0.60	35	0	100	2.9	2.0	1.04
Metals																					
Dissolved Aluminum	96	100	µg/l	33	24	27	241	50	3.19	42	29	31	190	50	2.39	36	26	28	105	50	1.03
Total Aluminum	96	100	µg/l	33	8	76	4055	295	4.67	42	13	69	1681	234	5.25	36	6	83	599	287	1.08
Dissolved Antimony	97	5	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Total Antimony	97	5	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	97	5	µg/l	24	23	4	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	97	5	µg/l	24	22	8	S.I.D.	S.I.D.	S.I.D.	34	32	6	S.I.D.	S.I.D.	S.I.D.	32	29	9	S.I.D.	S.I.D.	S.I.D.
Dissolved Barium	97	10	µg/l	24	2	92	39	33	0.81	34	2	94	57	58	0.41	32	17	47	14	5.0	0.92
Total Barium	97	10	µg/l	24	2	92	114	41	2.64	34	2	94	83	62	1.59	32	11	66	21	21	0.72
Dissolved Beryllium	97	1	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	19	19	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	97	1	µg/l	24	23	4	S.I.D.	S.I.D.	S.I.D.	34	33	3	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	97	100	µg/l	24	3	88	198	188	0.49	32	14	56	121	116	0.65	32	12	63	126	125	0.58
Total Boron	97	100	µg/l	24	1	96	261	254	0.41	32	8	75	178	170	0.59	32	5	84	181	171	0.52
Dissolved Cadmium	97	1	µg/l	24	21	13	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	31	3	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	97	1	µg/l	24	19	21	0.73	0.50	0.71	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	30	6	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	97	5	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium	97	5	µg/l	24	18	25	27	2.5	4.16	34	33	3	S.I.D.	S.I.D.	S.I.D.	32	29	9	S.I.D.	S.I.D.	S.I.D.

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Table 4-12. Summary of 1994-2000 Land Use Results by Site

	Data Included Since[a]	DL	Units	Commercial						Vacant						High Density Single Family Residential					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Chromium +6	94	10	µg/l	33	33	0	S.I.D.	S.I.D.	S.I.D.	41	41	0	S.I.D.	S.I.D.	S.I.D.	36	36	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	94	10	µg/l	33	33	0	S.I.D.	S.I.D.	S.I.D.	41	41	0	S.I.D.	S.I.D.	S.I.D.	36	36	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Copper	97	5	µg/l	24	3	88	14	11	0.84	34	31	9	S.I.D.	S.I.D.	S.I.D.	32	15	53	8.5	6.7	0.95
Total Copper	97	5	µg/l	24	0	100	39	22	1.57	34	15	56	15	5.5	3.14	32	2	94	15	11	0.57
Dissolved Iron	94	100	µg/l	39	17	56	382	106	2.81	45	35	22	202	50	3.27	38	27	29	123	50	1.20
Total Iron	94	100	µg/l	40	2	95	5319	567	5.24	45	14	69	3003	233	5.23	38	7	82	1117	546	1.36
Dissolved Lead	97	5	µg/l	24	20	17	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	28	13	S.I.D.	S.I.D.	S.I.D.
Total Lead	97	5	µg/l	24	15	38	18	2.5	2.80	34	31	9	S.I.D.	S.I.D.	S.I.D.	32	14	56	10	5.4	1.03
Dissolved Manganese	98	100	µg/l	14	14	0	S.I.D.	S.I.D.	S.I.D.	18	18	0	S.I.D.	S.I.D.	S.I.D.	11	10	9	S.I.D.	S.I.D.	S.I.D.
Total Manganese	98	100	µg/l	14	13	7	S.I.D.	S.I.D.	S.I.D.	18	14	22	67	50	0.48	11	10	9	S.I.D.	S.I.D.	S.I.D.
Dissolved Mercury	94	1	µg/l	37	35	5	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.	35	35	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	94	1	µg/l	37	35	5	S.I.D.	S.I.D.	S.I.D.	43	42	2	S.I.D.	S.I.D.	S.I.D.	35	34	3	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	97	5	µg/l	24	21	13	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Nickel	97	5	µg/l	24	16	33	15	2.5	3.69	34	29	15	S.I.D.	S.I.D.	S.I.D.	32	27	16	S.I.D.	S.I.D.	S.I.D.
Dissolved Selenium	94	5	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.	38	38	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	94	5	µg/l	40	35	13	S.I.D.	S.I.D.	S.I.D.	45	44	2	S.I.D.	S.I.D.	S.I.D.	38	38	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	97	1	µg/l	24	23	4	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	97	1	µg/l	24	22	8	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	31	3	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	97	5	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	97	5	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	94	50	µg/l	40	4	90	152	130	0.66	45	43	4	S.I.D.	S.I.D.	S.I.D.	38	30	21	44	25	1.42
Total Zinc	94	50	µg/l	40	0	100	241	192	0.71	45	33	27	46	25	1.67	38	13	66	79	66	0.75
SVOCs																					
Bis(2-ethylhexyl)phthalate	99	1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
PAHs																					
Acenaphthene	99	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	99	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Anthracene	99	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	4	20	S.I.D.	S.I.D.	1.24
Benzo(a)pyrene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	4	20	S.I.D.	S.I.D.	1.29
Benzo(k)fluoranthene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	4	20	S.I.D.	S.I.D.	1.18
Chrysene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	4	20	S.I.D.	S.I.D.	1.18
Dibenz(a,h)anthracene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.	5	3	40	0.53	0.050	1.67
Fluorene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	99	0.1	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.
Naphthalene	99	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.	5	3	40	0.04	0.025	0.59
Phenanthrene	99	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.	5	3	40	0.13	0.025	1.66
Pyrene	99	0.05	µg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.	5	1	80	0.83	0.37	1.44
All other SVOCs	94	0.05-5.0	µg/l	23	23	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	26	26	0	S.I.D.	S.I.D.	S.I.D.
Pesticides																					
Organochlorine Pesticides & PCBs	94	0.05-1.0	µg/l	19	19	0	S.I.D.	S.I.D.	S.I.D.	38	38	0	S.I.D.	S.I.D.	S.I.D.	31	31	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	96	5	µg/l	28	28	0	S.I.D.	S.I.D.	S.I.D.	38	38	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	98	25	µg/l	14	14	0	S.I.D.	S.I.D.	S.I.D.	18	18	0	S.I.D.	S.I.D.	S.I.D.	11	11	0	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides																					
Diazinon	96	0.01	µg/l	24	21	13	S.I.D.	S.I.D.	S.I.D.	36	36	0	S.I.D.	S.I.D.	S.I.D.	30	28	7	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	96	0.05	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	36	36	0	S.I.D.	S.I.D.	S.I.D.	30	30	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides																					
Thiobencarb	96	1	µg/l	24	24	0	S.I.D.	S.I.D.	S.I.D.	36	36	0	S.I.D.	S.I.D.	S.I.D.	30	30	0	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticieds	94	1.0-2.0	µg/l	28	28	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.	32	32	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides																					
2,4-D	96	10	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	35	35	0	S.I.D.	S.I.D.	S.I.D.	27	27	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	96	1	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	35	35	0	S.I.D.	S.I.D.	S.I.D.	27	27	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	96	2	µg/l	17	17	0	S.I.D.	S.I.D.	S.I.D.	35	35	0	S.I.D.	S.I.D.	S.I.D.	27	27	0	S.I.D.	S.I.D.	S.I.D.

CV = Coefficient of variation
DL = Detection Limit
S.I.D. = Statistically invalid Data, not enough data above detection limit collected

a) Detection limits have changed throughout the monitoring process. Only data matching the current detection limit is displayed in this table. The *Data Included Since* field indicates the first year of the storm season with the current detection limit.

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Table 4-12. Summary of 1994-2000 Land Use Results by Site

	Data Included Since[a]	DL	Units	Transportation						Light Industrial						Educational					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents																					
Cyanide	96	0.01	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
TPH	94	1	mg/l	4	0	100	3.1	2.8	0.47	5	1	80	1.7	1.4	0.68	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Oil and Grease	94	1	mg/l	4	0	100	3.1	2.8	0.47	5	1	80	1.7	1.4	0.68	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Total Phenols	94	0.1	mg/l	4	4	0	S.I.D.	S.I.D.	S.I.D.	5	5	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria																					
Total Coliform	94	20	MPN/100ml	4	0	100	692,500	600,000	0.82	5	0	100	454,000	160,000	1.42	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fecal Coliform	94	20	MPN/100ml	4	0	100	328,750	205,000	1.22	5	0	100	338,220	30,000	2.09	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Ratio Fecal Coliform/Total Coliform	94			0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fecal Streptococcus	94	20	MPN/100ml	4	0	100	176,000	195,000	0.68	5	0	100	253,000	160,000	1.46	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fecal Enterococcus	94	20	MPN/100ml	4	0	100	32,000	32,000	0.65	5	0	100	98,200	130,000	0.73	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
General Minerals																					
Ammonia	94	0.1	mg/l	62	16	74	0.29	0.16	1.52	47	7	85	0.59	0.32	1.35	40	12	70	0.33	0.16	1.62
Calcium	96	1.0	mg/l	61	0	100	8.4	7.7	0.46	40	0	100	12	8.8	1.01	39	0	100	16	10	0.71
Magnesium	96	1.0	mg/l	61	4	93	1.6	1.5	0.48	40	0	100	2.3	1.9	1.13	38	8	79	3.2	2.4	0.96
Potassium	94	1.0	mg/l	63	2	97	2.1	1.7	0.56	50	1	98	2.7	2.2	0.59	41	0	100	3.4	2.7	0.49
Sodium	96	1.0	mg/l	62	0	100	8.3	6.4	0.81	47	0	100	14	12	0.69	41	0	100	26	8.0	2.21
Bicarbonate	94	2.0	mg/l	63	0	100	20	18	0.57	47	0	100	26	20	0.92	40	0	100	39	28	0.76
Carbonate	94	2.0	mg/l	63	63	0	S.I.D.	S.I.D.	S.I.D.	47	47	0	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.
Chloride	94	2.0	mg/l	64	3	95	5.6	4.4	0.82	47	0	100	12	8.6	0.80	40	4	90	34	4.6	2.89
Fluoride	94	0.1	mg/l	64	41	36	0.10	0.05	0.97	47	22	53	0.13	0.11	0.94	40	24	40	0.14	0.050	1.21
Nitrate	94	0.1	mg/l	64	2	97	2.9	1.8	1.27	47	0	100	4.1	2.4	1.09	40	2	95	2.6	2.2	0.73
Sulfate	94	0.1	mg/l	64	0	100	9.5	6.4	1.07	47	0	100	12.6	9.2	1.02	40	0	100	17.3	9.3	1.23
Alkalinity	94	4.0	mg/l	63	0	100	20	16	0.55	47	0	100	25	19	0.94	40	0	100	36	26	0.72
Hardness	96	2.0	mg/l	61	0	100	27	24	0.48	40	0	100	39	30	1.02	39	0	100	52	40	0.79
COD	97	5	mg/l	62	7	87	50	33	0.99	36	4	89	80	51	0.92	40	10	75	37	34	0.65
pH	94	0-14		63	0	100	6.7	6.6	0.05	47	0	100	6.8	6.6	0.06	40	0	100	7.0	6.9	0.07
Specific Conductance	94	1.0	umhos/cm	63	0	100	99	84	0.66	43	0	100	147	119	0.77	39	0	100	243	111	1.41
Total Dissolved Solids	96	2.0	mg/l	61	0	100	62	54	0.59	40	0	100	95	77	0.80	39	0	100	147	68	1.35
Turbidity	94	0.1	NTU	64	0	100	31	22	1.25	47	0	100	76	55	1.59	41	0	100	64	36	1.14
Total Suspended Solids	96	2.0	mg/l	61	0	100	78	50	1.30	41	0	100	240	129	1.36	39	0	100	95	61	1.05
Volatile Suspended Solids	94	1.0	mg/l/hr	63	1	98	31	20	1.22	43	0	100	57	46	0.79	39	0	100	23	21	0.59
MBAS	97	0.05	mg/l	61	30	41	2.6	0.025	6.95	32	10	69	0.13	0.11	0.90	38	33	13	S.I.D.	S.I.D.	S.I.D.
Total Organic Carbon	94	1.0	mg/l	63	0	100	8.7	6.8	0.71	47	0	100	11.9	9.8	0.77	42	0	100	7.5	6.5	0.50
BOD	94	2.0	mg/l	54	0	100	21	19	0.60	37	0	100	20	17	0.67	34	0	100	13	12	0.58
Nutrients																					
Dissolved Phosphorus	94	0.05	mg/l	59	3	95	0.34	0.28	0.79	46	4	91	0.27	0.20	1.01	37	1	97	0.27	0.20	0.86
Total Phosphorus	94	0.05	mg/l	59	1	98	0.44	0.32	0.84	45	2	96	0.41	0.30	0.92	37	0	100	0.31	0.23	0.65
NH3-N	96	0.1	mg/l	62	19	69	0.24	0.14	1.51	48	9	81	0.48	0.26	1.36	40	12	70	0.28	0.15	1.58
Nitrate-N	96	0.1	mg/l	61	15	75	0.70	0.40	1.68	43	2	95	0.87	0.52	1.32	39	12	69	0.51	0.46	0.86
Nitrite-N	94	0.1	mg/l	64	10	84	0.09	0.06	0.72	47	9	81	0.09	0.05	0.73	39	13	67	0.09	0.05	1.41
TKN	96	0.1	mg/l	61	0	100	1.9	1.3	0.93	45	0	100	3.0	2.3	0.72	38	0	100	1.6	1.3	0.73
Metals																					
Dissolved Aluminum	96	100	µg/l	62	29	53	159	107	1.18	47	23	51	460	117	1.96	42	11	74	397	248	1.21
Total Aluminum	96	100	µg/l	63	10	84	672	354	1.65	47	7	85	1824	470	2.37	42	2	95	881	720	0.83
Dissolved Antimony	97	5	µg/l	54	53	2	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Total Antimony	97	5	µg/l	54	53	2	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	97	5	µg/l	54	54	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	39	7	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	97	5	µg/l	54	52	4	S.I.D.	S.I.D.	S.I.D.	37	34	8	S.I.D.	S.I.D.	S.I.D.	42	39	7	S.I.D.	S.I.D.	S.I.D.
Dissolved Barium	97	10	µg/l	54	15	72	19	17	0.75	37	6	84	34	26	0.81	42	6	86	28	26	0.72
Total Barium	97	10	µg/l	54	9	83	34	27	0.88	37	4	89	68	36	1.38	42	6	86	37	33	0.74
Dissolved Beryllium	97	1	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	34	34	0	S.I.D.	S.I.D.	S.I.D.	28	28	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	97	1	µg/l	54	54	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	97	100	µg/l	54	16	70	148	132	0.55	37	18	51	122	102	0.71	42	5	88	189	153	0.65
Total Boron	97	100	µg/l	54	5	91	219	214	0.50	36	10	72	187	181	0.63	42	4	90	254	227	0.58
Dissolved Cadmium	97	1	µg/l	54	50	7	S.I.D.	S.I.D.	S.I.D.	37	34	8	S.I.D.	S.I.D.	S.I.D.	42	40	5	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	97	1	µg/l	54	32	41	1.1	0.50	1.04	37	30	19	S.I.D.	S.I.D.	S.I.D.	42	34	19	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	97	5	µg/l	54	51	6	S.I.D.	S.I.D.	S.I.D.	37	33	11	S.I.D.	S.I.D.	S.I.D.	42	41	2	S.I.D.	S.I.D.	S.I.D.
Total Chromium	97	5	µg/l	54	40	26	4.8	2.5	1.15	37	25	32	6.8	2.5	1.60	42	33	21	3.6	2.5	0.74

R0012070

Table 4-12. Summary of 1994-2000 Land Use Results by Site

	Data Included Since[a]	DL	Units	Transportation						Light Industrial						Educational					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Chromium +6	94	10	µg/l	63	63	0	S.I.D.	S.I.D.	S.I.D.	47	47	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	94	10	µg/l	63	63	0	S.I.D.	S.I.D.	S.I.D.	47	47	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Copper	97	5	µg/l	54	0	100	33	27	0.63	37	5	86	20	14	1.07	42	8	81	13	9.9	0.94
Total Copper	97	5	µg/l	54	0	100	56	39	1.15	37	0	100	32	21	1.03	42	0	100	24	15	1.49
Dissolved Iron	94	100	µg/l	65	34	48	200	50	1.90	51	25	51	698	104	2.99	42	15	64	454	190	2.30
Total Iron	94	100	µg/l	65	2	97	1188	512	1.74	51	5	90	8504	600	4.26	42	4	90	2705	625	3.32
Dissolved Lead	97	5	µg/l	54	48	11	S.I.D.	S.I.D.	S.I.D.	37	32	14	S.I.D.	S.I.D.	S.I.D.	42	40	5	S.I.D.	S.I.D.	S.I.D.
Total Lead	97	5	µg/l	54	28	48	10	2.5	1.57	37	18	51	17	5.1	1.88	42	30	29	4.9	2.5	1.09
Dissolved Manganese	98	100	µg/l	27	25	7	S.I.D.	S.I.D.	S.I.D.	26	23	12	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.
Total Manganese	98	100	µg/l	27	25	7	S.I.D.	S.I.D.	S.I.D.	26	23	12	S.I.D.	S.I.D.	S.I.D.	17	17	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Mercury	94	1	µg/l	63	63	0	S.I.D.	S.I.D.	S.I.D.	48	48	0	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	94	1	µg/l	63	62	2	S.I.D.	S.I.D.	S.I.D.	48	45	6	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	97	5	µg/l	54	41	24	3.9	2.5	0.93	37	23	38	5.0	2.5	0.90	42	38	10	S.I.D.	S.I.D.	S.I.D.
Nickel	97	5	µg/l	54	29	46	6.0	2.5	1.07	37	15	59	9.8	6.0	1.47	42	26	38	4.7	2.5	0.69
Dissolved Selenium	94	5	µg/l	65	65	0	S.I.D.	S.I.D.	S.I.D.	51	51	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	94	5	µg/l	65	61	6	S.I.D.	S.I.D.	S.I.D.	51	48	6	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	97	1	µg/l	54	54	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	97	1	µg/l	54	54	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	97	5	µg/l	54	54	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	97	5	µg/l	54	54	0	S.I.D.	S.I.D.	S.I.D.	37	37	0	S.I.D.	S.I.D.	S.I.D.	42	42	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	94	50	µg/l	65	5	92	192	152	0.74	51	3	94	407	303	1.18	42	19	55	68	56	0.83
Total Zinc	94	50	µg/l	65	0	100	291	218	0.99	51	0	100	639	365	1.53	42	5	88	138	98	1.73
SVOCs																					
Bis(2-ethylhexyl)phthalate	99	1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
PAHs																					
Acenaphthene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Anthracene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(a)pyrene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Benzo(k)fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Chrysene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Dibenz(a,h)anthracene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fluorene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	99	0.1	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Naphthalene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Phenanthrene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Pyrene	99	0.05	µg/l	1	1	0	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
All other SVOCs	94	0.05-5.0	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.	23	23	0	S.I.D.	S.I.D.	S.I.D.
Pesticides																					
Organochlorine Pesticides & PCBs	94	0.05-1.0	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	20	20	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	96	5	µg/l	60	60	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	98	25	µg/l	27	25	7	S.I.D.	S.I.D.	S.I.D.	26	26	0	S.I.D.	S.I.D.	S.I.D.	17	15	12	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides																					
Diazinon	96	0.01	µg/l	57	56	2	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	96	0.05	µg/l	57	57	0	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides																					
Thiobencarb	96	1	µg/l	57	57	0	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticide	94	1.0-2.0	µg/l	58	58	0	S.I.D.	S.I.D.	S.I.D.	43	43	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides																					
2,4-D	96	10	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	96	1	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	96	2	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	22	22	0	S.I.D.	S.I.D.	S.I.D.	24	24	0	S.I.D.	S.I.D.	S.I.D.

CV = Coefficient of variation

DL = Detection Limit

S.I.D. = Statistically invalid Data, not enough data above detection limit collected

a) Detection limits have changed through out the monitoring process. Only data matching the current detection limit is displayed in this table. The Data Included Since field indicates the first year of the storm season with the current detection limit.

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Table 4-12. Summary of 1994-2000 Land Use Results by Site

	Data Included Since[a]	DL	Units	Multifamily Residential						Mixed Residential					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents															
Cyanide	96	0.01	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
TPH	94	1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
Oil and Grease	94	1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.
Total Phenols	94	0.1	mg/l	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	1	0	S.I.D.	S.I.D.	S.I.D.
Indicator Bacteria															
Total Coliform	94	20	MPN/100ml	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
Fecal Coliform	94	20	MPN/100ml	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
Ratio Fecal Coliform/Total Coliform	94			0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
Fecal Streptococcus	94	20	MPN/100ml	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	1	0	100	S.I.D.	S.I.D.	S.I.D.
Fecal Enterococcus	94	20	MPN/100ml	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.
General Minerals															
Ammonia	94	0.1	mg/l	38	9	76	0.47	0.29	1.44	42	4	90	0.67	0.39	1.13
Calcium	96	1.0	mg/l	35	0	100	19.3	8.0	1.20	39	1	97	7.5	6.4	0.70
Magnesium	96	1.0	mg/l	35	9	74	3.3	1.9	1.24	39	7	82	1.7	1.5	0.82
Potassium	94	1.0	mg/l	44	4	91	2.3	2.1	0.65	45	6	87	2.2	2.1	0.89
Sodium	96	1.0	mg/l	44	1	98	10	5.4	1.20	45	2	96	6.5	4.8	1.31
Bicarbonate	94	2.0	mg/l	38	0	100	39	17	1.19	40	0	100	17	14	0.82
Carbonate	94	2.0	mg/l	38	38	0	S.I.D.	S.I.D.	S.I.D.	40	40	0	S.I.D.	S.I.D.	S.I.D.
Chloride	94	2.0	mg/l	37	8	78	13	3.0	1.49	38	10	74	3.5	2.7	0.93
Fluoride	94	0.1	mg/l	37	20	46	0.16	0.05	1.07	38	25	34	0.11	0.05	0.98
Nitrate	94	0.1	mg/l	37	1	97	5.3	3.6	0.87	38	3	92	6.8	2.3	3.74
Sulfate	94	0.1	mg/l	37	0	100	15	4.1	1.52	38	0	100	7.4	5.0	0.94
Alkalinity	94	4.0	mg/l	39	0	100	37	17	1.16	40	0	100	16	14	0.73
Hardness	96	2.0	mg/l	35	0	100	55	26	1.11	39	1	97	25	20	0.75
COD	97	5	mg/l	43	6	86	60	26	2.02	45	8	82	64	34	1.27
pH	94	0-14		39	0	100	6.9	6.8	0.10	40	0	100	6.5	6.4	0.05
Specific Conductance	94	1.0	umhos/cm	33	0	100	169	61	1.18	40	1	98	85	58	0.85
Total Dissolved Solids	96	2.0	mg/l	33	0	100	105	42	1.19	40	1	98	53	37	0.88
Turbidity	94	0.1	NTU	39	0	100	23	10	1.55	40	0	100	21	15	1.06
Total Suspended Solids	96	2.0	mg/l	38	1	97	46	24	1.41	38	0	100	63	40	1.19
Volatile Suspended Solids	94	1.0	mg/l	38	2	94	19	13	1.01	37	2	95	35	25	1.33
MBAS	97	0.05	mg/l	36	26	28	0.049	0.025	1.13	39	25	36	0.068	0.025	1.66
Total Organic Carbon	94	1.0	mg/l	37	0	100	8.9	8.0	0.85	43	0	100	8.8	6.8	0.74
BOD	94	2.0	mg/l	31	2	94	11	9	0.91	34	0	100	18	14	0.90
Nutrients															
Dissolved Phosphorus	94	0.05	mg/l	30	1	97	0.16	0.10	1.04	39	2	95	0.20	0.14	0.87
Total Phosphorus	94	0.05	mg/l	30	1	97	0.19	0.14	1.00	39	1	97	0.26	0.18	0.99
NH3-N	94	0.1	mg/l	38	9	76	0.39	0.24	1.43	42	5	88	0.58	0.33	1.13
Nitrate-N	96	0.1	mg/l	37	12	68	1.10	0.80	1.01	38	13	66	0.55	0.44	0.91
Nitrite-N	94	0.1	mg/l	37	10	73	0.10	0.05	1.65	38	7	82	0.12	0.06	1.47
TKN	96	0.1	mg/l	41	0	100	2.0	1.5	1.11	43	1	98	2.5	1.7	0.95
Metals															
Dissolved Aluminum	96	100	µg/l	45	33	27	115	50	1.58	44	33	25	182	50	2.72
Total Aluminum	96	100	µg/l	45	5	89	387	300	0.91	45	6	87	513	271	1.69
Dissolved Antimony	97	5	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Total Antimony	97	5	µg/l	46	45	0	S.I.D.	S.I.D.	S.I.D.	45	44	2	S.I.D.	S.I.D.	S.I.D.
Dissolved Arsenic	97	5	µg/l	45	44	2	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Total Arsenic	97	5	µg/l	45	44	2	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Barium	97	10	µg/l	45	18	60	20	14	0.92	45	19	58	18	14	1.11
Total Barium	97	10	µg/l	46	13	71	25	20	0.81	45	12	73	29	22	1.45
Dissolved Beryllium	97	1	µg/l	31	31	0	S.I.D.	S.I.D.	S.I.D.	31	31	0	S.I.D.	S.I.D.	S.I.D.
Total Beryllium	97	1	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Boron	97	100	µg/l	42	12	71	148	128	0.65	44	21	52	114	111	0.66
Total Boron	97	100	µg/l	43	7	84	202	168	0.58	44	11	75	184	161	0.58
Dissolved Cadmium	97	1	µg/l	45	44	2	S.I.D.	S.I.D.	S.I.D.	45	43	4	S.I.D.	S.I.D.	S.I.D.
Total Cadmium	97	1	µg/l	45	44	2	S.I.D.	S.I.D.	S.I.D.	45	43	4	S.I.D.	S.I.D.	S.I.D.
Dissolved Chromium	97	5	µg/l	45	43	4	S.I.D.	S.I.D.	S.I.D.	45	44	2	S.I.D.	S.I.D.	S.I.D.
Total Chromium	97	5	µg/l	45	39	13	S.I.D.	S.I.D.	S.I.D.	45	42	7	S.I.D.	S.I.D.	S.I.D.

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Table ... 12. Summary of 1994-2000 Land Use Results by Site

	Data Included Since*	DL	Units	Multifamily Residential						Mixed Residential					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Chromium +6	94	10	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Total Chromium +6	94	10	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Copper	97	5	µg/l	45	20	56	6.9	6.0	0.91	45	17	62	12	8.0	1.42
Total Copper	97	5	µg/l	45	4	91	12	12	0.54	45	1	98	19	13	1.29
Dissolved Iron	94	100	µg/l	45	33	27	184	50	2.40	45	33	27	353	50	3.45
Total Iron	94	100	µg/l	45	9	80	791	350	2.14	45	10	78	1475	400	2.67
Dissolved Lead	97	5	µg/l	45	41	9	S.I.D.	S.I.D.	S.I.D.	45	40	11	S.I.D.	S.I.D.	S.I.D.
Total Lead	97	5	µg/l	45	31	31	5.8	2.5	1.48	45	23	49	11	2.5	2.60
Dissolved Manganese	98	100	µg/l	21	21	0	S.I.D.	S.I.D.	S.I.D.	20	18	10	S.I.D.	S.I.D.	S.I.D.
Total Manganese	98	100	µg/l	21	20	5	S.I.D.	S.I.D.	S.I.D.	20	18	10	S.I.D.	S.I.D.	S.I.D.
Dissolved Mercury	94	1	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	44	44	0	S.I.D.	S.I.D.	S.I.D.
Total Mercury	94	1	µg/l	40	40	0	S.I.D.	S.I.D.	S.I.D.	44	44	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Nickel	97	5	µg/l	45	44	2	S.I.D.	S.I.D.	S.I.D.	45	42	7	S.I.D.	S.I.D.	S.I.D.
Nickel	97	5	µg/l	45	39	13	S.I.D.	S.I.D.	S.I.D.	45	42	7	S.I.D.	S.I.D.	S.I.D.
Dissolved Selenium	94	5	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Total Selenium	94	5	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	44	2	S.I.D.	S.I.D.	S.I.D.
Dissolved Silver	97	1	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Total Silver	97	1	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Thallium	97	5	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Total Thallium	97	5	µg/l	45	45	0	S.I.D.	S.I.D.	S.I.D.	45	45	0	S.I.D.	S.I.D.	S.I.D.
Dissolved Zinc	94	50	µg/l	45	21	53	83	53	1.53	45	9	80	133	89	1.33
Total Zinc	94	50	µg/l	45	5	89	146	89	1.37	45	1	98	203	125	1.35
SVOCs															
Bis(2-ethylhexyl)phthalate	99	1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
PAHs															
Acenaphthene	99	0.05	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.
Acenaphthylene	99	0.05	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Anthracene	99	0.05	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Benzo(a)anthracene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	4	43	0.38	0.05	1.70
Benzo(a)pyrene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Benzo(b)fluoranthene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.
Benzo(k)fluoranthene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	6	14	S.I.D.	S.I.D.	S.I.D.
Chrysene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	2	71	0.62	0.30	1.32
Dibenz(a,h)anthracene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Fluoranthene	99	0.1	µg/l	6	4	33	0.17	0.050	1.54	7	2	71	0.29	0.27	1.00
Fluorene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Indeno (1,2,3-cd)pyrene	99	0.1	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Naphthalene	99	0.05	µg/l	6	6	0	S.I.D.	S.I.D.	S.I.D.	7	7	0	S.I.D.	S.I.D.	S.I.D.
Phenanthrene	99	0.05	µg/l	6	4	33	0.21	0.025	2.08	7	2	71	0.50	0.24	1.43
Pyrene	99	0.05	µg/l	6	4	33	0.20	0.025	1.95	7	2	71	0.35	0.30	1.03
All other SVOCs	94	0.05-5.0	µg/l	30	30	0	S.I.D.	S.I.D.	S.I.D.	33	33	0	S.I.D.	S.I.D.	S.I.D.
Pesticides															
Organochlorine Pesticides & PCBs	94	0.05-1.0	µg/l	38	38	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
Carbofuran	96	5	µg/l	43	43	0	S.I.D.	S.I.D.	S.I.D.	44	44	0	S.I.D.	S.I.D.	S.I.D.
Glyphosate	98	25	µg/l	21	20	5	S.I.D.	S.I.D.	S.I.D.	20	20	0	S.I.D.	S.I.D.	S.I.D.
Organo-Phosphate Pesticides															
Diazinon	96	0.01	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	39	33	15	S.I.D.	S.I.D.	S.I.D.
Chlorpyrifos	96	0.05	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
N- and P-Containing Pesticides															
Thiobencarb	96	1	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
All other N- and P- Pesticieds	94	1.0-2.0	µg/l	37	37	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
Phenoxyacetic Acid Herbicides															
2,4-D	96	10	µg/l	33	33	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
2,4,5-TP	96	1	µg/l	33	33	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.
Bentazon	96	2	µg/l	33	33	0	S.I.D.	S.I.D.	S.I.D.	39	39	0	S.I.D.	S.I.D.	S.I.D.

CV = Coefficient of variation
DL = Detection Limit
S.I.D. = Statistically Invalid Data, not enough data above detection limit collected
a) Detection limits have changed through out the monitoring process. Only data matching the current detection limit is displayed in this table. The Data Included Since field indicates the first year of the strom season with the current detection limit.

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Table 4-13. 1994-2000 Land Use Constituent Detection Rates

	Commercial	Vacant	High Density Single Family Residential	Trans-portation	Light Industrial	Educational	Multi-Family Residential	Mixed Residential
Miscellaneous Constituents								
Cyanide*	&	X	&	&	&	&	&	&
TPH	&	X	&	&	&	&	&	&
Oil and Grease	&	X	&	&	&	&	&	&
Total Phenols	&	X	&	&	&	&	&	&
Indicator Bacteria*	&	-	&	&	&	&	&	&
General Minerals								
Ammonia	-	X	-	-	-	X	-	-
Calcium	-	-	-	-	-	-	-	-
Magnesium	-	-	-	-	-	-	-	-
Potassium	-	-	-	-	-	-	-	-
Sodium	-	-	-	-	-	-	-	-
Bicarbonate	-	-	-	-	-	-	-	-
Carbonate	X	X	X	X	X	X	X	X
Chloride	-	-	-	-	-	-	-	-
Flouride	X	-	X	X	X	X	X	X
Nitrate	-	-	-	-	-	-	-	-
Sulfate	-	-	-	-	-	-	-	-
Alkalinity	-	-	-	-	-	-	-	-
Hardness	-	-	-	-	-	-	-	-
COD	-	X	-	-	-	-	-	-
pH	-	-	-	-	-	-	-	-
Specific Conductance	-	-	-	-	-	-	-	-
Total Dissolved Solids*	-	-	-	-	-	-	-	-
Turbidity*	-	-	-	-	-	-	-	-
Total Suspended Solids*	-	-	-	-	-	-	-	-
Volatile Suspended Solids	-	-	-	-	-	-	-	-
MBAS	X	X	X	X	-	X	X	X
Total Organic Carbon	-	-	-	-	-	-	-	-
BOD	-	-	-	-	-	-	-	-
Nutrients								
Dissolved Phosphorus*	-	X	-	-	-	-	-	-
Total Phosphorus*	-	X	-	-	-	-	-	-
NH3-N*	-	X	-	-	-	X	-	-
Nitrate-N*	-	-	-	X	-	X	X	X
Nitrite-N*	-	X	-	-	-	X	-	-
TKN*	-	-	-	-	-	-	-	-
Metals								
Dissolved Aluminum	X	X	X	X	X	-	X	X
Total Aluminum*	X	X	-	X	-	-	-	-
Dissolved Antimony	X	X	X	X	X	X	X	X
Total Antimony	X	X	X	X	X	X	X	X
Dissolved Arsenic	X	X	X	X	X	X	X	X
Total Arsenic	X	X	X	X	X	X	X	X
Dissolved Barium	-	-	-	-	-	-	-	-
Total Barium	-	-	-	-	-	-	-	-
Dissolved Beryllium	X	X	X	X	X	X	X	X
Total Beryllium	X	X	X	X	X	X	X	X
Dissolved Boron	-	X	X	-	X	-	-	X
Total Boron	-	-	-	-	-	-	-	X
Dissolved Cadmium*	X	X	X	X	X	X	X	X
Total Cadmium	X	X	X	X	X	X	X	X

Table 4-13. 1994-2000 Land Use Constituent Detection Rates

	Commercial	Vacant	High Density Single Family Residential	Trans-portation	Light Industrial	Educational	Multi-Family Residential	Mixed Residential
Dissolved Chromium	X	X	X	X	X	X	X	X
Total Chromium	X	X	X	X	X	X	X	X
Dissolved Chromium +6	X	X	X	X	X	X	X	X
Total Chromium +6	X	X	X	X	X	X	X	X
Dissolved Copper*	-	X	-	-	-	-	-	-
Total Copper*	-	-	-	-	-	-	-	-
Dissolved Iron	-	X	X	X	-	-	X	X
Total Iron	-	-	-	-	-	-	-	-
Dissolved Lead*	X	X	X	X	X	X	X	X
Total Lead*	X	X	-	X	X	X	X	X
Dissolved Manganese	X	X	X	X	X	X	X	X
Total Manganese	X	X	X	X	X	X	X	X
Dissolved Mercury	X	X	X	X	X	X	X	X
Total Mercury*	X	X	X	X	X	X	X	X
Dissolved Nickel*	X	X	X	X	X	X	X	X
Total Nickel*	-	X	X	X	-	X	X	X
Dissolved Selenium	X	X	X	X	X	X	X	X
Total Selenium	X	X	X	X	X	X	X	X
Dissolved Silver	X	X	X	X	X	X	X	X
Total Silver	X	X	X	X	X	X	X	X
Dissolved Thallium	X	X	X	X	X	X	X	X
Total Thallium	X	X	X	X	X	X	X	X
Dissolved Zinc*	-	X	X	-	-	-	-	-
Total Zinc*	-	X	X	-	-	-	-	-
SVOCs								
Bis(2-ethylhexyl)phthalate*	&	&	&	&	&	&	&	&
PAHs								
Phenanthrene*	&	&	&	&	&	&	&	&
Pyrene*	&	&	&	&	&	&	&	&
All other PAHs	&	&	&	&	&	&	&	&
All other SVOCs	X	X	X	X	X	X	X	X
Pesticides								
Organochlorine Pesticides & PCBs	X	X	X	X	X	X	X	X
Carbofuran	X	X	X	X	X	X	X	X
Glyphosate	X	X	X	X	X	X	X	X
Organo-Phosphate Pesticides								
Diazinon*	X	X	X	X	X	X	X	X
Chlorpyrifos*	X	X	X	X	X	X	X	X
N- and P-Containing Pesticides								
Thiobencarb	X	X	X	X	X	X	X	X
All other N- and P- Pesticieds	X	X	X	X	X	X	X	X
Phenoxyacetic Acid Herbicides								
2,4-D	X	X	X	X	X	X	X	X
2,4,5-TP	X	X	X	X	X	X	X	X
Bentazon	X	X	X	X	X	X	X	X

X = less than 25% detection in ten consecutive samples

- = more than 25% detection in ten consecutive samples

& = less than 10 samples tested

* Constituent of concern

Table 4-14. Summary of Mean Standard Error of Land Use Stations

Land Use Type	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
Transportation	Ammonia	40	0.40	0.51	0.08	0.39	0.42	0.06	0.0001	0.3012	Lognormal	16.4%	Y
Transportation	Bis(2-ethylhexyl)phthalate	29	13.41	17.30	3.21	14.57	25.95	4.47	0.0001	0.8236	Lognormal	30.7%	N
Transportation	Dissolved Copper	52	31.70	21.14	2.93	33.77	31.58	4.28	0.0002	0.0123		9.2%	Y
Transportation	Dissolved Nickel	22	5.69	5.15	1.10	5.55	4.05	0.86	0.0001	0.0028		19.3%	Y
Transportation	Dissolved Phosphorus	47	0.32	0.20	0.03	0.35	0.31	0.04	0.0116	0.0083		9.2%	Y
Transportation	Dissolved Zinc	52	201.02	140.87	19.53	219.04	229.64	30.90	0.0001	0.0005		9.7%	Y
Transportation	NH3-N	39	0.34	0.43	0.07	0.33	0.35	0.05	0.0001	0.1621	Lognormal	16.3%	Y
Transportation	Nitrate	50	3.65	4.06	0.57	3.55	3.38	0.47	0.0001	0.6601	Lognormal	13.2%	Y
Transportation	Nitrate-N	49	0.96	1.29	0.18	0.92	1.04	0.14	0.0001	0.541	Lognormal	15.6%	Y
Transportation	Nitrite-N	50	0.10	0.07	0.01	0.10	0.08	0.01	0.0001	0.4081	Lognormal	10.5%	Y
Transportation	TKN	50	2.02	1.81	0.26	1.97	1.47	0.21	0.0001	0.2096	Lognormal	10.4%	Y
Transportation	Total Cadmium	26	1.40	1.22	0.24	1.39	1.14	0.22	0.0001	0.0032		17.1%	Y
Transportation	Total Chromium	31	6.70	5.46	0.98	6.64	5.55	0.98	0.0001	0.0021		14.6%	Y
Transportation	Total Copper	52	59.18	58.93	8.17	56.89	40.86	5.61	0.0001	0.1899	Lognormal	9.9%	Y
Transportation	Total Lead	37	15.03	19.40	3.19	14.60	20.91	3.25	0.0001	0.004		21.2%	Y
Transportation	Total Nickel	38	7.64	7.26	1.18	7.57	6.40	1.02	0.0001	0.0156		15.4%	Y
Transportation	Total Phosphorus	47	0.44	0.32	0.05	0.46	0.39	0.06	0.0001	0.2144	Lognormal	12.2%	Y
Transportation	Total Suspended Solids	50	90.76	108.00	15.27	86.19	81.14	11.22	0.0001	0.1717	Lognormal	13.0%	Y
Transportation	Total Zinc	52	306.96	296.30	41.09	297.66	220.71	30.26	0.0001	0.2052	Lognormal	10.2%	Y
Light Industrial	Ammonia	45	0.60	0.81	0.12	0.62	1.05	0.14	0.0001	0.0132		20.1%	Y
Light Industrial	Bis(2-ethylhexyl)phthalate	21	9.71	9.68	2.11	10.78	17.06	3.56	0.0007	0.6052	Lognormal	33.1%	N
Light Industrial	Dissolved Copper	39	14.12	10.02	1.60	14.86	14.34	2.25	0.0011	0.065	Lognormal	15.1%	Y
Light Industrial	Dissolved Nickel	23	5.40	4.18	0.87	5.52	4.76	0.98	0.0001	0.0784	Lognormal	17.8%	Y
Light Industrial	Dissolved Phosphorus	44	0.21	0.16	0.02	0.22	0.23	0.03	0.0001	0.1935	Lognormal	14.9%	Y
Light Industrial	Dissolved Zinc	47	360.66	373.51	54.48	428.35	682.33	92.09	0.0001	0.0002		15.1%	Y
Light Industrial	NH3-N	46	0.49	0.66	0.10	0.49	0.77	0.11	0.0001	0.0077		19.9%	Y
Light Industrial	Nitrate	46	4.44	4.56	0.67	4.38	4.72	0.67	0.0001	0.3263	Lognormal	15.4%	Y
Light Industrial	Nitrate-N	45	1.03	1.22	0.18	1.00	1.15	0.17	0.0001	0.4249	Lognormal	16.6%	Y
Light Industrial	Nitrite-N	46	0.09	0.07	0.01	0.09	0.06	0.01	0.0001	0.0687	Lognormal	9.9%	Y
Light Industrial	TKN	45	2.68	1.97	0.29	2.72	2.24	0.33	0.0001	0.7043	Lognormal	12.1%	Y
Light Industrial	Total Chromium	29	6.51	5.08	0.94	6.49	5.44	1.00	0.0001	0.0015		14.5%	Y
Light Industrial	Total Copper	47	47.66	141.91	20.70	35.11	41.24	5.78	0	0.0122		43.4%	N
Light Industrial	Total Lead	33	15.41	15.58	2.71	15.78	19.77	3.31	0.0001	0.1001	Lognormal	21.0%	Y
Light Industrial	Total Nickel	33	10.01	13.60	2.37	9.33	8.43	1.44	0.0001	0.0231		23.6%	Y
Light Industrial	Total Phosphorus	43	0.36	0.30	0.05	0.38	0.42	0.06	0.0001	0.3174	Lognormal	16.4%	Y
Light Industrial	Total Suspended Solids	42	174.33	192.35	29.68	179.77	203.07	30.28	0.0001	0.3733	Lognormal	16.8%	Y
Light Industrial	Total Zinc	47	491.64	543.39	79.26	488.33	428.35	61.37	0.0001	0.0384		16.1%	Y
Mixed Residential	Ammonia	28	0.83	0.88	0.17	0.98	1.90	0.33	0.0001	0.0834	Lognormal	33.5%	N
Mixed Residential	Dissolved Copper	27	16.70	21.06	4.05	17.16	24.94	4.58	0.0001	0.0205		24.3%	Y
Mixed Residential	Dissolved Phosphorus	25	0.23	0.21	0.04	0.24	0.26	0.05	0.0001	0.5799	Lognormal	20.7%	Y
Mixed Residential	Dissolved Zinc	27	178.63	216.58	41.68	174.09	193.27	36.25	0.0001	0.3782	Lognormal	20.8%	Y

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Table 4-14. Summary of Mean Standard Error of Land Use Stations

Land Use Type	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
Mixed Residential	NH3-N	28	0.69	0.73	0.14	0.80	1.51	0.26	0.0001	0.0479		20.0%	Y
Mixed Residential	Nitrate	24	9.91	31.61	6.45	7.29	15.48	2.90	0.0001	0.0001		65.1%	N
Mixed Residential	Nitrate-N	24	0.77	0.46	0.09	0.83	0.76	0.15	0.1754	0.0196	Normal	12.4%	Y
Mixed Residential	Nitrite-N	24	0.15	0.21	0.04	0.14	0.17	0.03	0.0001	0.187	Lognormal	23.0%	Y
Mixed Residential	TKN	29	3.04	2.67	0.49	3.51	4.85	0.86	0.0001	0.0048		16.3%	Y
Mixed Residential	Total Copper	27	23.82	29.68	5.71	22.81	21.64	4.10	0.0001	0.3478	Lognormal	17.9%	Y
Mixed Residential	Total Phosphorus	25	0.31	0.31	0.06	0.31	0.34	0.07	0.0001	0.6015	Lognormal	21.2%	Y
Mixed Residential	Total Suspended Solids	23	82.13	89.10	18.58	79.81	80.22	16.44	0.0001	0.3618	Lognormal	20.6%	Y
Mixed Residential	Total Zinc	27	255.96	342.39	65.89	236.79	245.20	46.19	0.0001	0.0226		25.7%	N
Multi-Family Residential	Ammonia	26	0.55	0.81	0.16	0.60	1.39	0.24	0.0001	0.008		28.7%	N
Multi-Family Residential	Bis(2-ethylhexyl)phthalate	17	30.04	54.21	13.15	29.61	78.55	17.98	0.0001	0.7204	Lognormal	60.7%	N
Multi-Family Residential	Dissolved Copper	26	9.26	7.29	1.43	9.47	8.52	1.65	0.0004	0.0487		15.4%	Y
Multi-Family Residential	Dissolved Zinc	26	118.50	158.83	31.15	112.38	119.44	22.91	0.0001	0.0778	Lognormal	20.4%	Y
Multi-Family Residential	NH3-N	26	0.47	0.67	0.13	0.48	1.00	0.18	0.0001	0.0086		28.2%	N
Multi-Family Residential	Nitrate	24	7.25	4.59	0.94	7.68	7.06	1.42	0.0741	0.0786	Normal	12.9%	Y
Multi-Family Residential	Nitrate-N	24	1.64	1.04	0.21	1.73	1.59	0.32	0.076	0.0787	Normal	12.9%	Y
Multi-Family Residential	Nitrite-N	24	0.13	0.20	0.04	0.11	0.10	0.02	0.0001	0.0332		31.7%	N
Multi-Family Residential	TKN	28	2.40	2.52	0.48	2.29	1.70	0.32	0.0001	0.1133	Lognormal	13.9%	Y
Multi-Family Residential	Total Copper	31	13.44	6.63	1.19	13.65	7.51	1.34	0.007	0.2523	Lognormal	9.8%	Y
Multi-Family Residential	Total Suspended Solids	23	60.87	77.51	16.16	58.52	79.87	16.07	0.0001	0.1461	Lognormal	27.5%	N
Multi-Family Residential	Total Zinc	31	173.90	235.31	42.26	164.12	185.23	32.31	0.0001	0.0611	Lognormal	19.7%	Y
Educational	Ammonia	28	0.23	0.21	0.04	0.25	0.33	0.06	0.0001	0.0001		17.4%	Y
Educational	Bis(2-ethylhexyl)phthalate	10	14.50	15.30	4.84	16.99	30.88	10.17	0.031	0.5983	Lognormal	59.9%	N
Educational	Dissolved Copper	29	15.00	13.28	2.47	15.19	14.54	2.65	0.0001	0.5367	Lognormal	17.4%	Y
Educational	Dissolved Phosphorus	25	0.29	0.26	0.05	0.29	0.25	0.05	0.0001	0.1323	Lognormal	17.4%	Y
Educational	Dissolved Zinc	24	78.58	64.44	13.15	79.32	67.24	13.57	0.0001	0.0103		16.7%	Y
Educational	NH3-N	28	0.20	0.17	0.03	0.21	0.24	0.04	0.0001	0.0002		16.6%	Y
Educational	Nitrate	26	3.05	1.86	0.36	3.15	2.35	0.46	0.0176	0.2314	Lognormal	14.5%	Y
Educational	Nitrate-N	25	0.65	0.35	0.07	0.65	0.37	0.07	0.0111	0.3601	Lognormal	11.3%	Y
Educational	TKN	27	1.81	1.31	0.25	1.78	1.00	0.19	0.0001	0.0522	Lognormal	10.8%	Y
Educational	Total Copper	29	28.89	42.45	7.88	25.73	21.75	3.99	0.0001	0.001		27.3%	N
Educational	Total Phosphorus	25	0.33	0.21	0.04	0.33	0.19	0.04	0.0001	0.287	Lognormal	11.6%	Y
Educational	Total Suspended Solids	27	120.44	110.41	21.25	140.69	217.18	39.59	0.0003	0.2178	Lognormal	28.1%	N
Educational	Total Zinc	29	155.90	286.82	53.26	137.70	148.76	26.94	0.0001	0.007		34.2%	N
HDSFR	Ammonia	22	0.48	0.52	0.11	0.56	1.04	0.21	0.0002	0.0179		22.8%	Y
HDSFR	Bis(2-ethylhexyl)phthalate	15	14.22	21.84	5.64	13.51	23.86	6.03	0.0001	0.1512	Lognormal	44.6%	N
HDSFR	Dissolved Copper	20	11.56	8.77	1.96	12.26	12.94	2.85	0.0295	0.0624	Lognormal	23.2%	Y
HDSFR	Dissolved Phosphorus	21	0.34	0.17	0.04	0.34	0.20	0.04	0.1261	0.5482	Normal	11.2%	Y
HDSFR	NH3-N	22	0.43	0.42	0.09	0.50	0.84	0.17	0.0009	0.0137		20.8%	Y
HDSFR	Nitrate	21	5.29	6.32	1.38	5.07	5.51	1.18	0.0001	0.3442	Lognormal	23.3%	Y
HDSFR	Nitrate-N	21	1.19	1.43	0.31	1.15	1.26	0.27	0.0001	0.3775	Lognormal	23.5%	Y

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Table 4-14. Summary of Mean Standard Error of Land Use Stations

Land Use Type	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
HDSFR	TKN	25	3.20	3.30	0.66	3.13	2.93	0.58	0.0001	0.3953	Lognormal	18.4%	Y
HDSFR	Total Copper	26	23.06	16.35	3.21	23.81	20.22	3.92	0.0027	0.3238	Lognormal	16.5%	Y
HDSFR	Total Lead	19	20.70	23.68	5.43	23.08	44.50	9.69	0.0005	0.0348		26.3%	N
HDSFR	Total Phosphorus	21	0.48	0.33	0.07	0.50	0.39	0.09	0.0081	0.7729	Lognormal	17.1%	Y
HDSFR	Total Suspended Solids	19	131.58	124.69	28.61	135.80	141.49	31.99	0.0001	0.8471	Lognormal	23.6%	Y
HDSFR	Total Zinc	26	87.31	64.89	12.73	90.24	86.31	16.64	0.0027	0.0028		14.6%	Y
Commercial	Ammonia	30	6.54	6.46	1.18	8.32	18.85	3.06	0	0.143	Lognormal	36.8%	N
Commercial	Dissolved Chromium +6	26	12.28	9.03	1.77	12.57	10.57	2.05	0.002	0.857	Lognormal	16.3%	Y
Commercial	Dissolved Copper	26	247.83	590.58	115.82	414.86	3219.04	452.17	0	0.029		46.7%	N
Commercial	Dissolved Phosphorus	31	78.17	75.95	13.64	787.73	26264.38	2415.90	0	0		17.5%	Y
Commercial	Dissolved Zinc	22	68.15	69.89	14.90	92.22	259.13	49.32	0.003	0.021		21.9%	Y
Commercial	NH3-N	27	0.23	0.31	0.06	0.22	0.24	0.05	0	0.17	Lognormal	20.5%	Y
Commercial	Nitrate	30	49.40	47.53	8.68	53.60	77.85	13.50	0	0.108	Lognormal	25.2%	N
Commercial	Nitrate-N	30	3.55	3.23	0.59	3.55	3.50	0.63	0	0.169	Lognormal	17.6%	Y
Commercial	Nitrite-N	27	386.03	371.19	71.44	1943.80	24569.04	3072.04	0.001	0		18.5%	Y
Commercial	TKN	32	196.34	216.73	38.31	1009.66	19221.47	1781.57	0	0		19.5%	Y
Commercial	Total Cadmium	12	5.59	3.62	1.05	5.73	4.24	1.22	0.038	0.171	Lognormal	21.4%	Y
Commercial	Total Chromium +6	26	29.77	19.61	3.85	30.33	23.07	4.49	0.009	0.788	Lognormal	14.8%	Y
Commercial	Total Copper	37	714.73	1044.99	171.80	950.54	3720.60	466.62	0	0.063	Lognormal	49.1%	N
Commercial	Total Lead	13	42.46	42.08	11.67	42.70	45.55	12.59	0.002	0.225	Lognormal	29.5%	N
Commercial	Total Mercury	14	5.20	3.39	0.91	5.46	4.67	1.24	0.071	0.17	Normal	17.4%	Y
Commercial	Total Phosphorus	32	5.84	2.80	0.49	12.11	41.12	5.89	0	0		8.5%	Y
Commercial	Total Suspended Solids	29	11.30	25.91	4.81	10.07	311.76	33.05	0	0		42.6%	N
Commercial	Total Zinc	11	251.73	115.79	34.91	255.29	129.70	39.11	0.303	0.681	Normal	13.9%	Y
Vacant	Bis(2-ethylhexyl)phthalate	20	20.96	37.70	8.43	21.93	58.24	11.90	0.0001	0.2674	Lognormal	54.3%	N
Vacant	Nitrate	35	5.95	3.31	0.56	6.03	3.89	0.65	0.0025	0.0541	Lognormal	10.8%	Y
Vacant	Nitrate-N	35	1.34	0.75	0.13	1.36	0.88	0.15	0.0025	0.0543	Lognormal	10.9%	Y
Vacant	Nitrite-N	20	0.04	0.02	0.00	0.04	0.02	0.00	0.0001	0.2195	Lognormal	8.7%	Y
Vacant	TKN	35	1.16	2.23	0.38	1.01	0.97	0.16	0.0001	0.0261		32.3%	N
Vacant	Total Copper	25	13.98	15.98	3.20	13.67	17.48	3.38	0.0001	0.0364		22.9%	Y
Vacant	Total Phosphorus	24	0.13	0.15	0.03	0.12	0.12	0.02	0.0001	0.0143		23.6%	Y
Vacant	Total Suspended Solids	33	149.36	227.54	39.61	186.07	817.22	107.23	0.0001	0.0266		26.5%	N
Vacant	Total Zinc	20	48.40	50.95	11.39	46.40	40.40	8.95	0.0001	0.0114		23.5%	Y

* If a constituent is neither normal nor lognormal, we assume that it is normal.

HDSFR = High Density Single Family Residential

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Table 4-15. Comparison of Critical Source Results Before and After BMP Implementation

			Auto Dismantling-Control					Auto Dismantling-BMP					BMP	
Class Constituent	DL	Units	No. of Samples	Percent Detects	Mean	Median	CV	No. of Samples	Percent Detects	Mean	Median	CV	Post BMP Median	Percent Change
Miscellaneous Constituents														
Oil and Grease	1	mg/l	98	56	7.4	1.6	2.08	24	92	7.0	5.2	0.92	Increased	222%
TPH as Gasoline	0.5	mg/l	105	9	S.I.D.	S.I.D.	S.I.D.	24	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
TPH as Diesel	0.5	mg/l	105	2	S.I.D.	S.I.D.	S.I.D.	22	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Indicator Bacteria[1]														
Total Coliform	20	MPN/100ml	24	100	381,667	300,000	0.69	24	100	603,375	300,000	0.96	No Change	0%
Fecal Coliform	20	MPN/100ml	24	100	169,651	130,000	1.01	24	100	416,708	300,000	1.00	Increased	131%
Ratio Fecal Coliform/Total Coliform			0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Fecal Streptococcus	20	MPN/100ml	24	100	407,167	240,000	1.63	24	100	951,542	300,000	2.08	Increased	25%
Fecal Enterococcus	20	MPN/100ml	24	100	216,883	110,000	1.63	24	100	480,429	240,000	2.10	Increased	118%
General Minerals														
COD	5	mg/l	35	100	114	84	0.91	6	83	72	62	0.83	Decreased	-26%
pH	0-14		133	100	6.6	6.5	0.06	26	100	6.4	6.4	0.03	Decreased	-2%
Specific Conductance	1.0	umhos/cm	131	100	203	189	0.58	26	100	145	131	0.46	Decreased	-31%
Total Dissolved Solids	2.0	mg/l	27	100	104	90	0.43	8	100	71	66	0.38	Decreased	-27%
Total Suspended Solids	2.0	mg/l	29	100	71	50	0.73	6	100	58	56.5	0.53	Increased	13%
MBAS	0.05	mg/l	35	60	0.17	0.08	1.54	6	100	0.10	0.09	0.28	Increased	6%
Total Organic Carbon	1.0	mg/l	31	100	22	18	0.59	6	100	13	12	0.23	Decreased	-34%
Metals														
Dissolved Aluminum	100	µg/l	37	41	189	50	1.84	8	0	&	&	&	Possible Decrease	0%
Total Aluminum	100	µg/l	37	100	918	329	2.57	6	50	115	90	0.75	Decreased	-73%
Dissolved Cadmium	1	µg/l	37	54	1.6	1.0	1.09	6	33	1.0	0.5	0.80	Decreased	-50%
Total Cadmium	1	µg/l	37	81	2.6	2.0	0.88	6	83	1.7	1.4	0.77	Decreased	-31%
Dissolved Chromium	5	µg/l	37	14	S.I.D.	S.I.D.	S.I.D.	6	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Total Chromium	5	µg/l	37	46	6.0	2.5	1.07	6	17	&	&	&	Possible Decrease	0%
Dissolved Copper	5	µg/l	37	100	42	31	0.91	6	100	18	14	0.51	Decreased	-54%
Total Copper	5	µg/l	37	100	62	42	0.96	6	100	25	21	0.59	Decreased	-51%
Dissolved Iron	100	µg/l	37	41	307	50	2.23	6	33	108	50	0.83	No Change	0%
Total Iron	100	µg/l	37	95	1580	650	2.21	6	67	215	210	0.71	Decreased	-68%
Dissolved Lead	5	µg/l	37	38	20	2.5	3.03	6	17	&	&	&	Possible Decrease	0%
Total Lead	5	µg/l	37	100	46	17	2.12	6	67	6.4	5.9	0.63	Decreased	-65%
Dissolved Nickel	5	µg/l	37	95	16	15	0.65	6	83	8.5	7.2	0.52	Decreased	-51%
Nickel	5	µg/l	37	100	20	17	0.60	6	100	12	11	0.33	Decreased	-35%
Dissolved Zinc	50	µg/l	37	100	283	192	1.06	6	100	228	202	0.53	Increased	5%
Total Zinc	50	µg/l	37	100	355	254	0.86	6	100	281	252	0.43	Decreased	-1%
SVOCs														
Bis(2-ethythexyl)phthalate	3	µg/l	105	98	33	26	0.90	22	95	33	11	2.09	Decreased	-57%
PAHs[2]	0.5-5.0	µg/l	105	0	S.I.D.	S.I.D.	S.I.D.	22	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
All other SVOCs	0.5-1.0	µg/l	105	0	S.I.D.	S.I.D.	S.I.D.	22	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	

1 Indicator Bacteria tested during 1999-2000 storm season only

2 PAHs tested during 1999-2000 storm season only

S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

& = Statistically valid data in the control sites but detected in less than 20% of the samples in the BMP sites

CV = Coefficient of variation

DL = Detection Limit

Possible Decrease = Less than 20% detects BMP, but existing data shows a possible lowered median.

R0012079

Table 4-15. Comparison of Critical Source Results Before and After BMP Implementation

			Auto Repair-Control					Auto Repair-BMP					BMP	
Class Constituent	DL	Units	No. of Samples	Percent Detects	Mean	Median	CV	No. of Samples	Percent Detects	Mean	Median	CV	Post BMP Median	Percent Change
Miscellaneous Constituents														
Oil and Grease	1	mg/l	97	63	10	3.2	1.62	24	100	10	6.6	0.79	Increased	105%
TPH as Gasoline	0.5	mg/l	98	0	S.I.D.	S.I.D.	S.I.D.	24	4	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
TPH as Diesel	0.5	mg/l	97	0	S.I.D.	S.I.D.	S.I.D.	23	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Indicator Bacteria[1]														
Total Coliform	20	MPN/100ml	21	100	44,510	500	4.40	24	100	97,428	40,000	1.06	Increased	7900%
Fecal Coliform	20	MPN/100ml	21	100	4,935	300	3.95	24	100	51,568	19,500	1.51	Increased	6400%
Ratio Fecal Coliform/Total Coliform			9	100	39%	33%	0.58	2	S.I.D.	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Fecal Streptococcus	20	MPN/100ml	21	100	4,368	1,300	1.48	24	100	53,939	22,500	1.30	Increased	1631%
Fecal Enterococcus	20	MPN/100ml	21	100	2,873	700	2.16	24	100	21,189	5,000	1.85	Increased	614%
General Minerals														
COD	5	mg/l	29	97	112	62	1.40	7	71	97	46	1.51	Decreased	-27%
pH	0-14		118	100	6.5	6.6	0.11	28	100	6.0	6.0	0.09	Decreased	-9%
Specific Conductance	1.0	umhos/cm	120	100	114	81	0.96	28	100	80	50	0.75	Decreased	-39%
Total Dissolved Solids	2.0	mg/l	23	100	80	48	0.68	7	100	49	32	0.61	Decreased	-33%
Total Suspended Solids	2.0	mg/l	27	100	184	121	1.17	7	100	144	86	1.06	Decreased	-29%
MBAS	0.05	mg/l	31	55	0.20	0.066	1.66	7	100	0.14	0.15	0.32	Increased	124%
Total Organic Carbon	1.0	mg/l	28	100	25.9	13.2	1.47	7	100	21	11	1.14	Decreased	-17%
Metals														
Dissolved Aluminum	100	µg/l	32	34	151	50	1.20	7	0	&	&	&	Possible Decrease	0%
Total Aluminum	100	µg/l	32	81	876	385	1.88	7	14	&	&	&	Possible Decrease	-87%
Dissolved Cadmium	1	µg/l	31	26	1.02	0.50	1.03	7	0	&	&	&	Possible Decrease	0%
Total Cadmium	1	µg/l	31	58	2.35	1.70	1.21	7	14	&	&	&	Possible Decrease	-71%
Dissolved Chromium	5	µg/l	32	13	S.I.D.	S.I.D.	S.I.D.	7	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Total Chromium	5	µg/l	32	47	7.6	2.5	1.22	7	0	&	&	&	Possible Decrease	0%
Dissolved Copper	5	µg/l	32	91	40	29.2	0.85	7	100	35	22.0	1.04	Decreased	-25%
Total Copper	5	µg/l	32	94	76	51	1.45	7	100	43	28	0.89	Decreased	-45%
Dissolved Iron	100	µg/l	32	53	366	95	1.78	7	29	99	50	0.89	Decreased	-47%
Total Iron	100	µg/l	32	84	2820	1119	1.72	7	57	224	260	0.78	Decreased	-77%
Dissolved Lead	5	µg/l	32	66	48	13	1.86	7	100	47	43	0.83	Increased	220%
Total Lead	5	µg/l	32	81	246	51	3.50	7	100	75	60	0.68	Increased	16%
Dissolved Nickel	5	µg/l	32	56	7.2	5.3	0.77	7	14	&	&	&	Possible Decrease	-53%
Nickel	5	µg/l	32	76	33	12	3.18	7	43	9.7	2.5	1.15	Decreased	-79%
Dissolved Zinc	50	µg/l	32	88	232	189	0.98	7	100	221	229	0.43	Increased	21%
Total Zinc	50	µg/l	32	94	466	276	1.75	7	100	263	256	0.39	Decreased	-7%
SVOCs														
Bis(2-ethylhexyl)phthalate	3	µg/l	97	90	32	18	1.07	23	96	53	26	1.98	Increased	44%
PAHs[2]	0.5-5.0	µg/l	98	0	S.I.D.	S.I.D.	S.I.D.	23	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
All other SVOCs	0.5-1.0	µg/l	98	0	S.I.D.	S.I.D.	S.I.D.	23	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	

1 Indicator Bacteria tested during 1999-2000 storm season only

2 PAHs tested during 1999-2000 storm season only

S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

& = Statistically valid data in the control sites but detected in less than 20% of the samples in the BMP sites

CV = Coefficient of variation

DL = Detection Limit

Possible Decrease = Less than 20% detects BMP, but existing data shows a possible lowered median.

R0012080

Table 4-15. Comparison of Critical Source Results Before and After BMP Implementation

			Fabricated Metal-Control					Fabricated Metal-BMP					BMP	
Class Constituent	DL	Units	No. of Samples	Percent Detects	Mean	Median	CV	No. of Samples	Percent Detects	Mean	Median	CV	Post BMP Median	Percent Change
Miscellaneous Constituents														
Oil and Grease	1	mg/l	49	73	13.6	3.5	1.98	20	85	5	3.9	0.92	Increased	11%
TPH as Gasoline	0.5	mg/l	49	0	S.I.D.	S.I.D.	S.I.D.	20	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
TPH as Diesel	0.5	mg/l	49	0	S.I.D.	S.I.D.	S.I.D.	20	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Indicator Bacteria[1]														
Total Coliform	20	MPN/100ml	15	100	288,713	30,000	2.17	20	100	61,506	1,300	3.26	Decreased	-96%
Fecal Coliform	20	MPN/100ml	15	100	84,875	14,000	1.67	20	100	56,419	415	3.58	Decreased	-97%
Ratio Fecal Coliform/Total Coliform			2	S.I.D.	S.I.D.	S.I.D.	S.I.D.	2	S.I.D.	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
Fecal Streptococcus	20	MPN/100ml	15	100	286,931	9,000	1.92	20	100	59,740	500	1.73	Decreased	-94%
Fecal Enterococcus	20	MPN/100ml	15	100	236,303	1,400	2.37	20	100	16,939	95	2.08	Decreased	-93%
General Minerals														
COD	5	mg/l	15	93	87	76	0.64	6	63	42	49	0.65	Decreased	-35%
pH	0-14		64	100	6.1	6.0	0.10	23	100	6.1	6.0	0.07	Decreased	-1%
Specific Conductance	1.0	umhos/cm	64	100	122	89	1.12	23	100	51	30	1.94	Decreased	-67%
Total Dissolved Solids	2.0	mg/l	15	100	69	64	0.55	6	100	22	22	0.33	Decreased	-66%
Total Suspended Solids	2.0	mg/l	15	100	316	176	1.72	6	100	97	99	0.57	Decreased	-44%
MBAS	0.05	mg/l	15	100	0.27	0.25	0.63	6	67	0.060	0.057	0.58	Decreased	-77%
Total Organic Carbon	1.0	mg/l	15	100	22	23	0.70	6	100	5.2	5.2	0.31	Decreased	-76%
Metals														
Dissolved Aluminum	100	µg/l	15	67	434	205	0.99	6	67	633	129	1.39	Decreased	-37%
Total Aluminum	100	µg/l	15	100	1859	1020	1.55	6	83	670	211	1.28	Decreased	-79%
Dissolved Cadmium	1	µg/l	15	33	0.93	0.50	0.67	6	0	&	&	&	Possible Decrease	0%
Total Cadmium	1	µg/l	15	53	1.5	1.2	1.04	6	17	&	&	&	Possible Decrease	-58%
Dissolved Chromium	5	µg/l	15	27	7.4	2.5	1.74	6	0	&	&	&	Possible Decrease	0%
Total Chromium	5	µg/l	15	53	12	7.1	1.55	6	0	&	&	&	Possible Decrease	-65%
Dissolved Copper	5	µg/l	15	100	265	122	1.33	6	100	42	25	0.89	Decreased	-80%
Total Copper	5	µg/l	15	100	475	235	1.26	6	100	39	30	0.66	Decreased	-87%
Dissolved Iron	100	µg/l	15	100	719	511	0.75	6	67	405	280	1.10	Decreased	-45%
Total Iron	100	µg/l	15	100	2054	942	1.27	6	67	548	460	0.96	Decreased	-51%
Dissolved Lead	5	µg/l	15	100	54	36	0.85	6	50	31	10	1.58	Decreased	-72%
Total Lead	5	µg/l	15	100	151	126	1.04	6	100	51	13	1.39	Decreased	-89%
Dissolved Nickel	5	µg/l	15	93	58	20	1.73	6	0	&	&	&	Possible Decrease	-87%
Nickel	5	µg/l	15	100	72	23	1.51	8	17	&	&	&	Possible Decrease	-89%
Dissolved Zinc	50	µg/l	15	100	494	373	0.92	6	100	268	210	0.54	Decreased	-44%
Total Zinc	50	µg/l	15	100	574	449	0.79	6	100	310	299	0.43	Decreased	-34%
SVOCs														
Bis(2-ethylhexyl)phthalate	3	µg/l	49	86	14	9	1.24	20	95	20	8.3	1.61	Decreased	-3%
PAHs[2]	0.5-5.0	µg/l	49	0	S.I.D.	S.I.D.	S.I.D.	20	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	
All other SVOCs	0.5-1.0	µg/l	49	0	S.I.D.	S.I.D.	S.I.D.	20	0	S.I.D.	S.I.D.	S.I.D.	S.I.D.	

1 Indicator Bacteria tested during 1999-2000 storm season only

2 PAHs tested during 1999-2000 storm season only

S.I.D. = Statistically Invalid Data, not enough data above detection limit collected

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DL = Detection Limit

Possible Decrease = Less than 20% detects BMP, but existing data shows a possible lowered median.

R0012081

Table 4-16. Installed Critical Source BMPs for the 1999-2000 Storm Season

BMP EQUIPMENT/SUPPLIES	WHOLESALE TRADE INDUSTRIES			AUTO REPAIR INDUSTRIES			METAL FABRICATION INDUSTRIES		
	T1	T2	T3	T4	T5	T6	T7	T8	T9
Oil Absorbent Fabrics	X	X	X	X	X	X	X	X	X
65 Gallon Salvage Drums	X	X	X	X	X	X			
Spill Control Pallets	X	X	X	X	X	X			
2 - Drum Poly Pallets	X	X	X	X	X	X			
Tarps	X	X	X	X	X	X			
Safety Drum Funnel	X	X	X	X	X	X			
Cleaners/Degreasers	X	X	X	X	X	X			
8' Oil Booms	X	X	X	X	X	X			
Commercial Shelving	X	X	X	X	X	X			
Absorbent Drum Covers	X	X	X	X	X	X			
Drum Pallets	X	X	X						
Canopy		X						X	
Sand Absorbents							X	X	X
Powerful Magnets							X	X	X
Drip Pans							X	X	X
Wooden Pallets							X	X	X

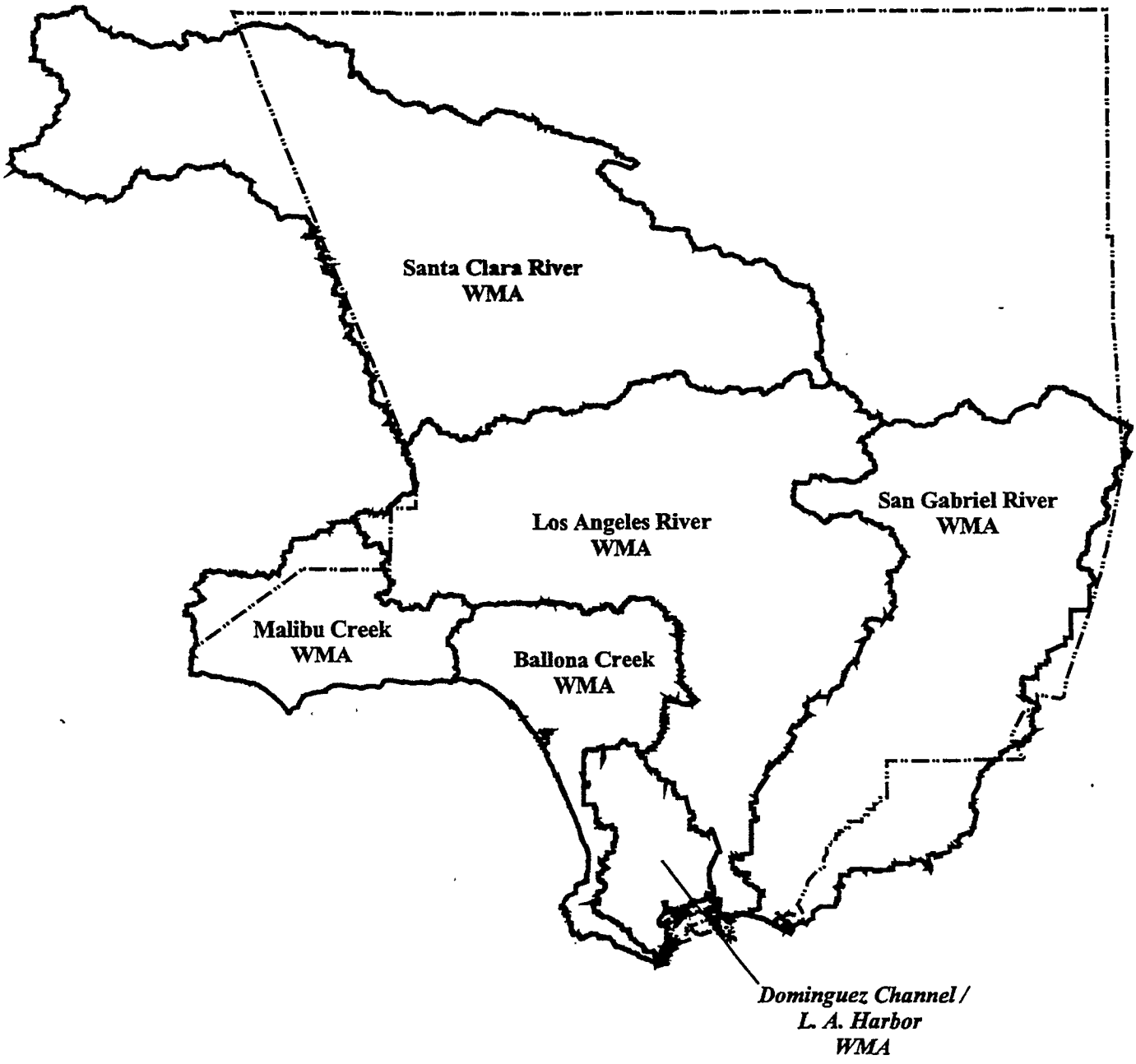
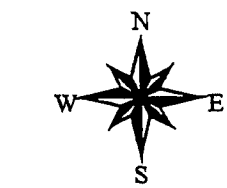


Figure 1-1

Los Angeles County
1996 Municipal NPDES Stormwater Permit Area



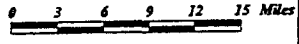
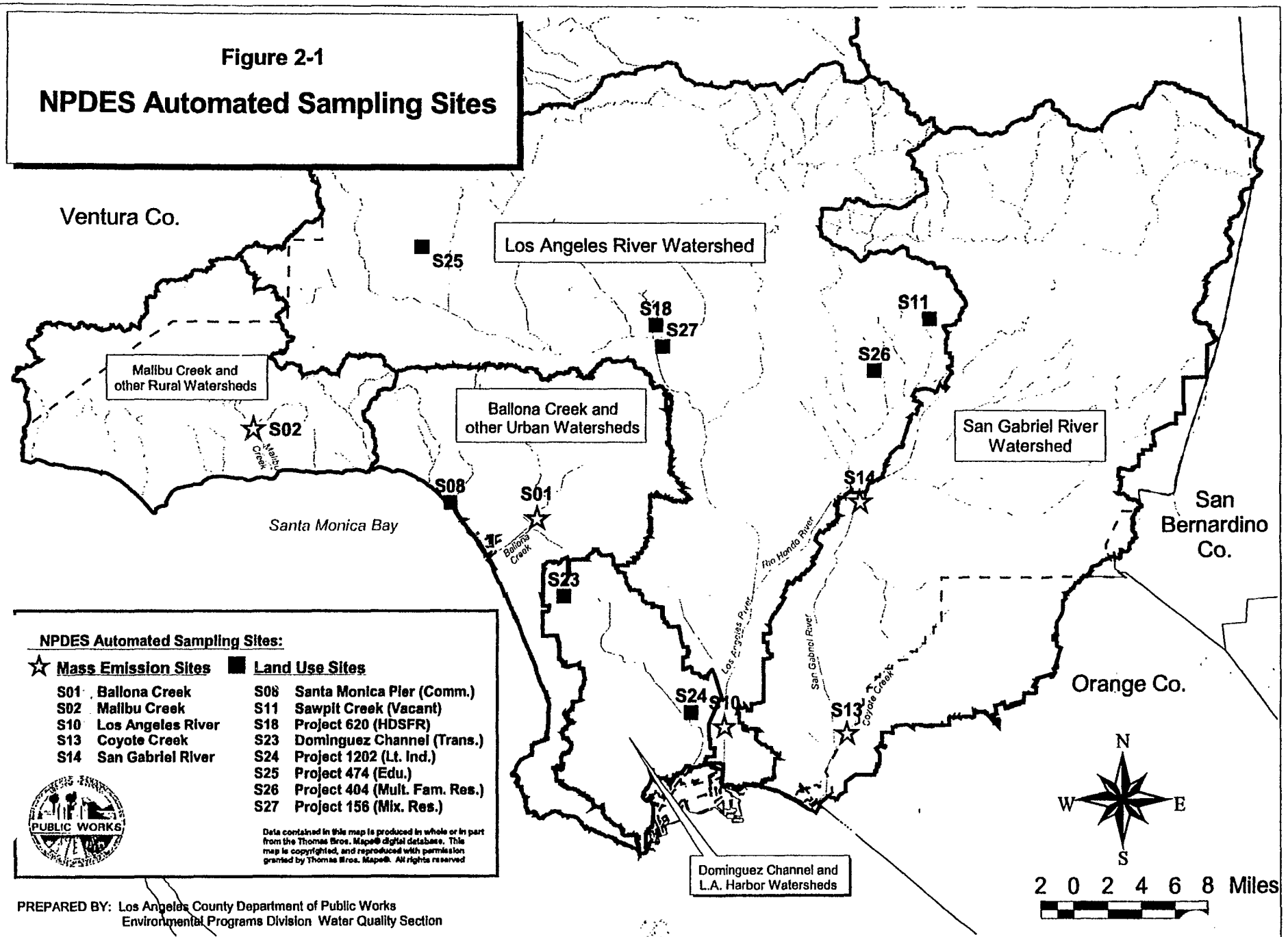


Figure 2-1

NPDES Automated Sampling Sites



NPDES Automated Sampling Sites:

Mass Emission Sites

S01	Ballona Creek
S02	Malibu Creek
S10	Los Angeles River
S13	Coyote Creek
S14	San Gabriel River

Land Use Sites

S08	Santa Monica Pier (Comm.)
S11	Sawpit Creek (Vacant)
S18	Project 620 (HDSFR)
S23	Dominguez Channel (Trans.)
S24	Project 1202 (Lt. Ind.)
S25	Project 474 (Edu.)
S26	Project 404 (Mult. Fam. Res.)
S27	Project 156 (Mix. Res.)

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PREPARED BY: Los Angeles County Department of Public Works
Environmental Programs Division Water Quality Section

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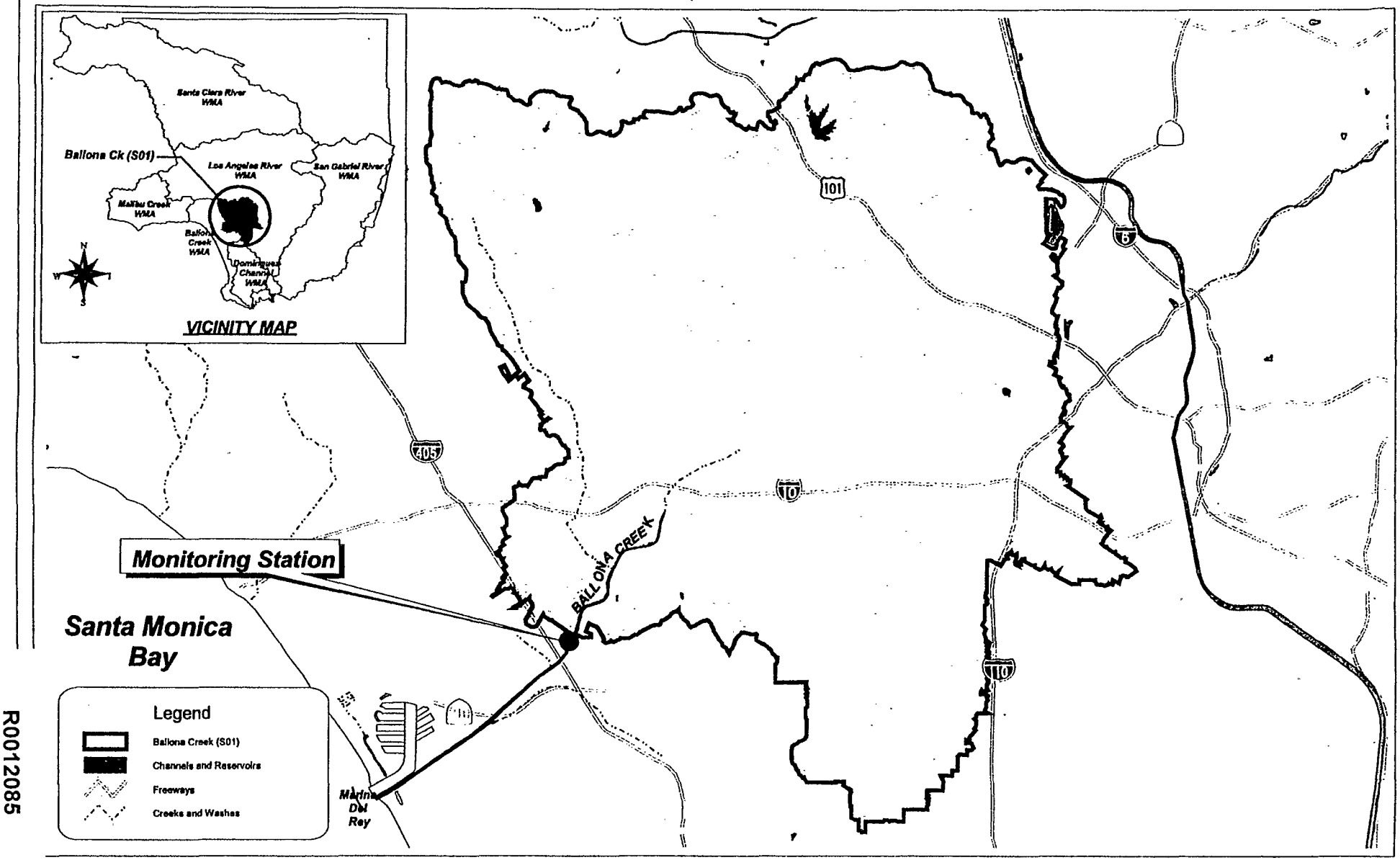

R0012085

Figure 2-2

BALLONA CREEK (S01)
at Sawtelle Blvd.
Los Angeles
(Mass Emission Monitoring Site)
1990 Population = 1.5 Million

Land Use Distribution	Area (Acres)	Percent
High Density Residential	22,722	40.0%
Light Industrial	1,959	3.5%
Vacant	6,303	11.1%
Retail/Commercial	5,646	9.9%
Multi-Family Residential	7,009	12.3%
Transportation	651	1.5%
Education	1,556	2.7%
Mixed Residential	3,810	6.7%
Other	6,988	12.3%
Total	56,844	100.0%

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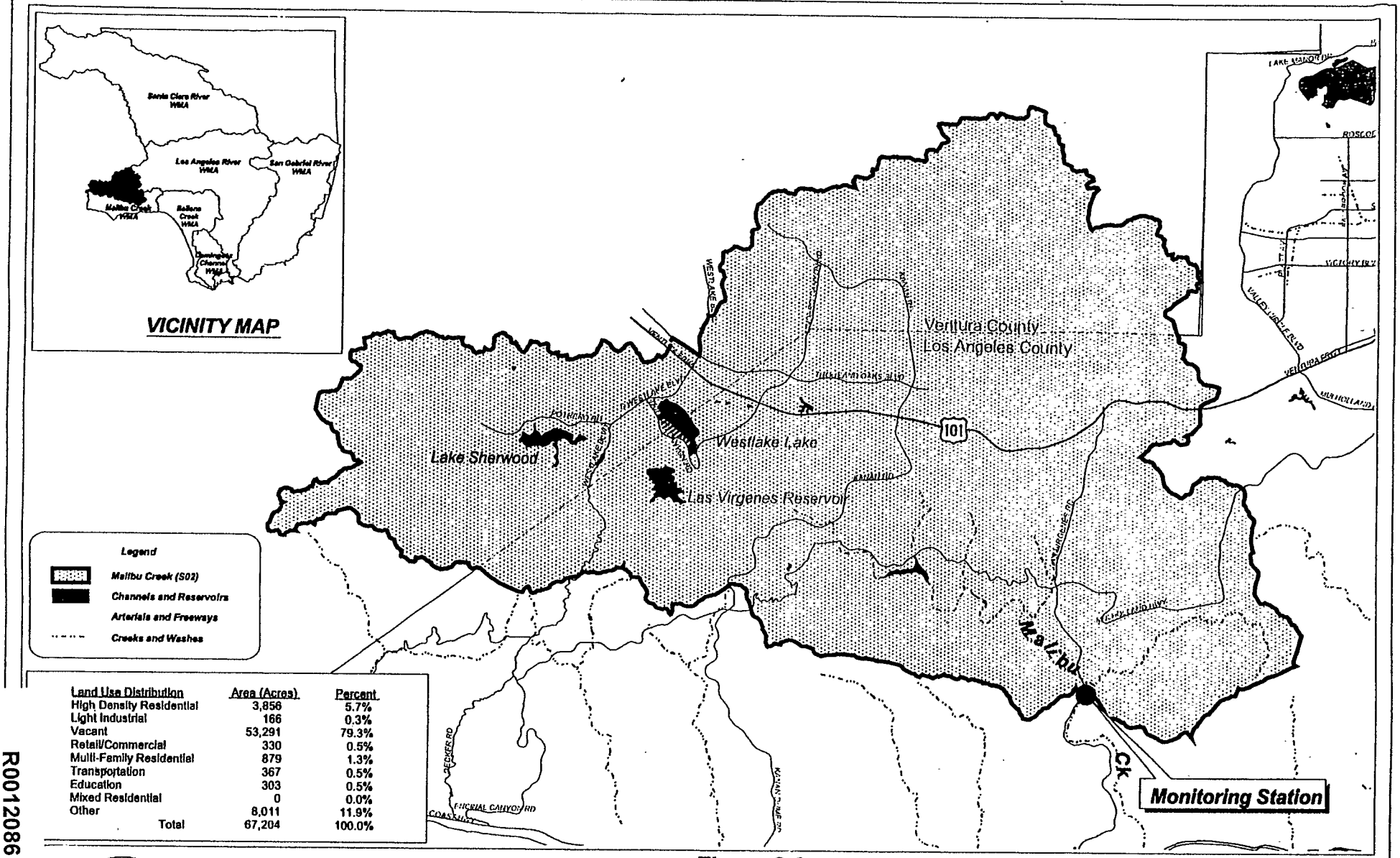

Land Use Distribution	Area (Acres)	Percent
High Density Residential	3,856	5.7%
Light Industrial	166	0.3%
Vacant	53,291	79.3%
Retail/Commercial	330	0.5%
Multi-Family Residential	879	1.3%
Transportation	367	0.5%
Education	303	0.5%
Mixed Residential	0	0.0%
Other	8,011	11.9%
Total	67,204	100.0%

R0012086

Figure 2-3

MALIBU CREEK (S02) at Piuma Rd.

Unincorporated L.A. County
(Mass Emission Monitoring Site)
1990 Population = 64,000

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N W E S

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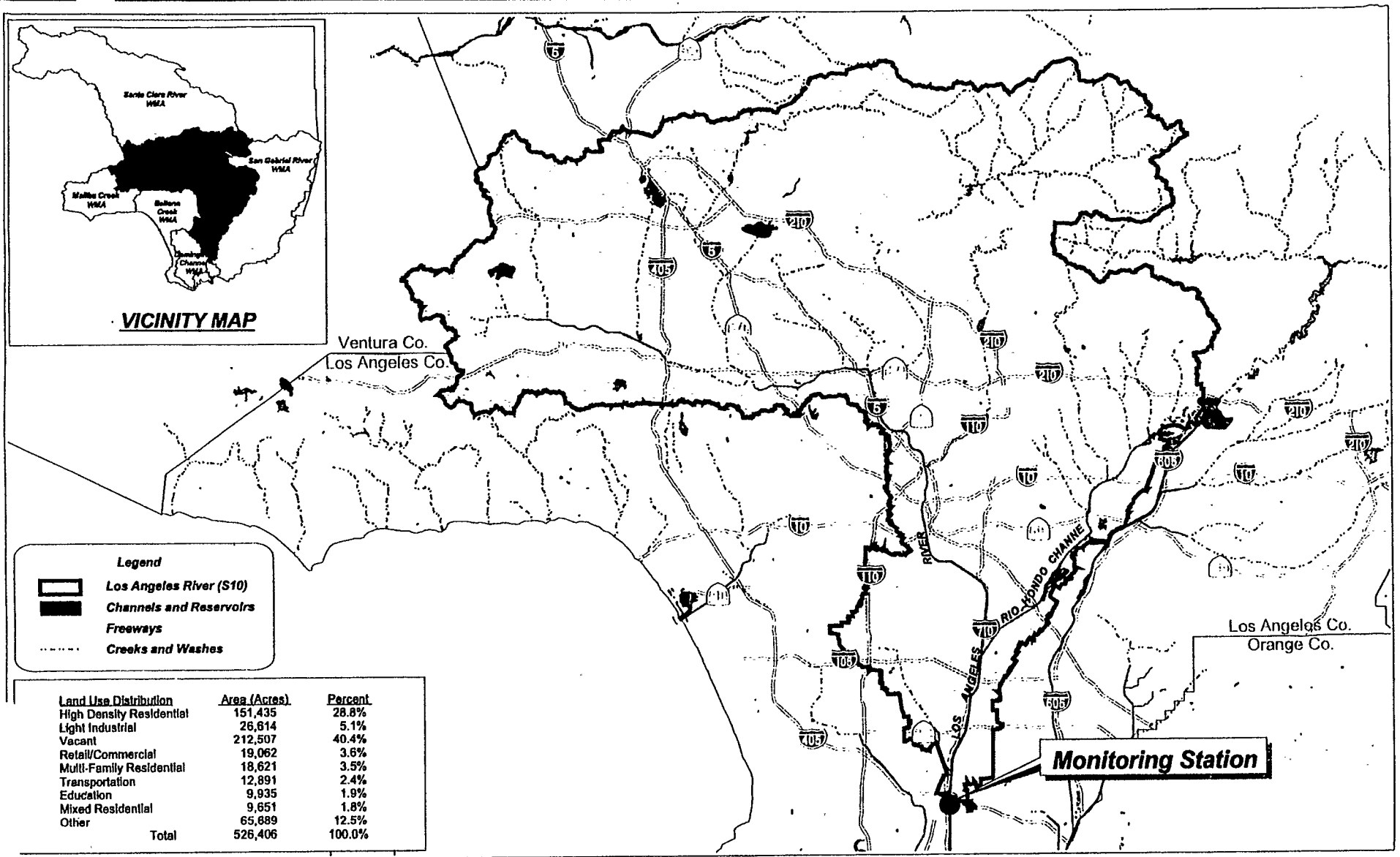

R0012087

Figure 2-4

LOS ANGELES RIVER (S10) at Wardlow Rd.

Long Beach

(Mass Emission Monitoring Site)

1990 Population = 4.2 Million

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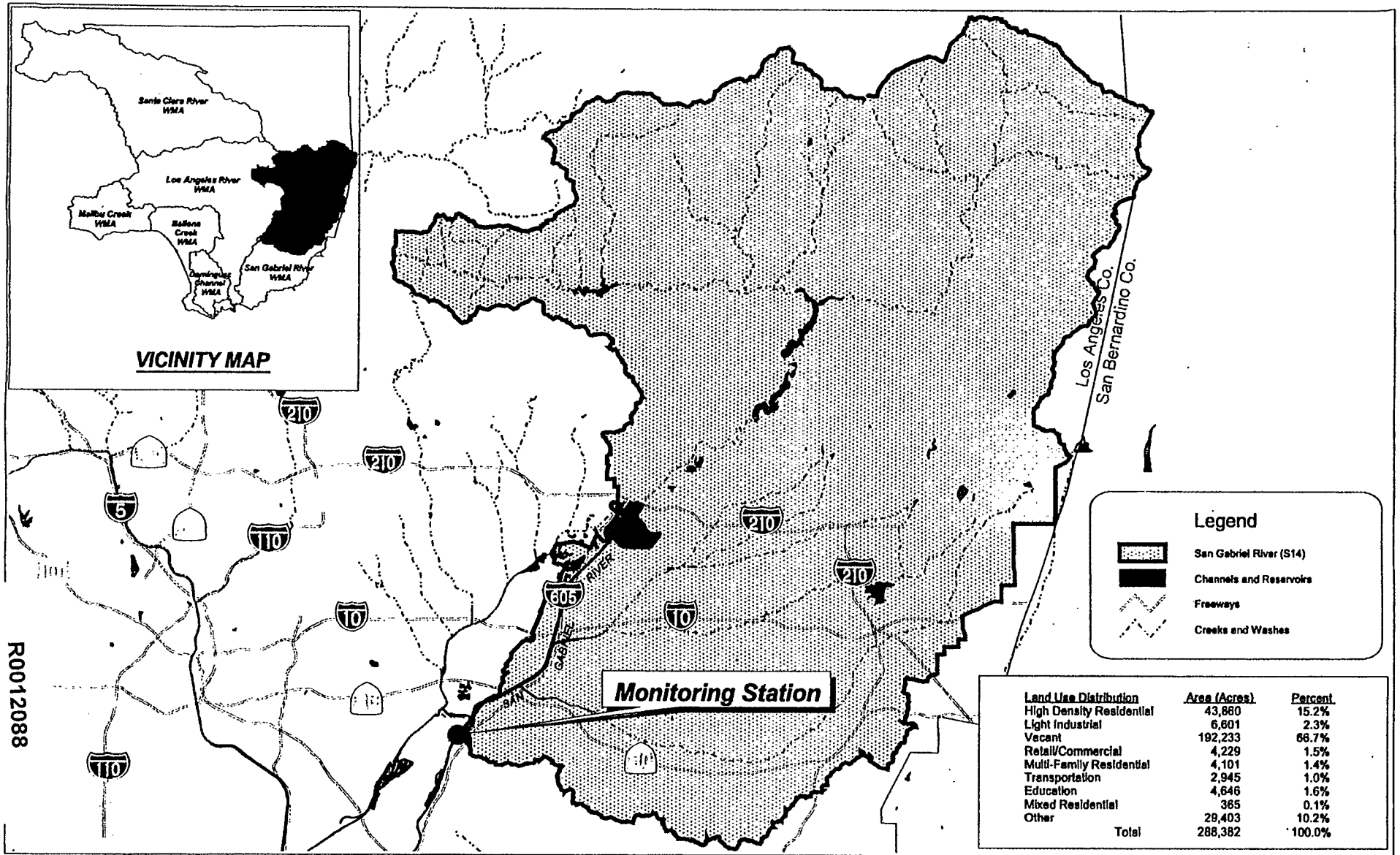

R0012088

Figure 2-5

SAN GABRIEL RIVER (S14)
at San Gabriel Pkwy.
Pico Rivera
(Mass Emission Monitoring Site)
1990 Population = 844,000

LOS ANGELES COUNTY PUBLIC WORKS
Public Service That Works

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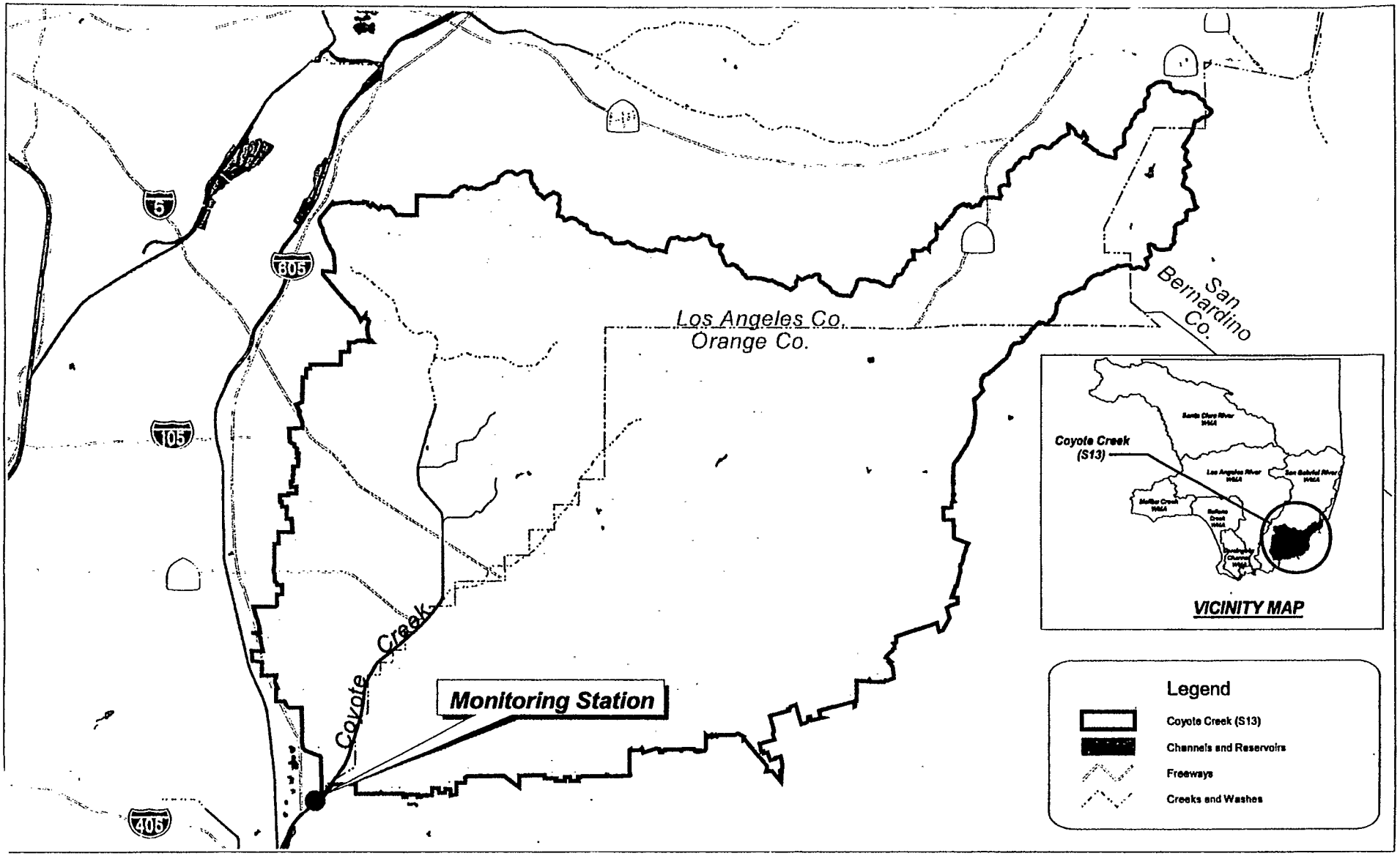

LOS ANGELES COUNTY PUBLIC WORKS
Public Service That Works

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Figure 2-6

COYOTE CREEK (S13) at Spring St.

Long Beach

(Mass Emission Monitoring Site)

1990 Population = 876,000

Land Use Distribution	Area (Acres)	Percent
High Density Residential	36,402	38.3%
Light Industrial	8,000	8.4%
Vacant	13,550	14.3%
Retail/Commercial	5,366	5.6%
Multi-Family Residential	5,836	6.1%
Transportation	1,718	1.8%
Education	4,129	4.3%
Mixed Residential	155	0.2%
Other	19,954	21.0%
Total	95,111	100.0%

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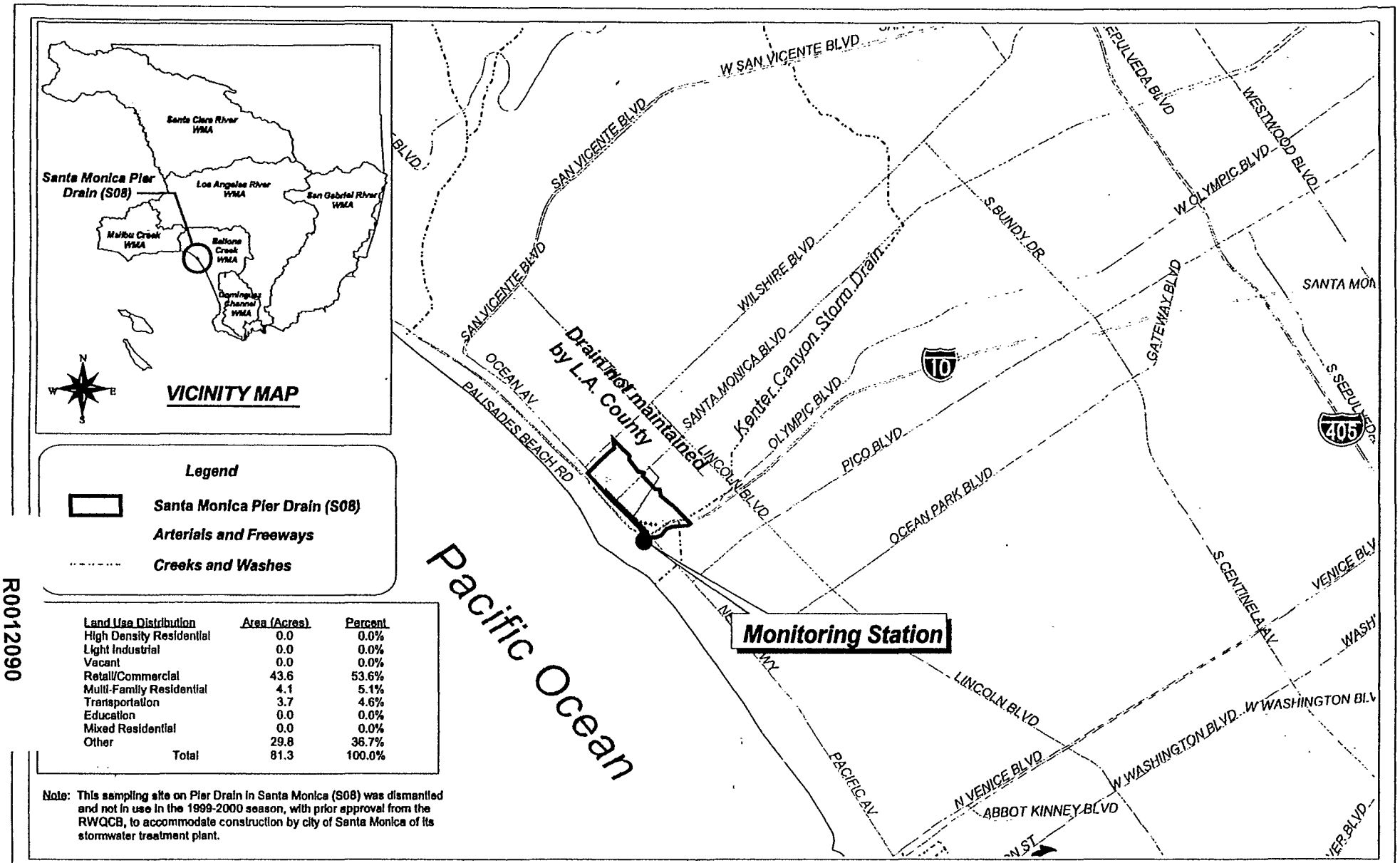
R0012089



Land Use Distribution	Area (Acres)	Percent
High Density Residential	0.0	0.0%
Light Industrial	0.0	0.0%
Vacant	0.0	0.0%
Retail/Commercial	43.6	53.6%
Multi-Family Residential	4.1	5.1%
Transportation	3.7	4.6%
Education	0.0	0.0%
Mixed Residential	0.0	0.0%
Other	29.8	36.7%
Total	81.3	100.0%

Note: This sampling site on Pier Drain in Santa Monica (S08) was dismantled and not in use in the 1999-2000 season, with prior approval from the RWQCB, to accommodate construction by city of Santa Monica of its stormwater treatment plant.

R0012090

Figure 2-7

SANTA MONICA PIER (S08) at Appian Way Santa Monica (Retail/Commercial Land Use Monitoring Site) 1990 Population = 400

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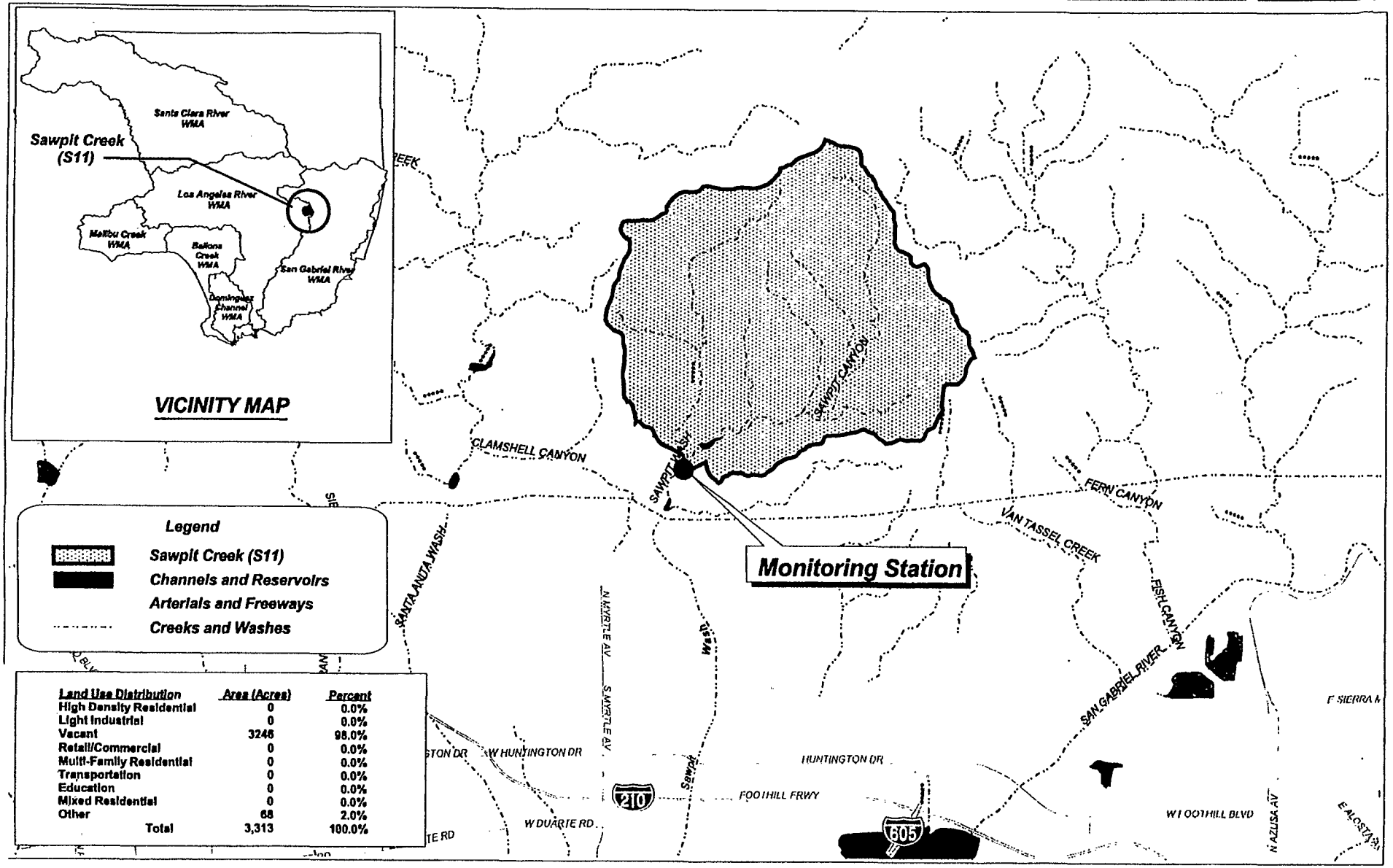

Land Use Distribution	Area (Acres)	Percent
High Density Residential	0	0.0%
Light Industrial	0	0.0%
Vacant	3246	98.0%
Retail/Commercial	0	0.0%
Multi-Family Residential	0	0.0%
Transportation	0	0.0%
Education	0	0.0%
Mixed Residential	0	0.0%
Other	68	2.0%
Total	3,313	100.0%

R0012091

Figure 2-8

SAWPIT CREEK (S11) at Monrovia Cr.

Monrovia
(Vacant Land Use Monitoring Site)
1990 Population = 2,000

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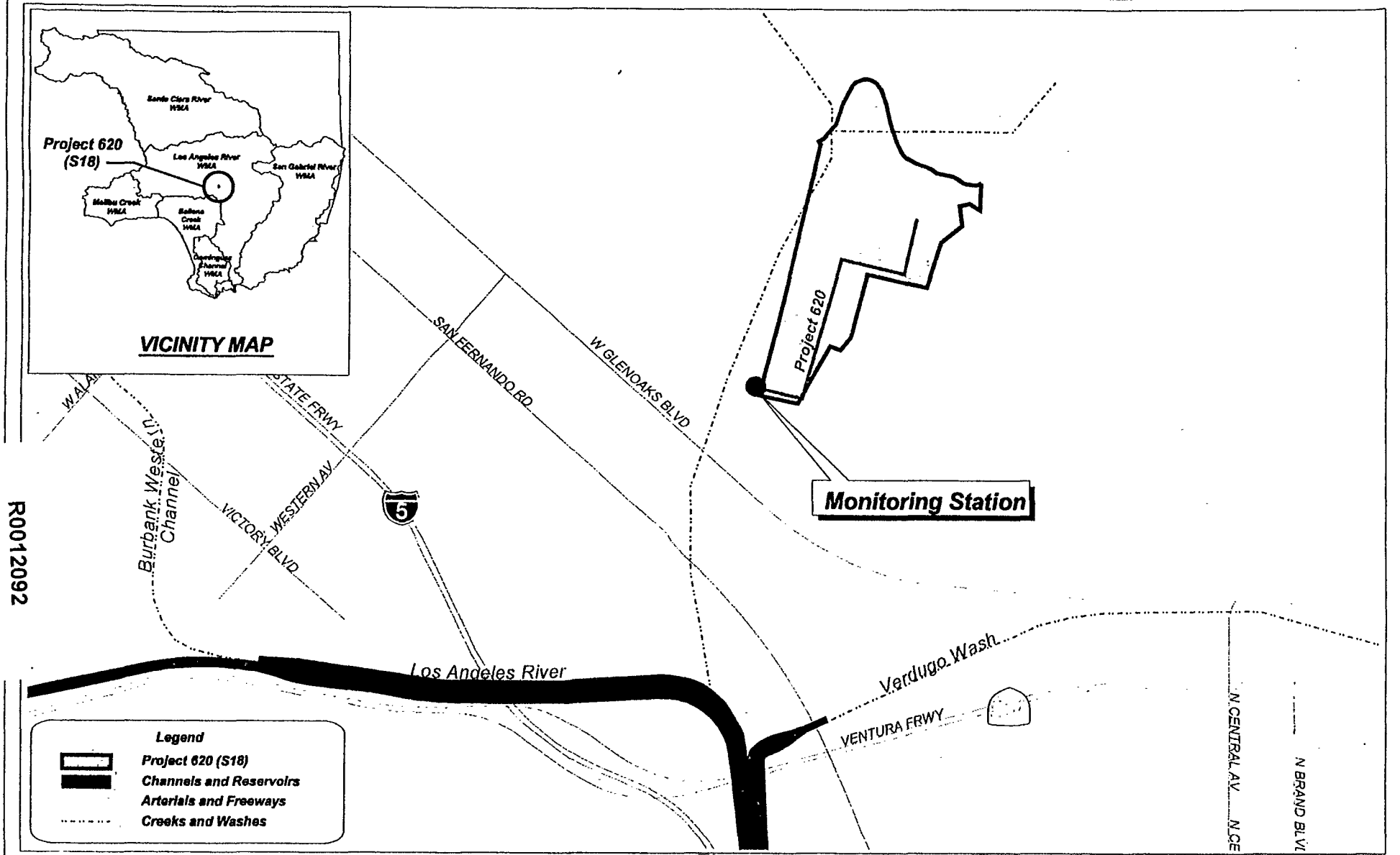

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Figure 2-9

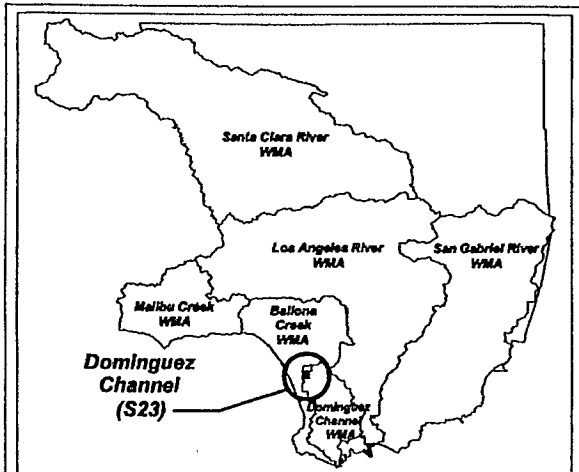
PROJECT 620 (S18) at Glenwood Rd.

Glendale

(High Density Single Family Residential Land Use Monitoring Site)

1990 Po[illegible]ation = 3,000

Land Use Distribution	Area (Acres)	Percent
High Density Residential	120.4	100.0%
Light Industrial	0.0	0.0%
Vacant	0.0	0.0%
Retail/Commercial	0.0	0.0%
Multi-Family Residential	0.0	0.0%
Transportation	0.0	0.0%
Education	0.0	0.0%
Mixed Residential	0.0	0.0%
Other	0.0	0.0%
Total	120.4	100.0%



VICINITY MAP

Legend

- Dominguez Channel (S23)
- Channels and Reservoirs
- Arterials and Freeways

Land Use Distribution	Area (Acres)	Percent
High Density Residential	5	0.6%
Light Industrial	153	17.0%
Vacant	0	0.0%
Retail/Commercial	1	0.1%
Multi-Family Residential	0	0.0%
Transportation	678	75.2%
Education	0	0.0%
Mixed Residential	0	0.0%
Other	65	7.1%
Total	902	100.0%

R0012093

Figure 2-10

DOMINGUEZ CHANNEL (S23) at 116th St.

Unincorporated L.A. County

(Transportation Land Use Monitoring Site)

1990 Population = 2,000



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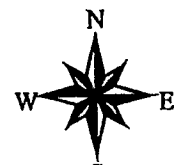

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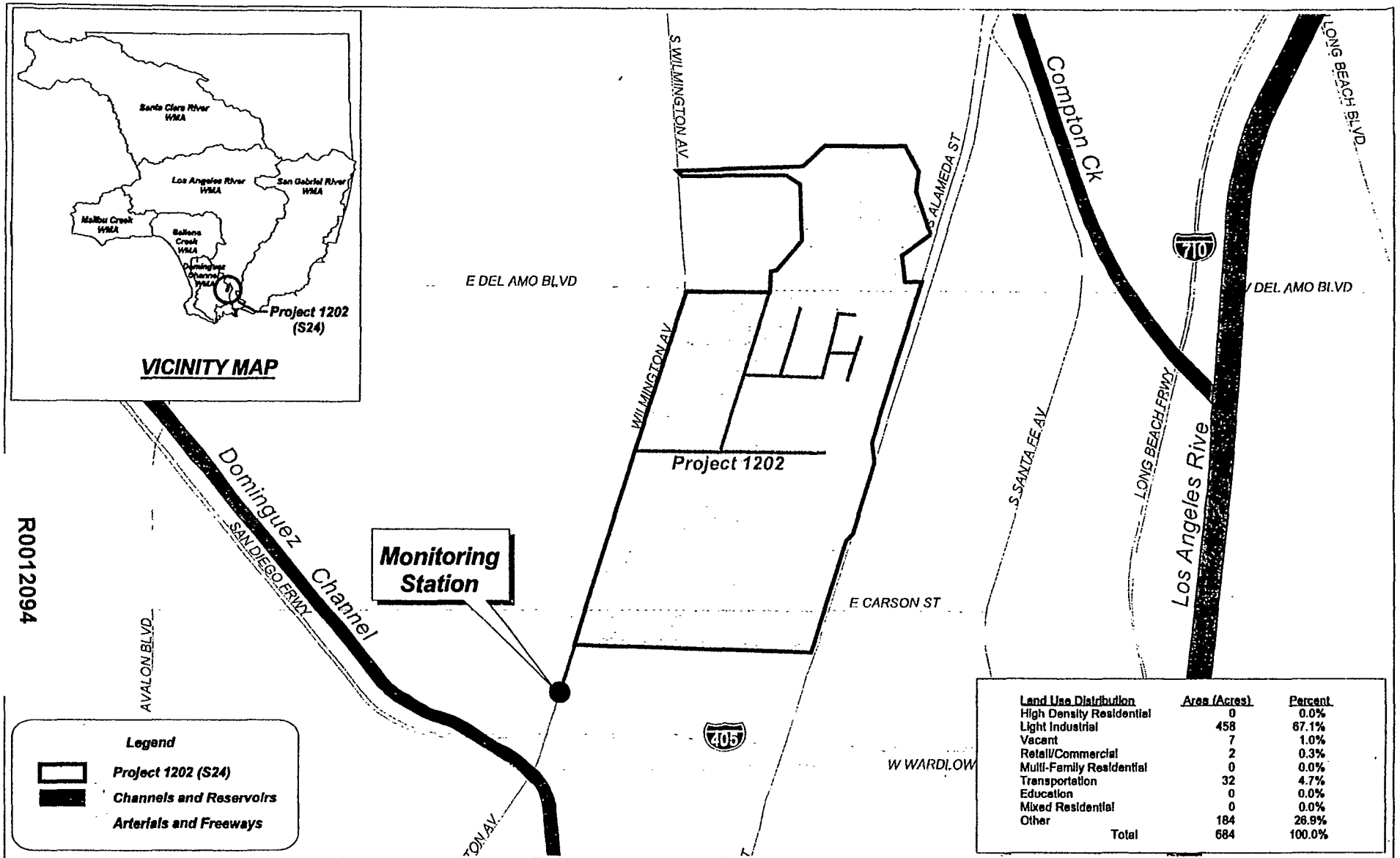

Figure 2-11

PROJECT 1202 (S24) at Wilmington Ave.

Carson

(Light Industrial Land Use Monitoring Site)

1990 Population = 3,000

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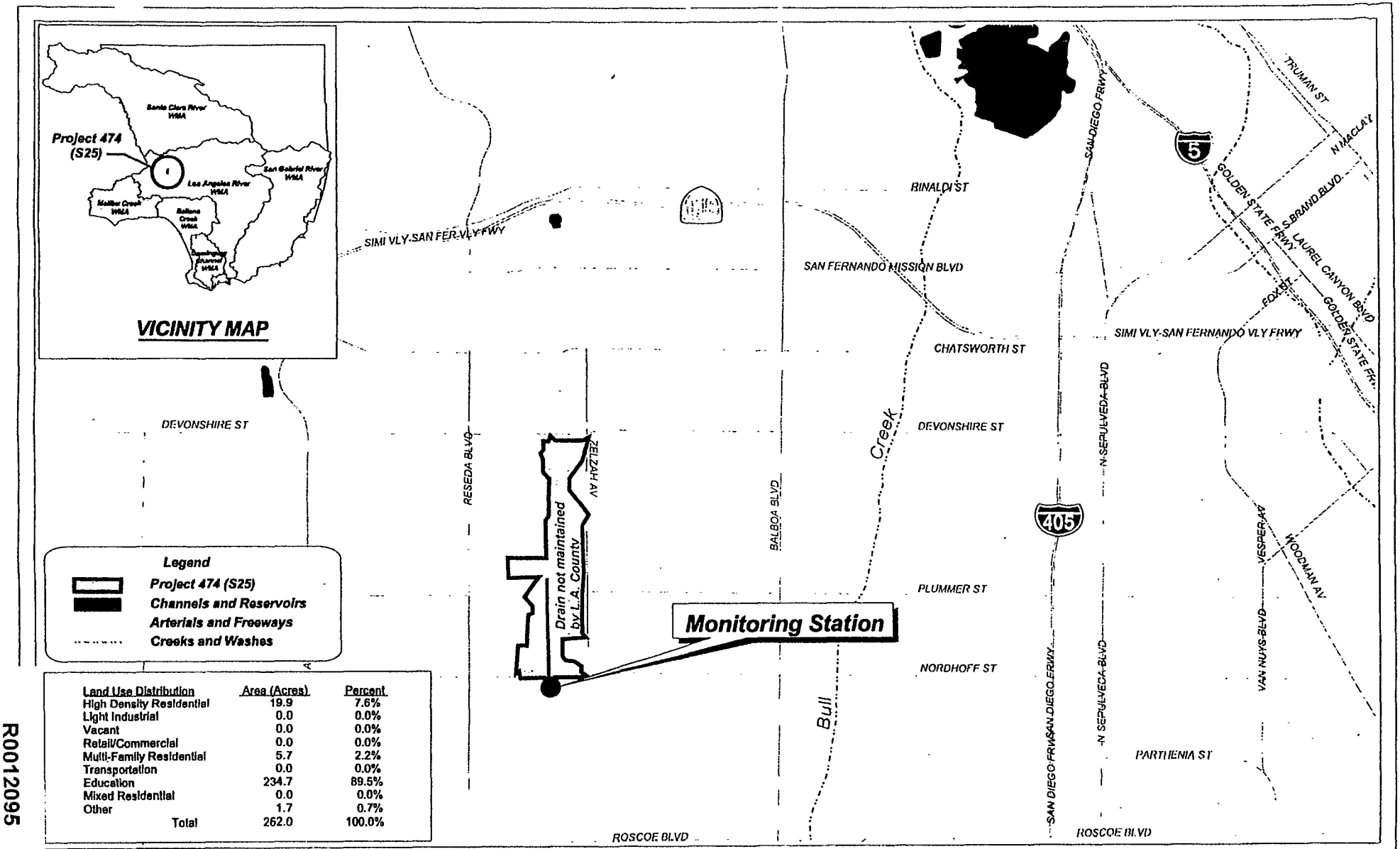

Figure 2-12

PROJECT 474 (S25) at Nordoff St.

Los Angeles (Educational Land Use Monitoring Site) 1990 Population = 4,000

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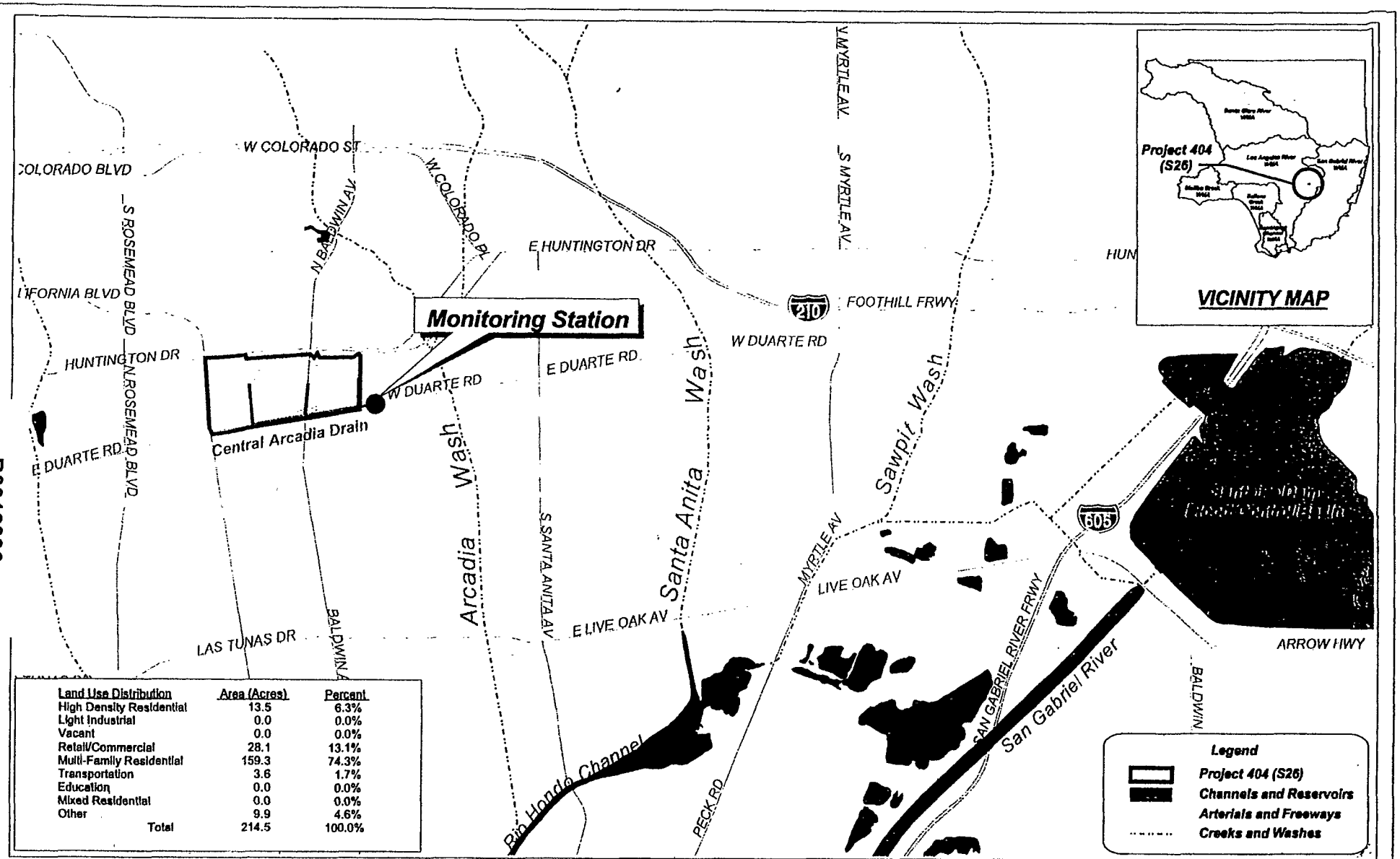

R0012096

Land Use Distribution	Area (Acres)	Percent
High Density Residential	13.5	6.3%
Light Industrial	0.0	0.0%
Vacant	0.0	0.0%
Retail/Commercial	28.1	13.1%
Multi-Family Residential	159.3	74.3%
Transportation	3.6	1.7%
Education	0.0	0.0%
Mixed Residential	0.0	0.0%
Other	9.9	4.6%
Total	214.5	100.0%

Figure 2-13

PROJECT 404 (S26)
at La Cadena Ave.
Arcadia
(Multi-Family Residential Land Use Monitoring Site)
1990 Population = 4,000

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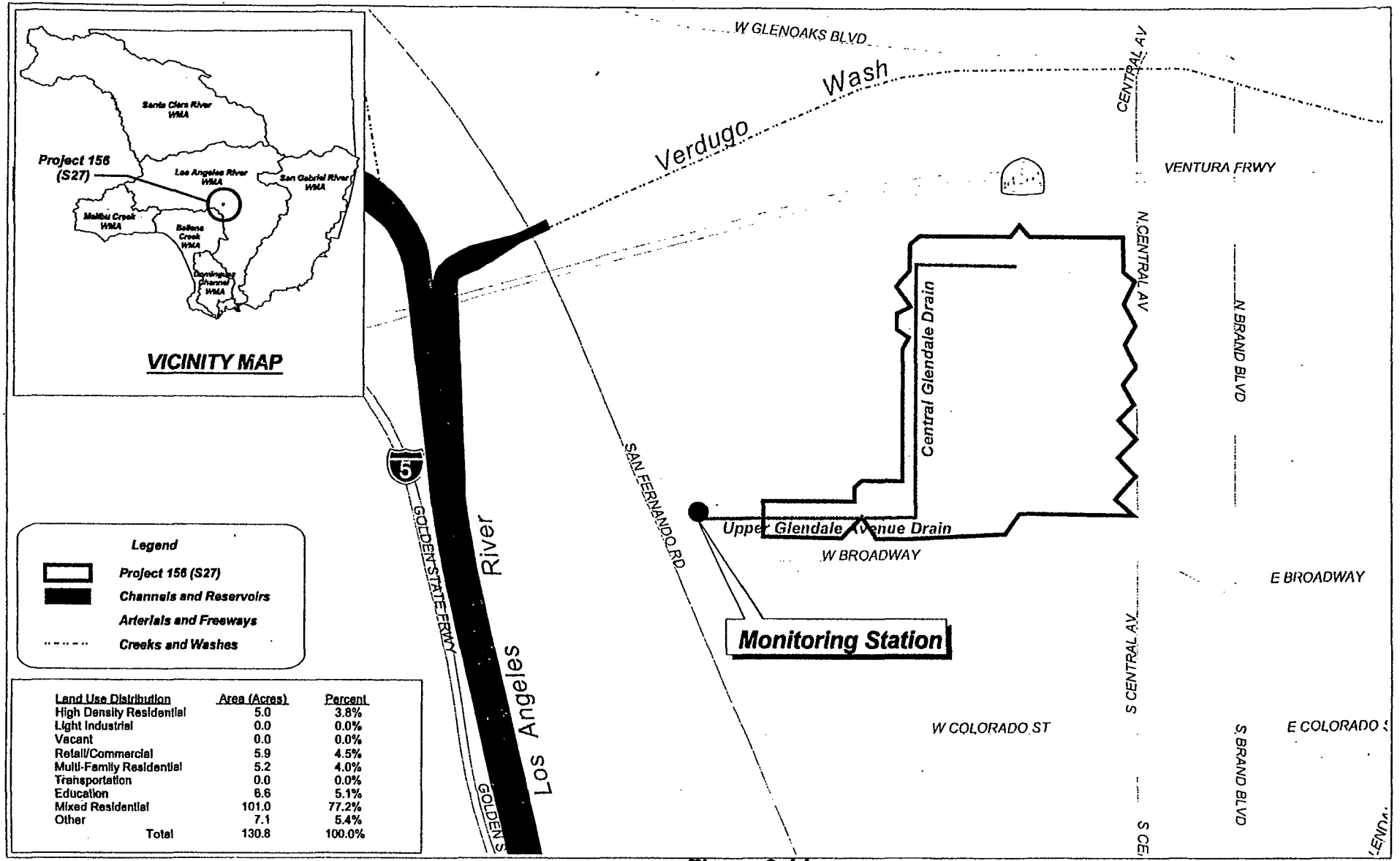

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Figure 2-14

PROJECT 156 (S27) at Concord St. Glendale (Mixed Residential Land Use Monitoring Site) 1990 Population = 3,000

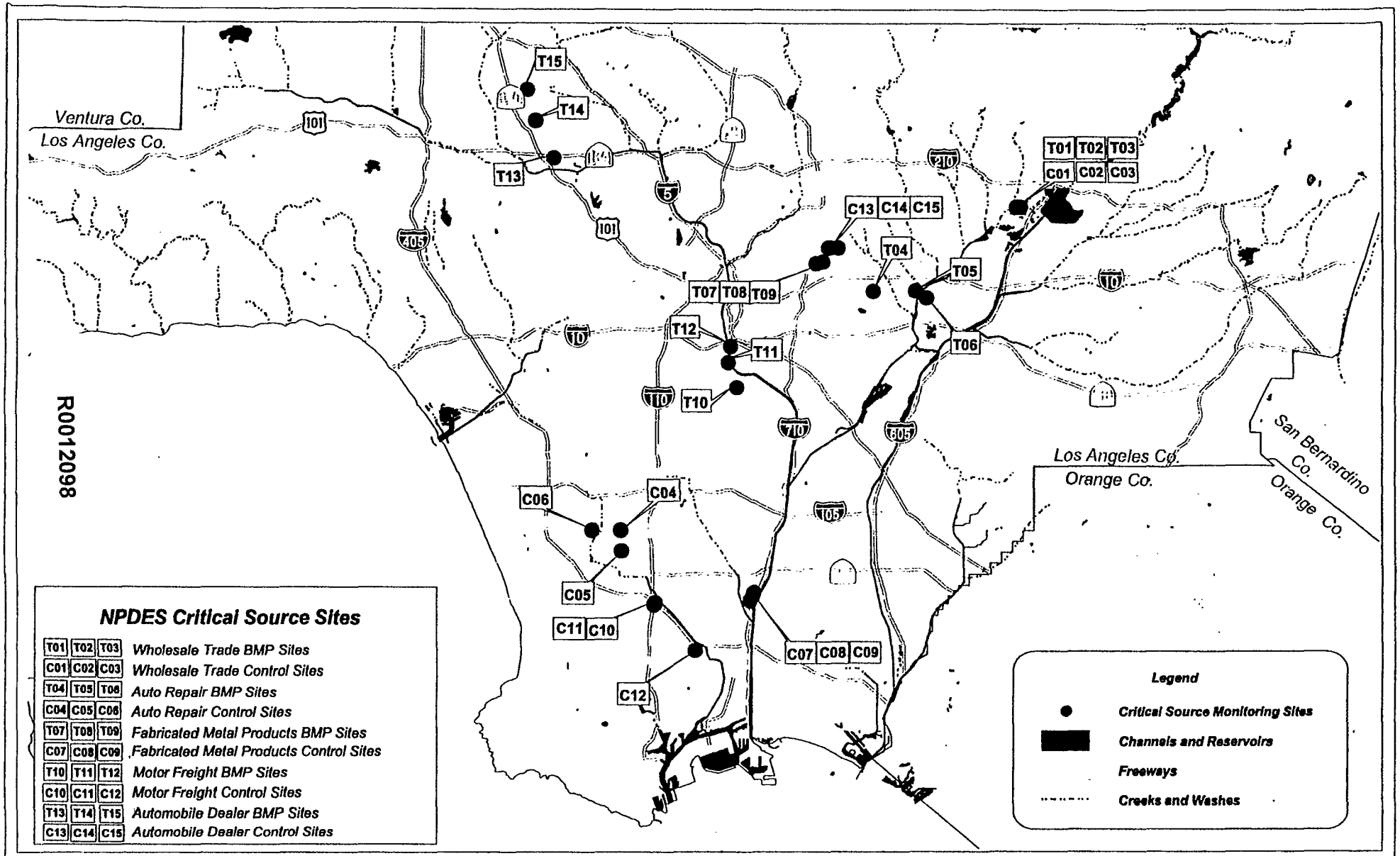

Figure 2-15

CRITICAL SOURCE SAMPLING SITES

For 1999-2000 Storm Season

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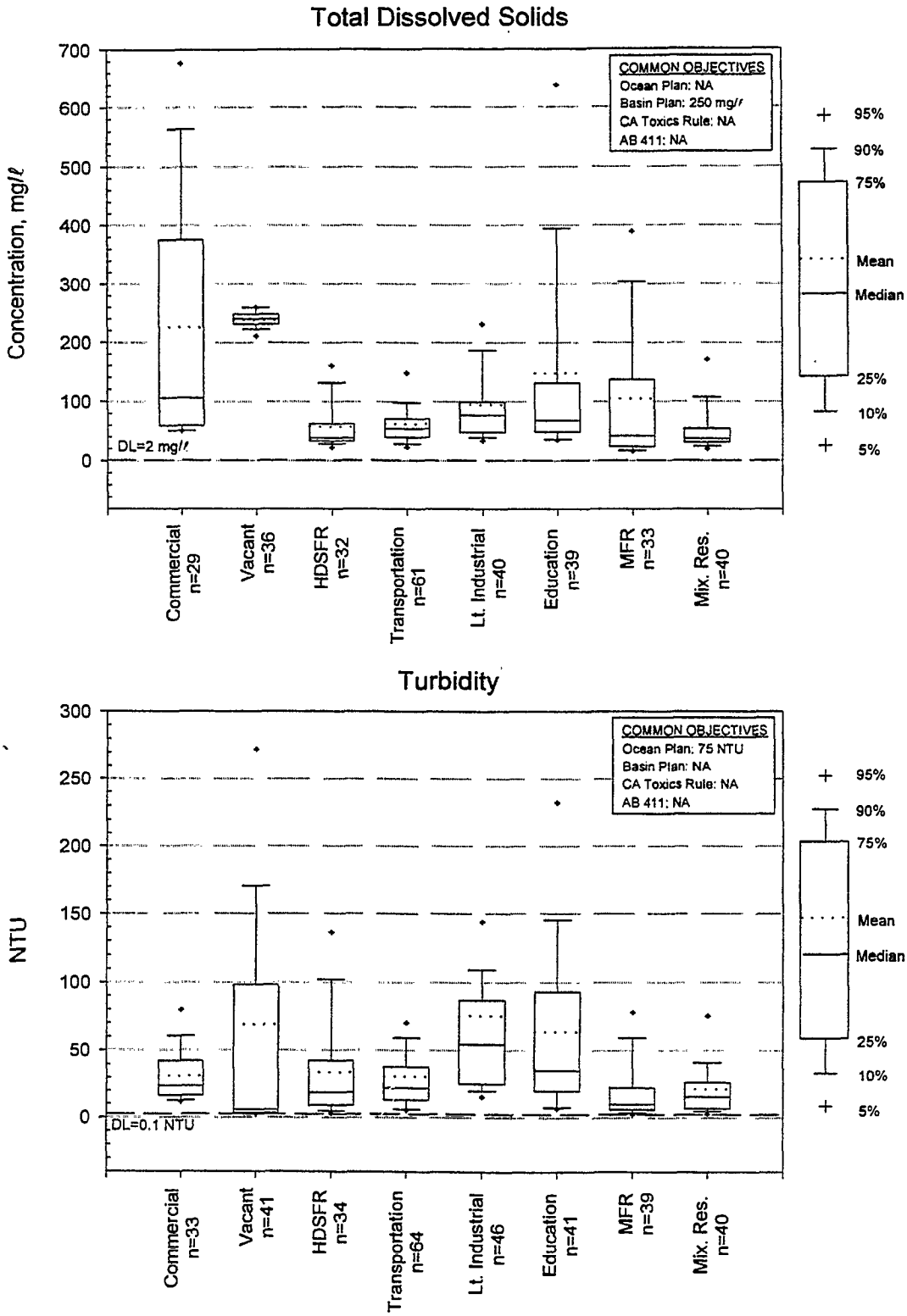
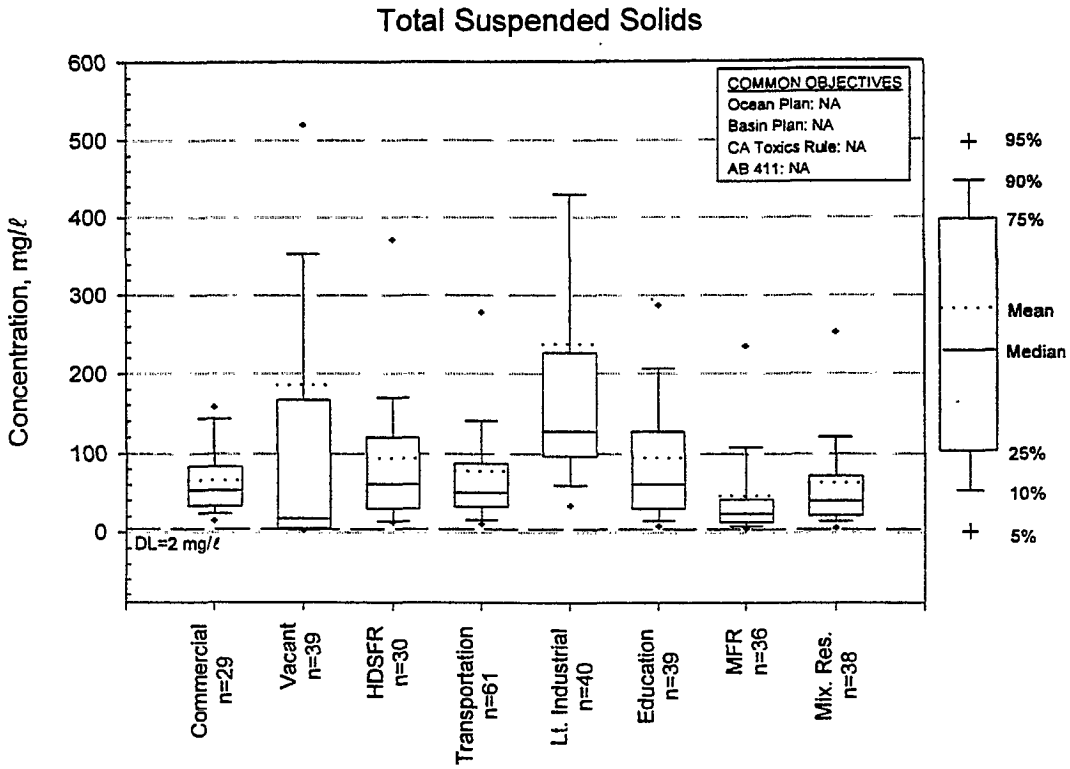
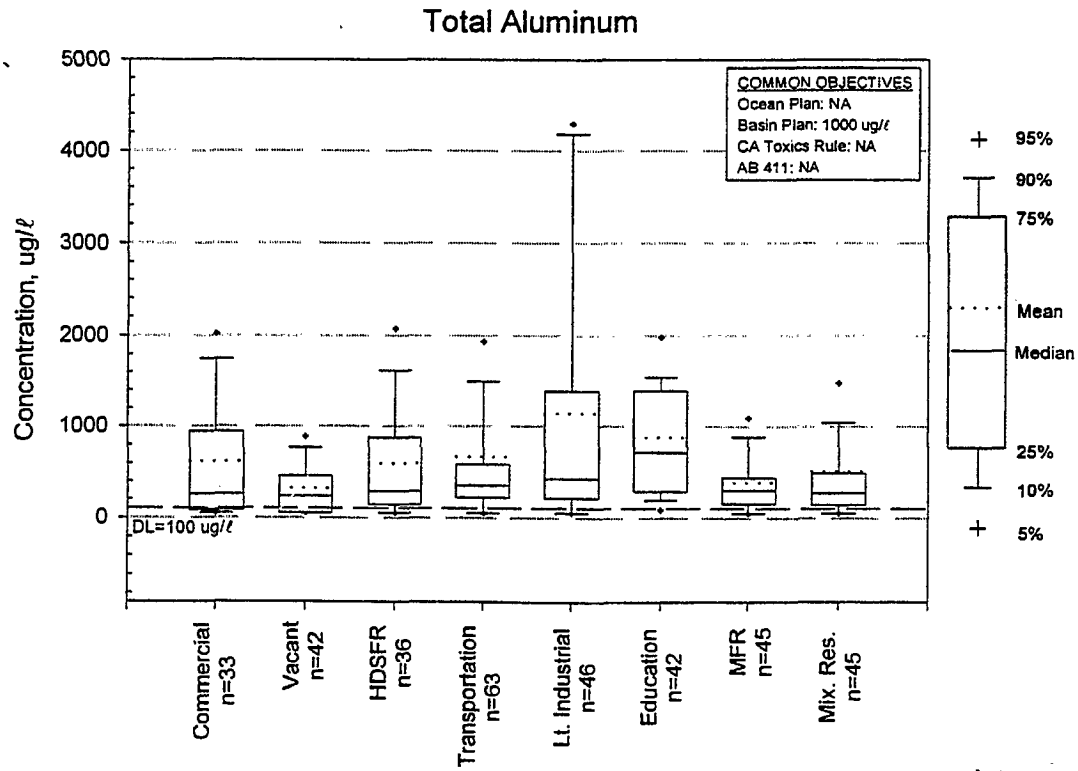
Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1

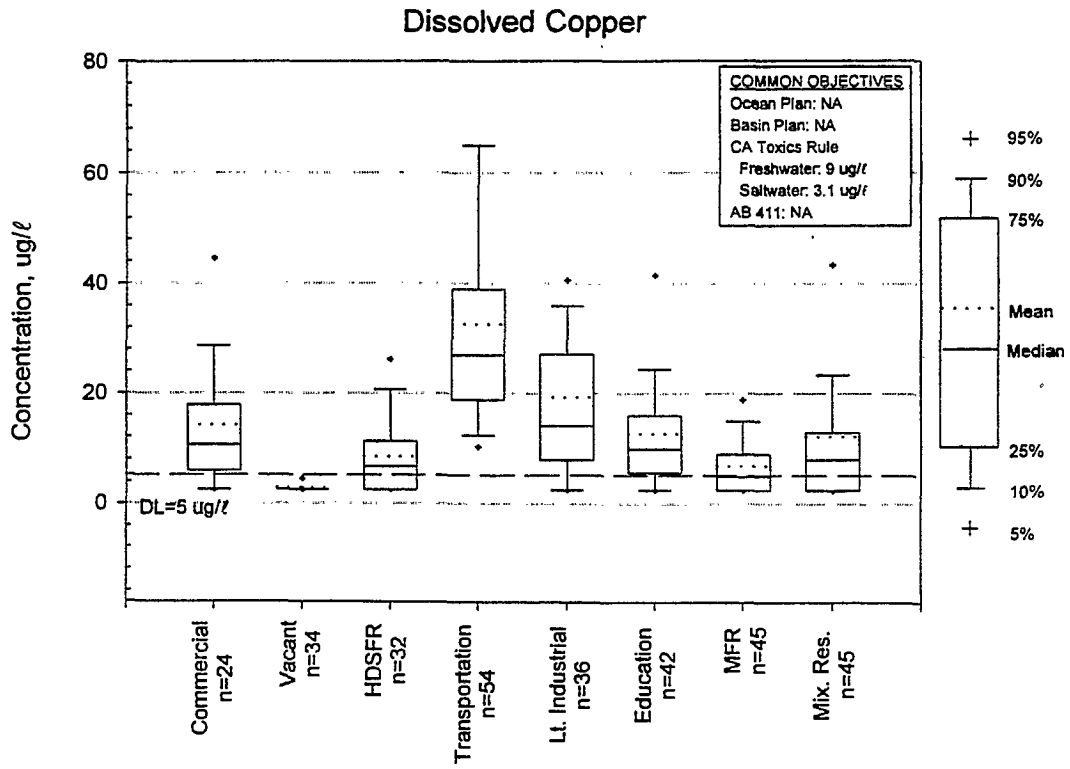


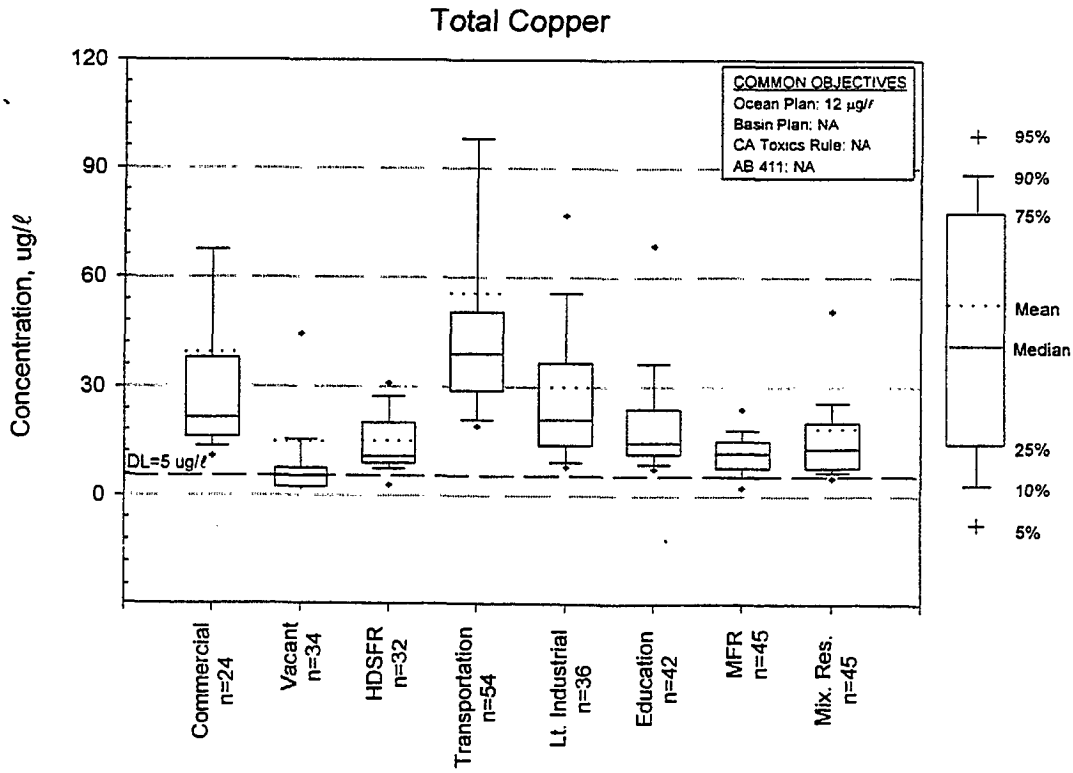
Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1



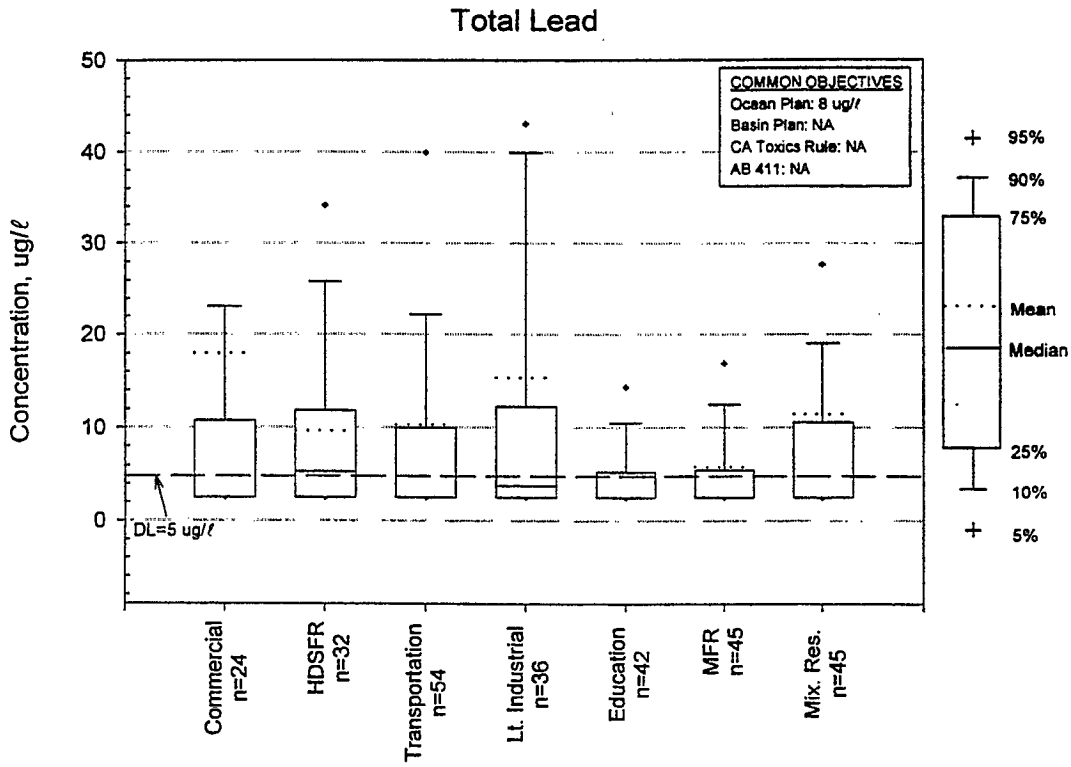


Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1

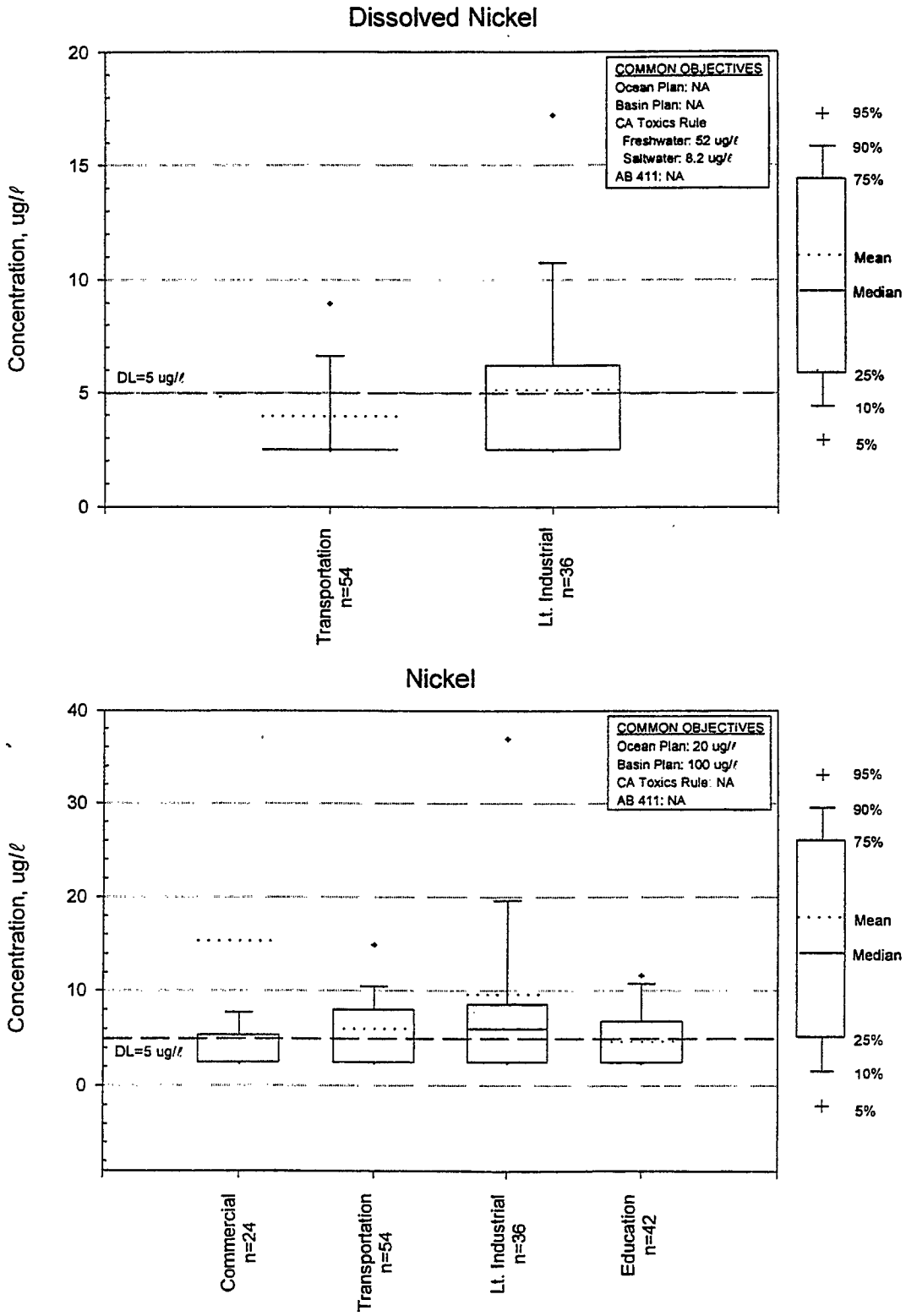




Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1



Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1



R0012103

Land Use Box Plots
1994-2000 Storm Seasons
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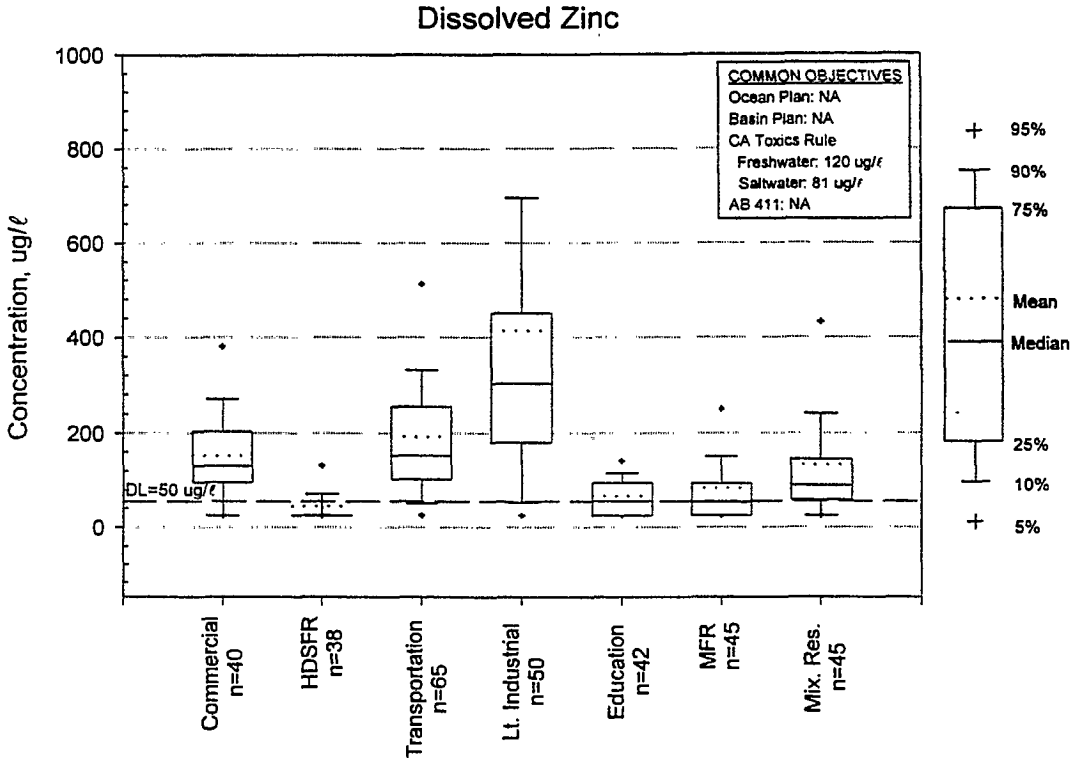

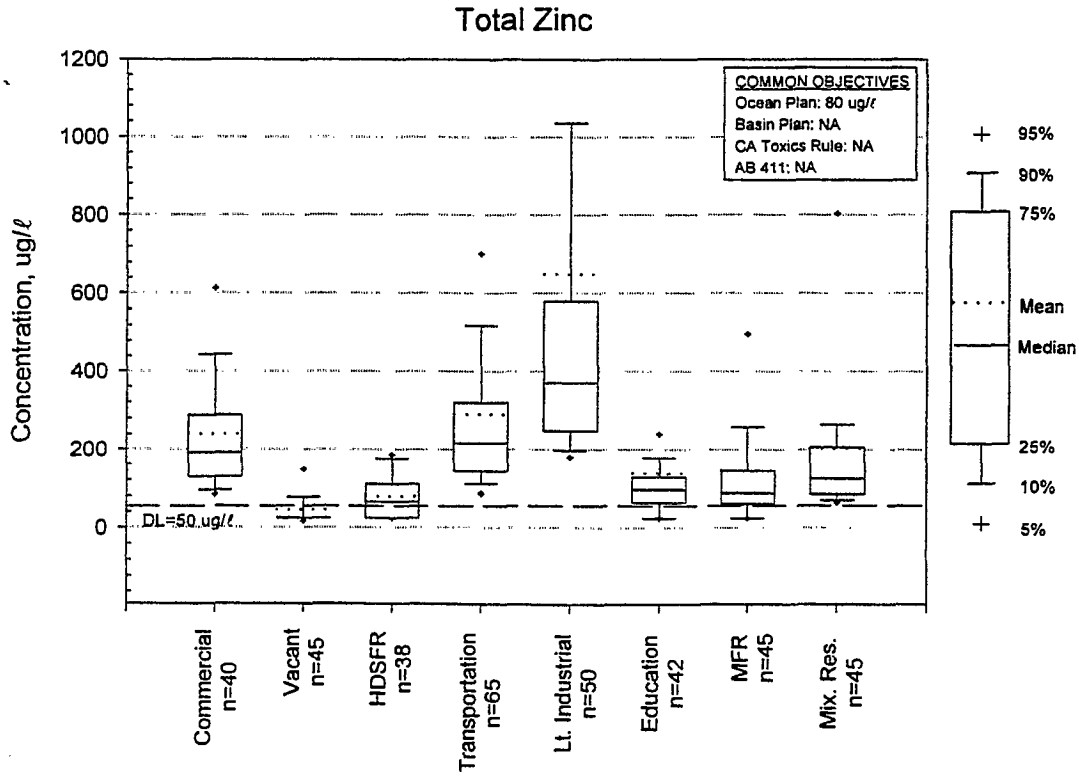

R0012104

Land Use Box Plots
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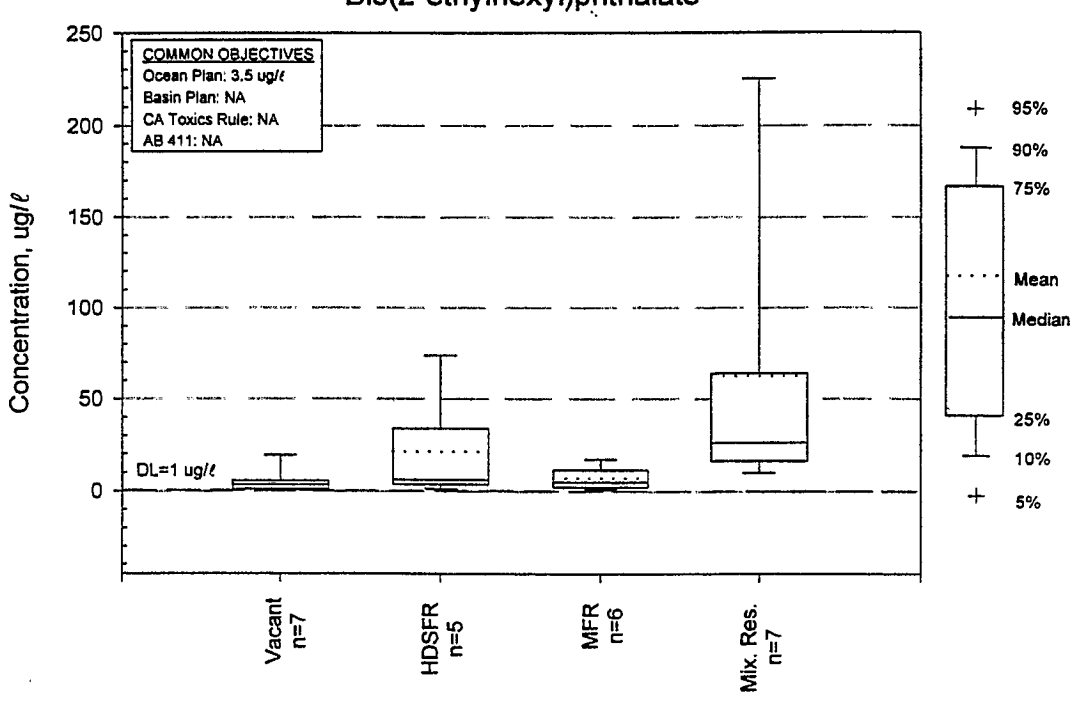
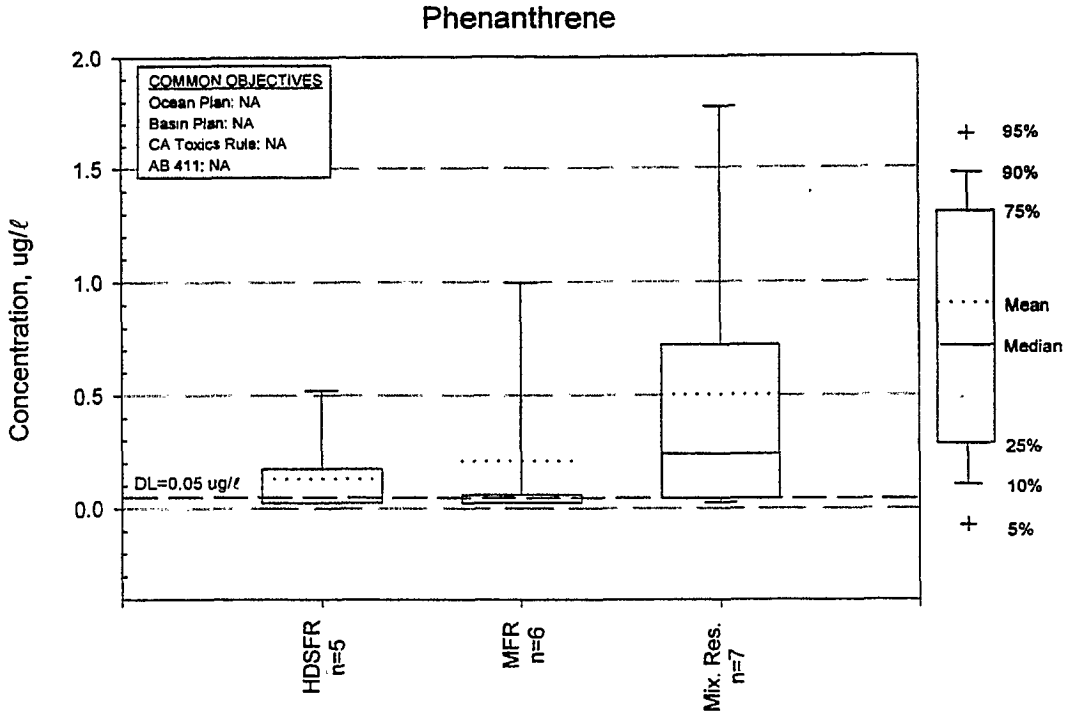
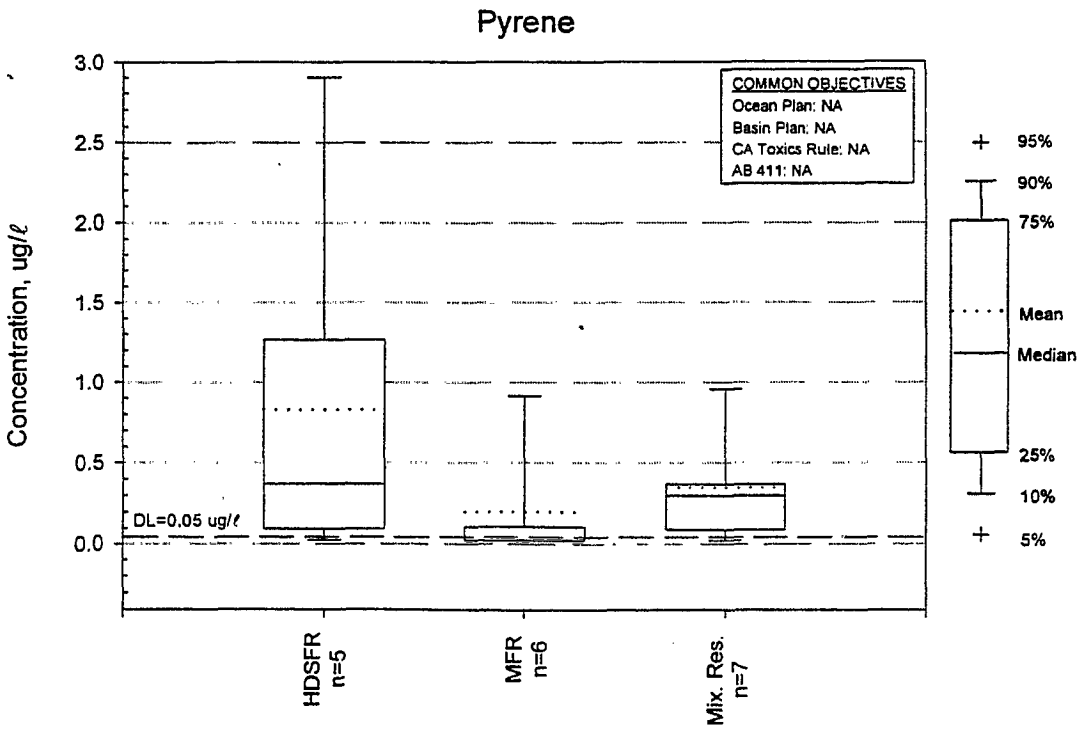
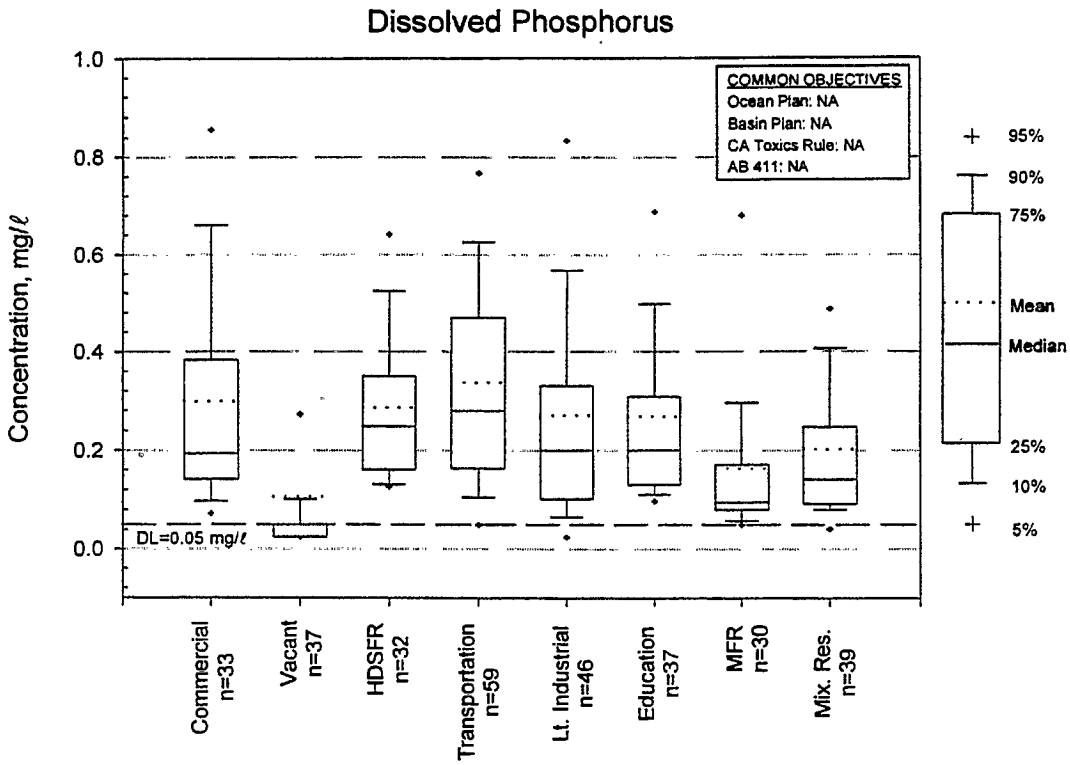


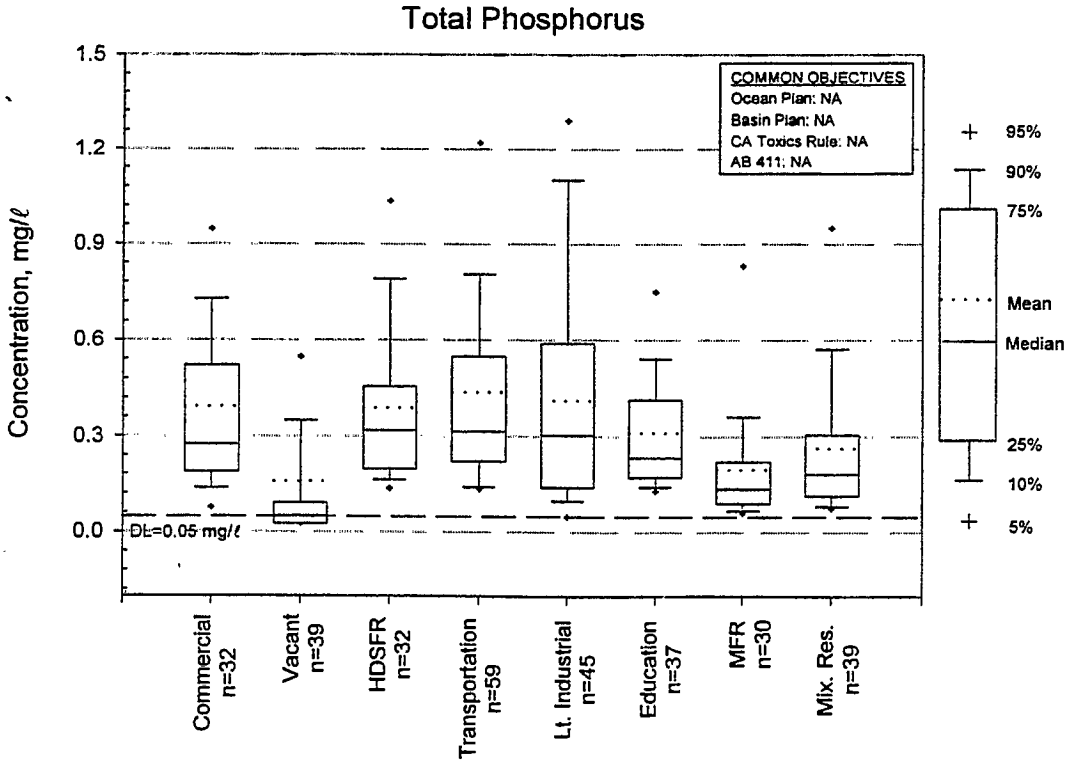
Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1



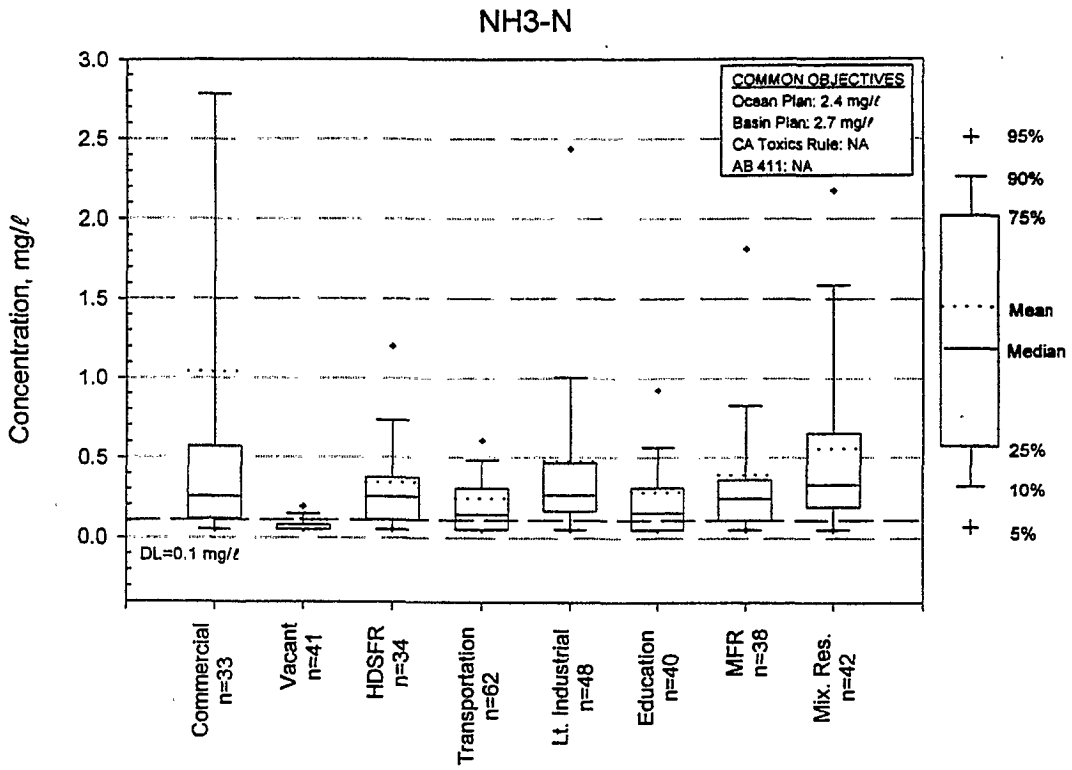


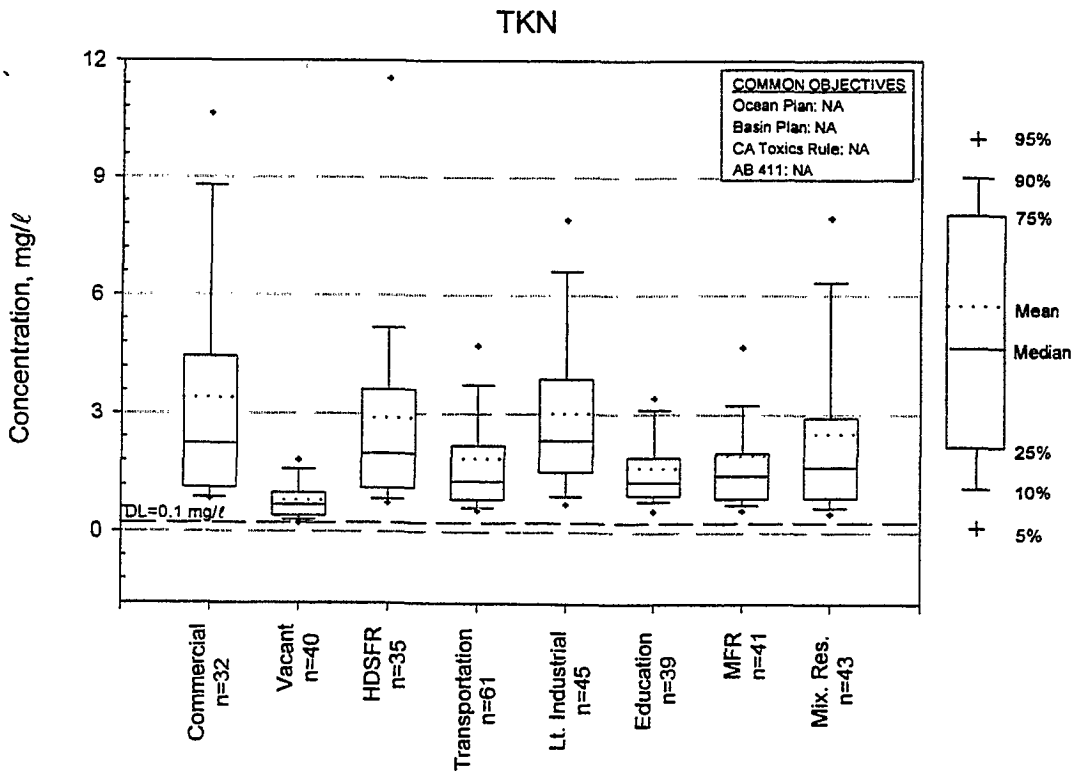
Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1



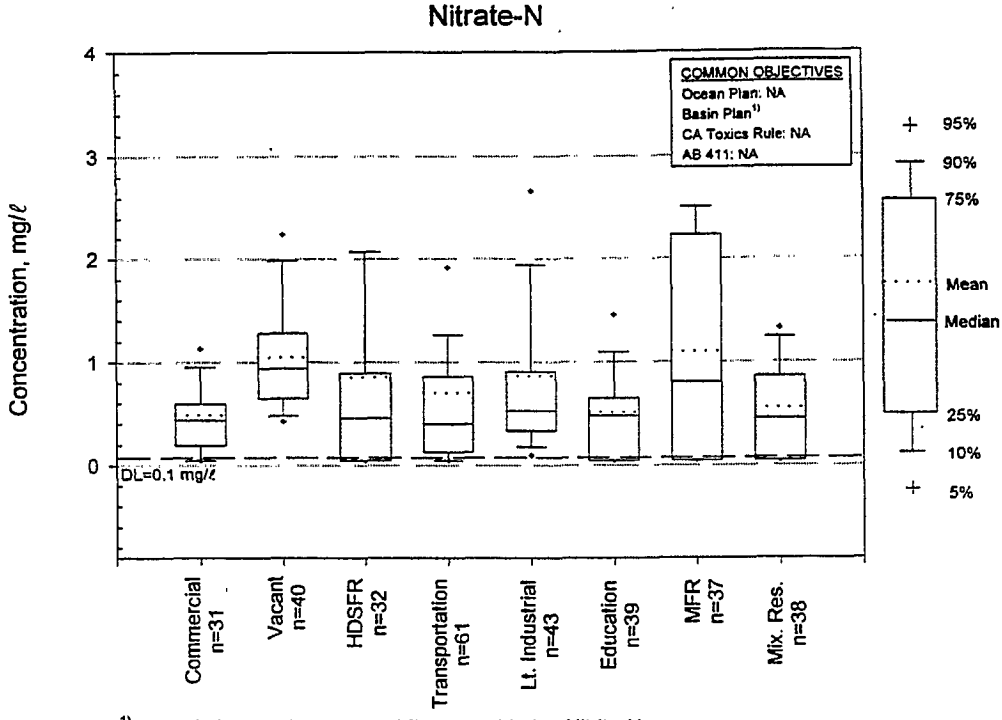


Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1

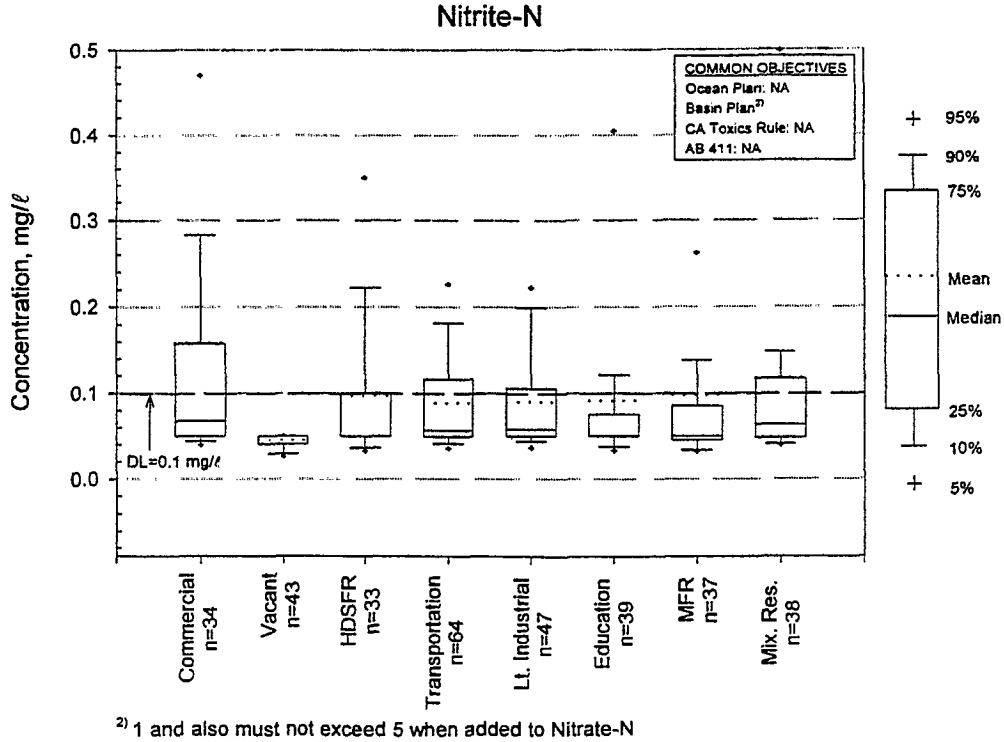




Land Use Box Plots
1994-2000 Storm Seasons
Figure 4-1



[1)] 10 and also must not exceed 5 when added to Nitrite-N



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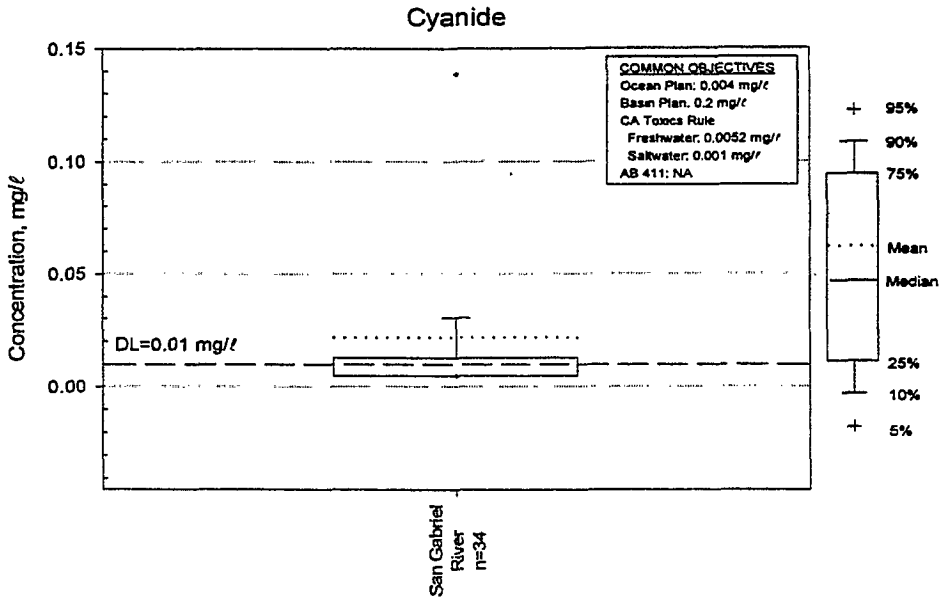
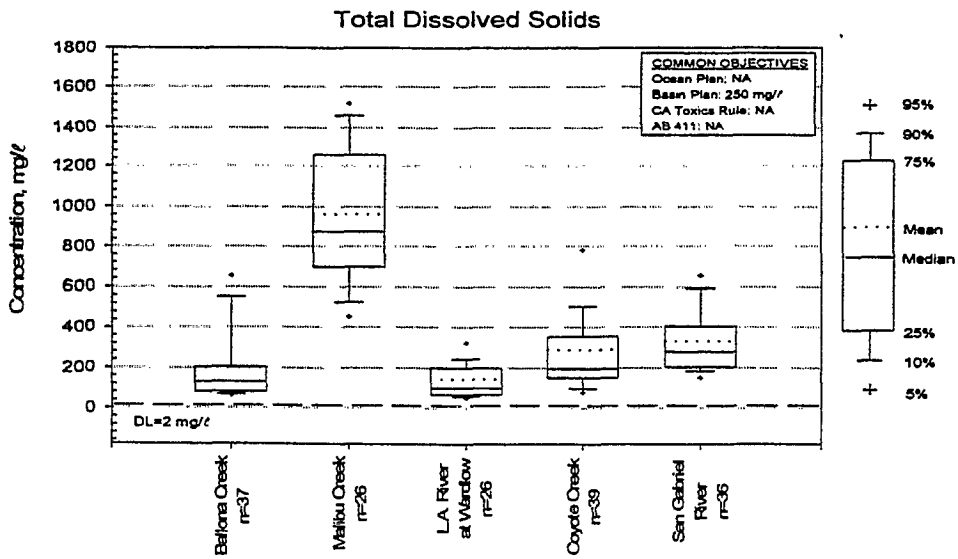
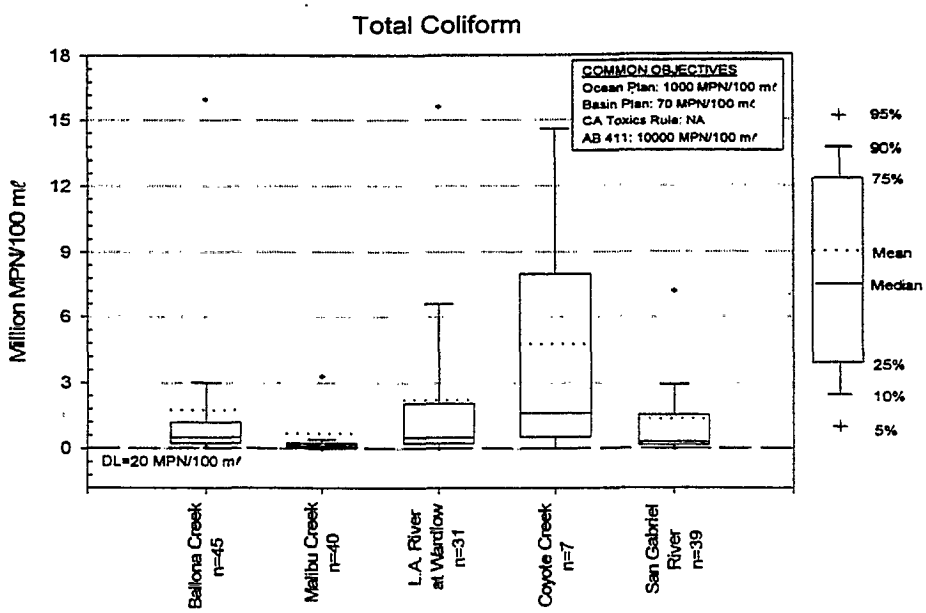
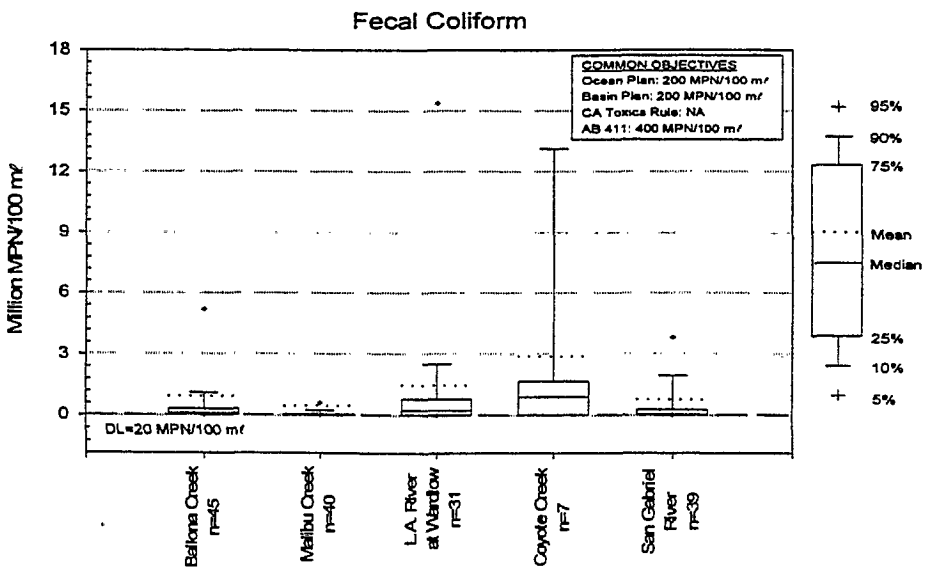
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



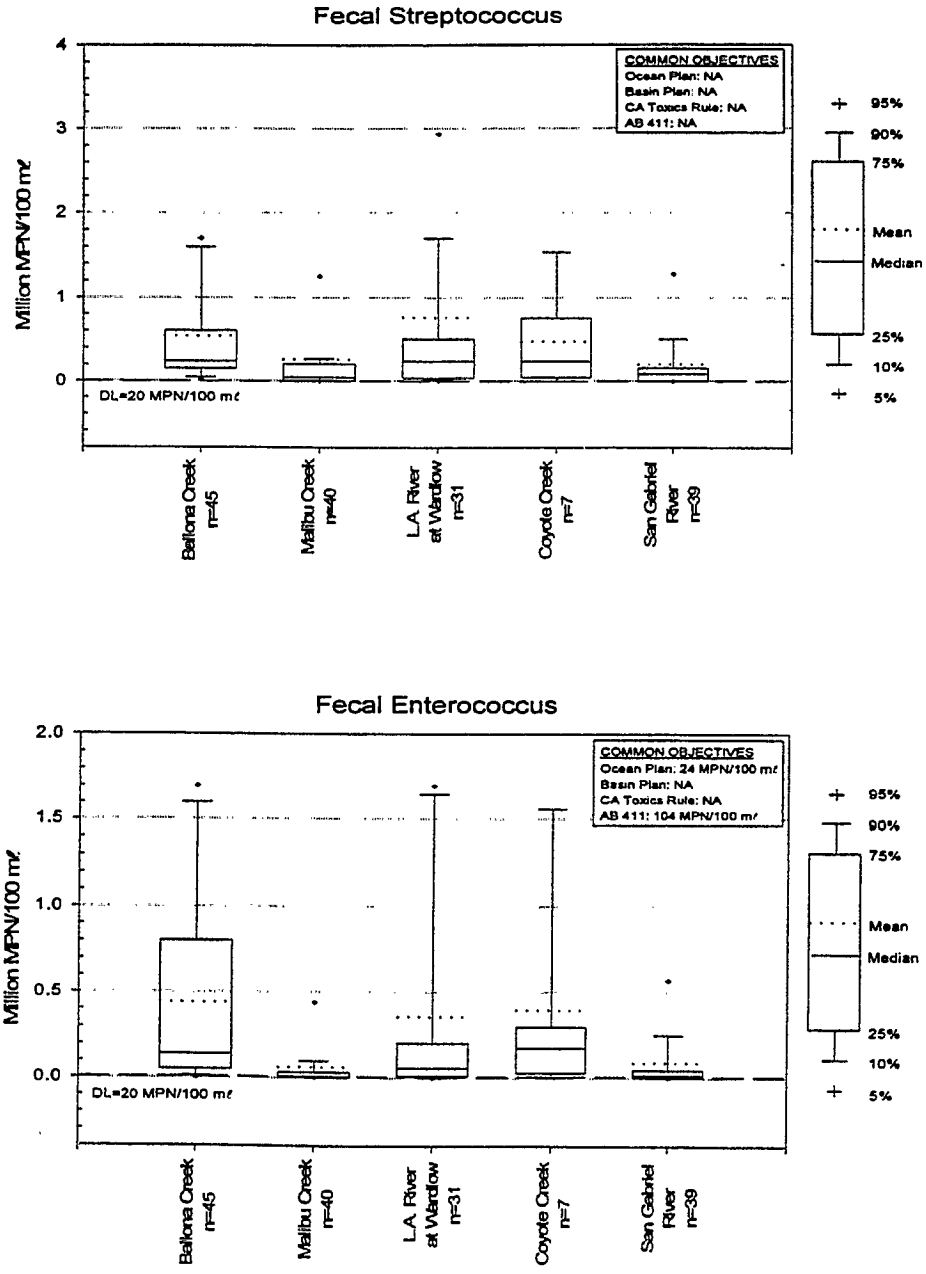


Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2

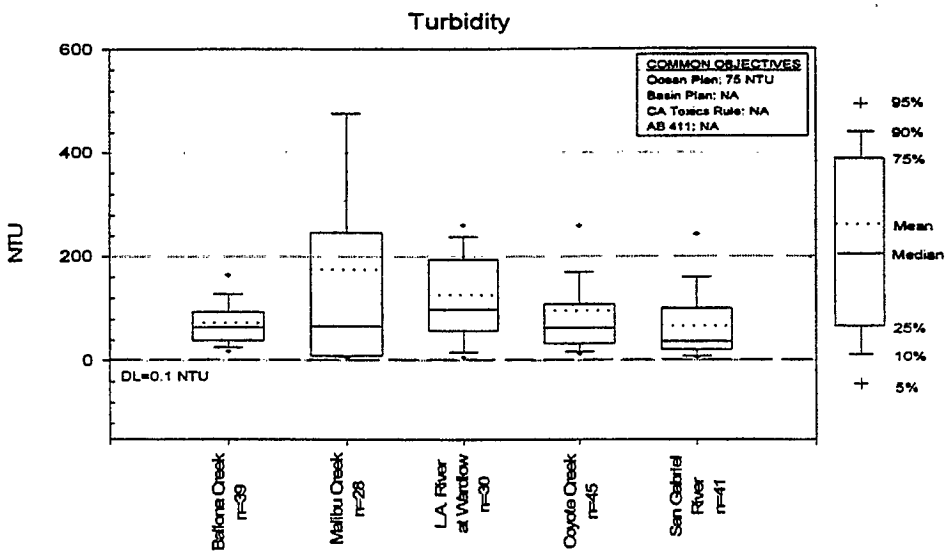


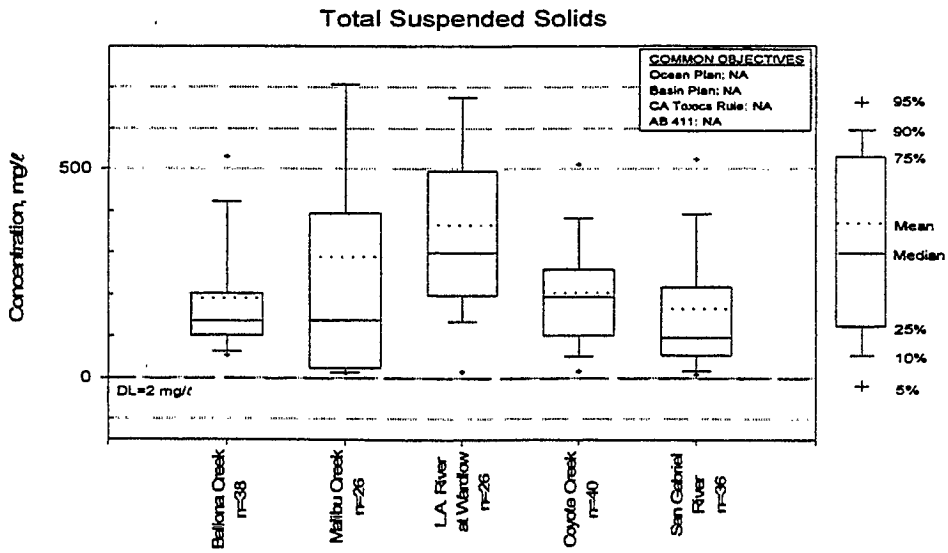


Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2

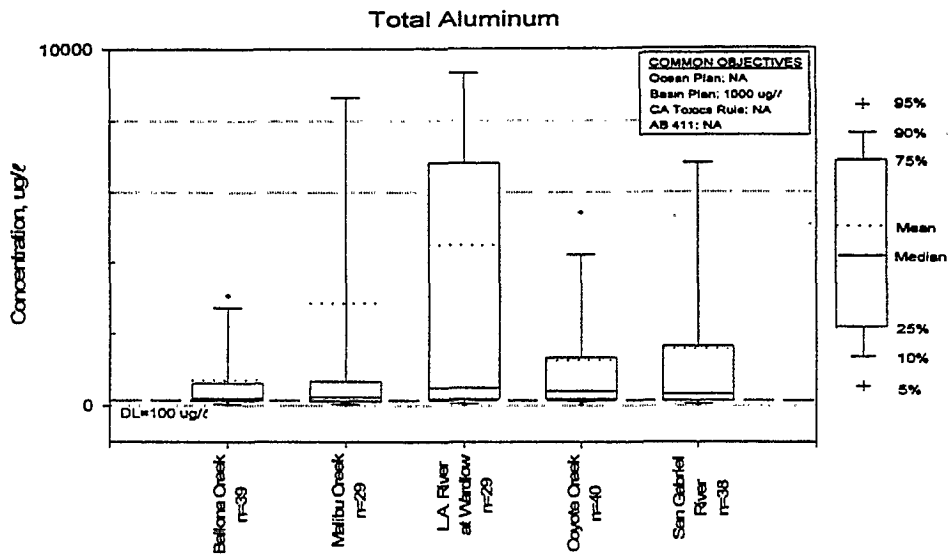


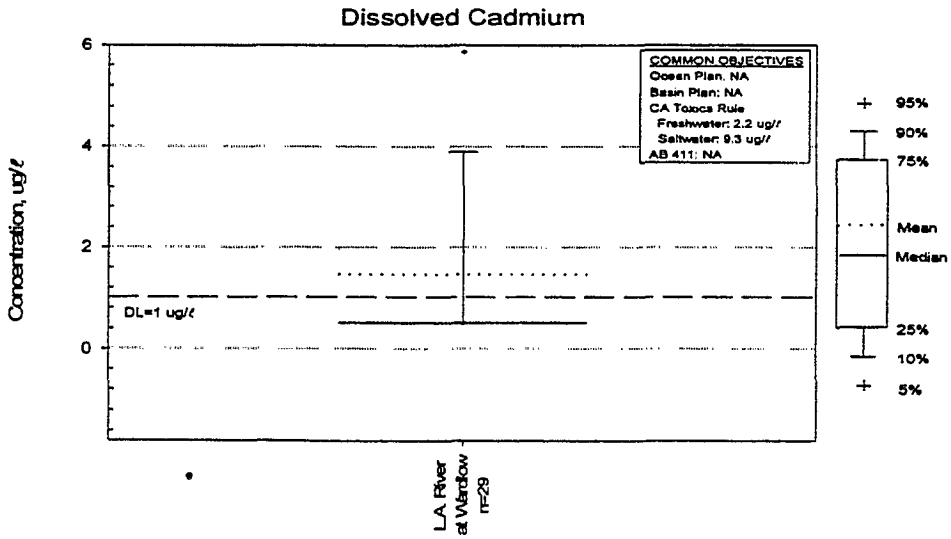
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



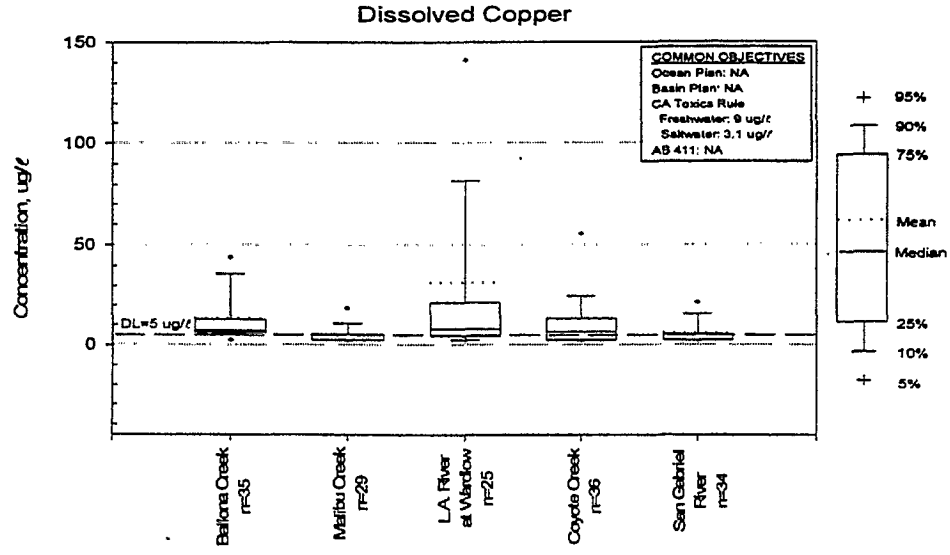


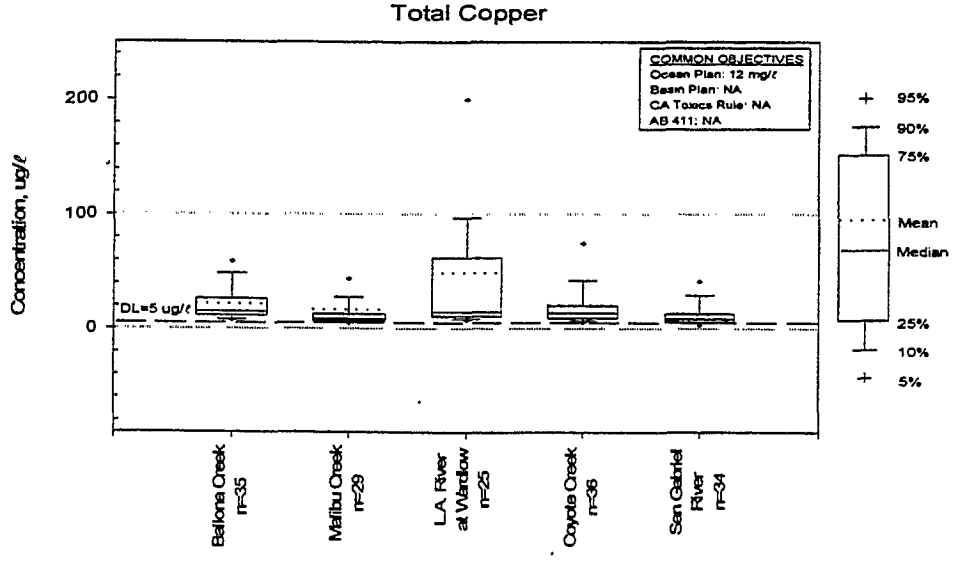
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



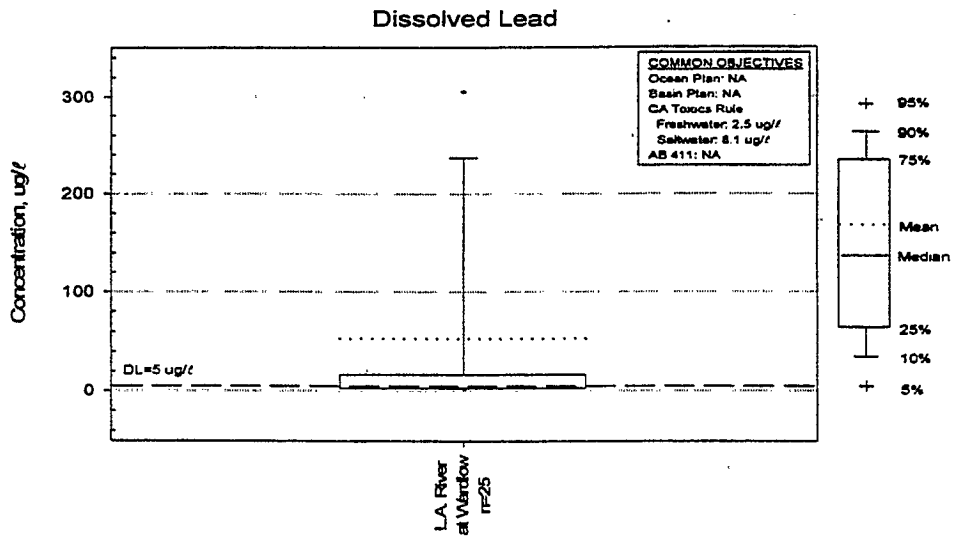


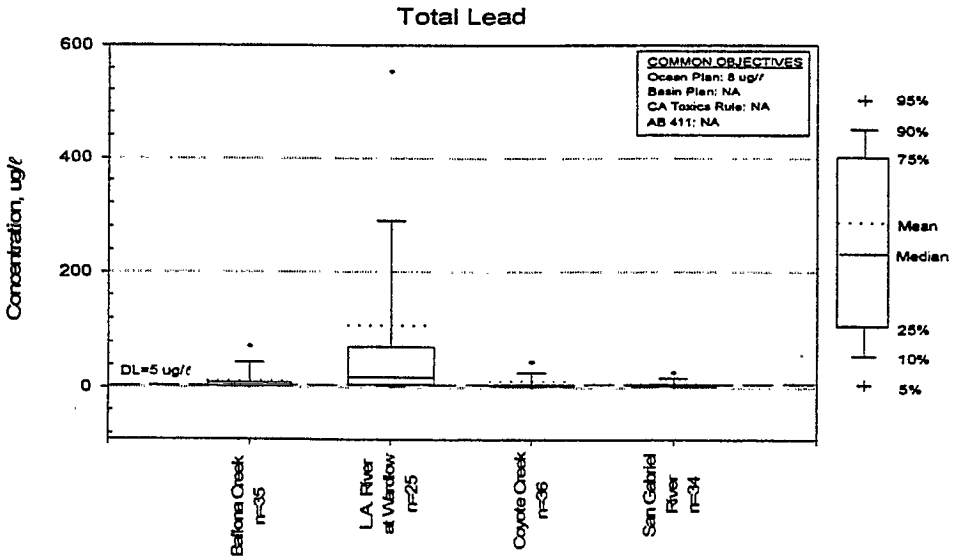
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



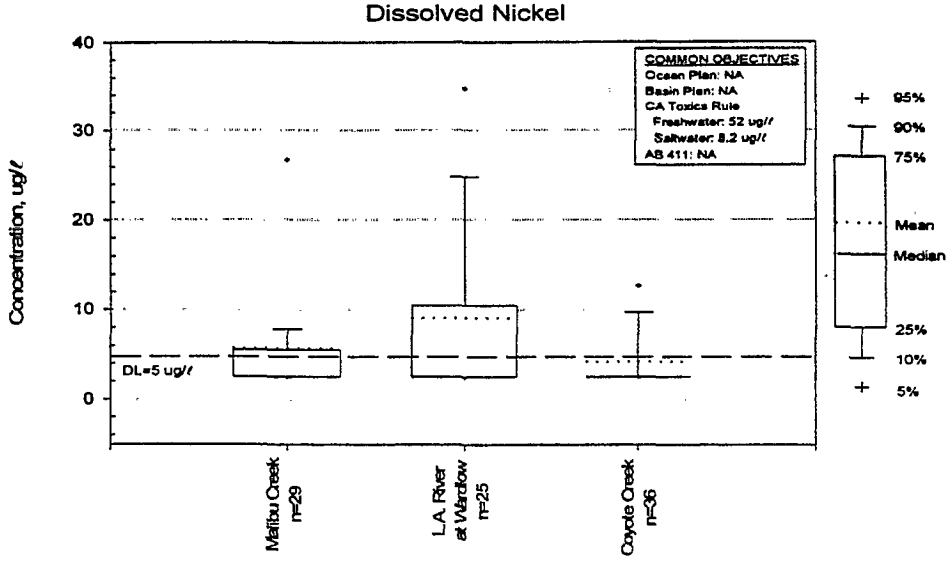


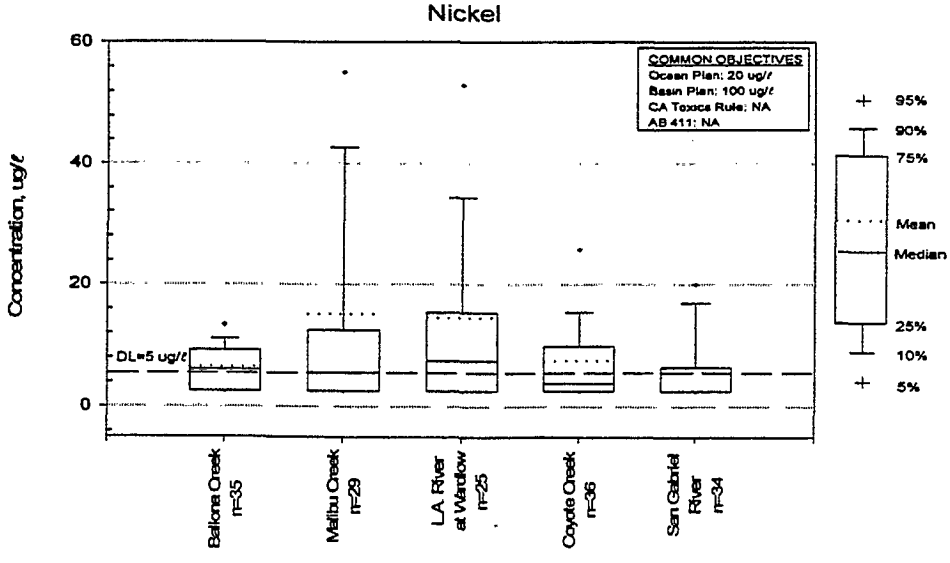
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



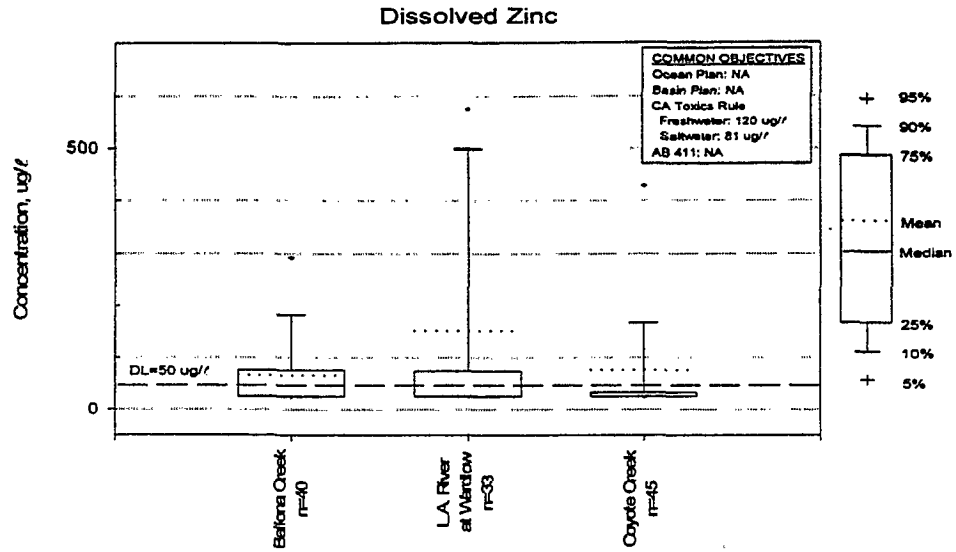


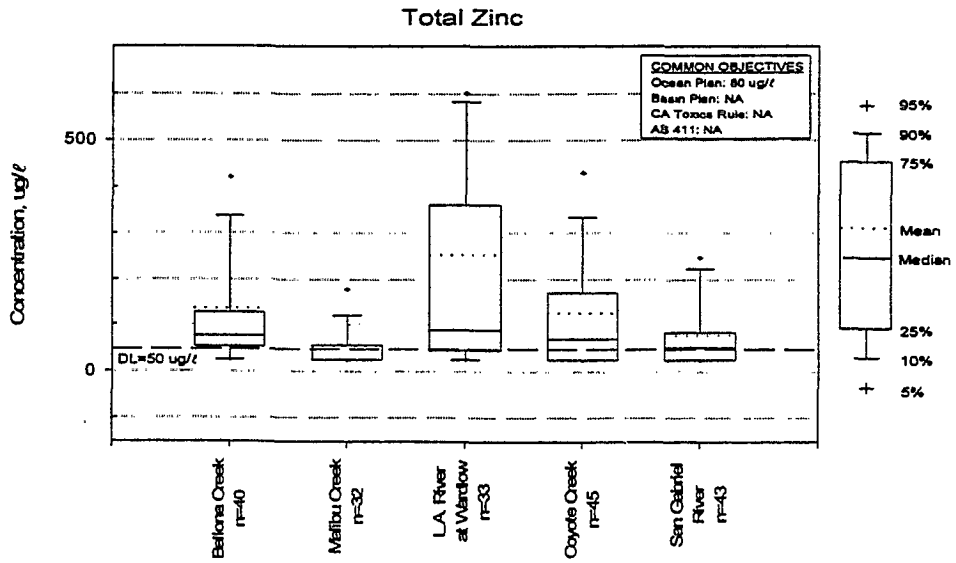
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



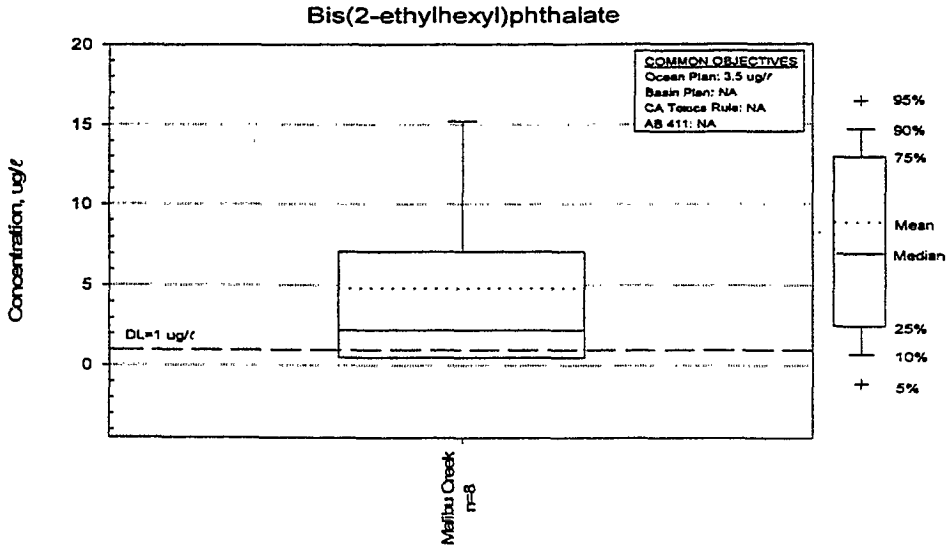


Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2

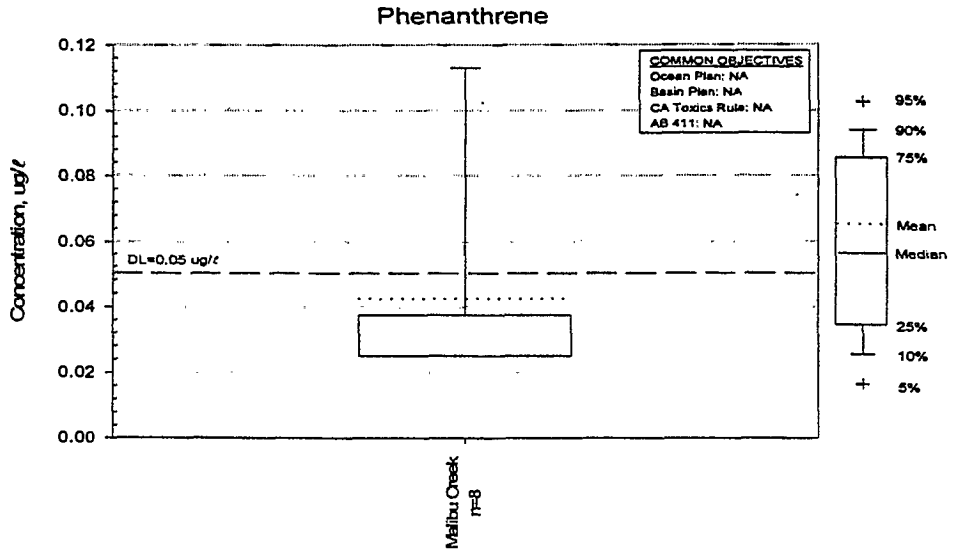


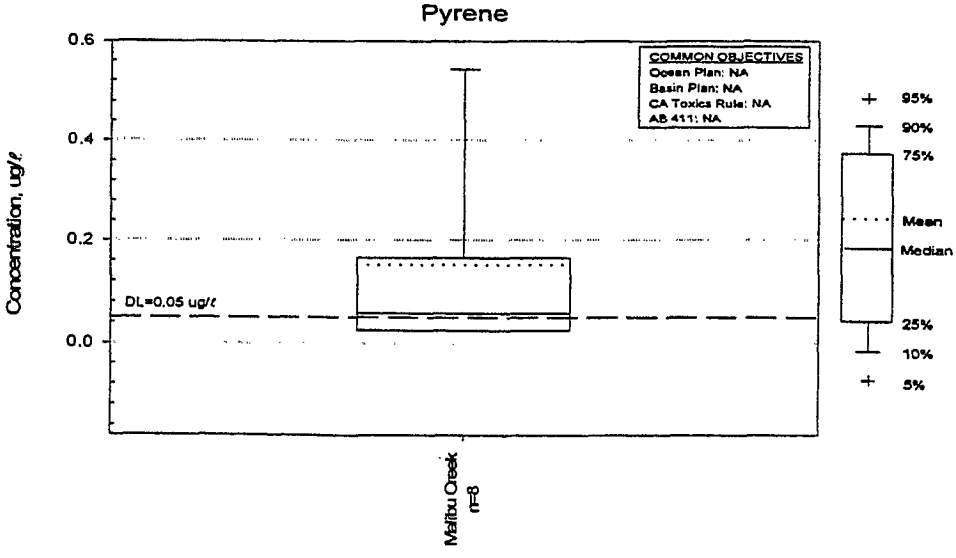


Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2

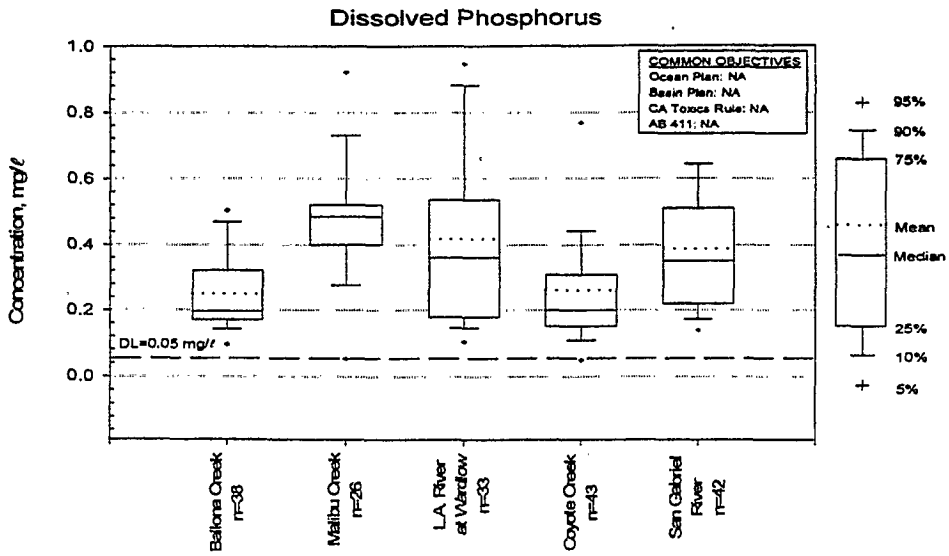


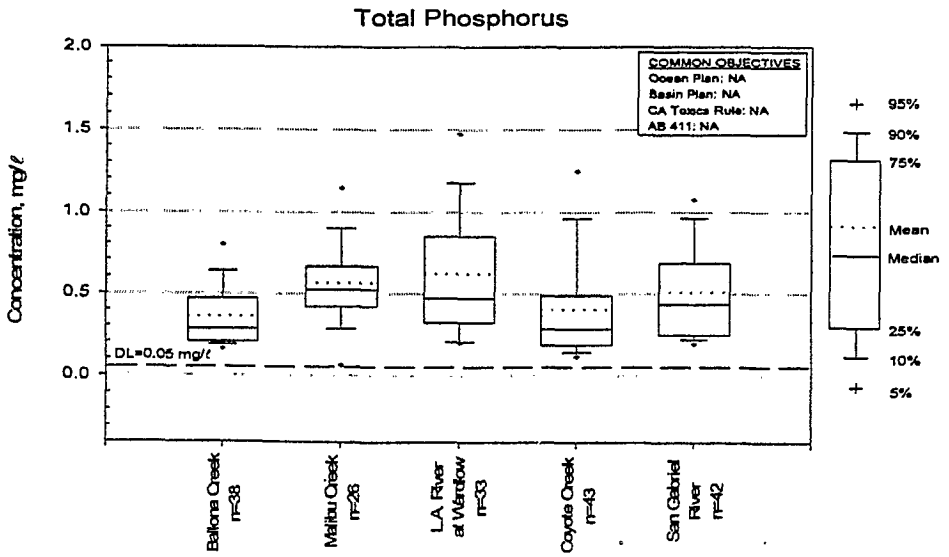
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



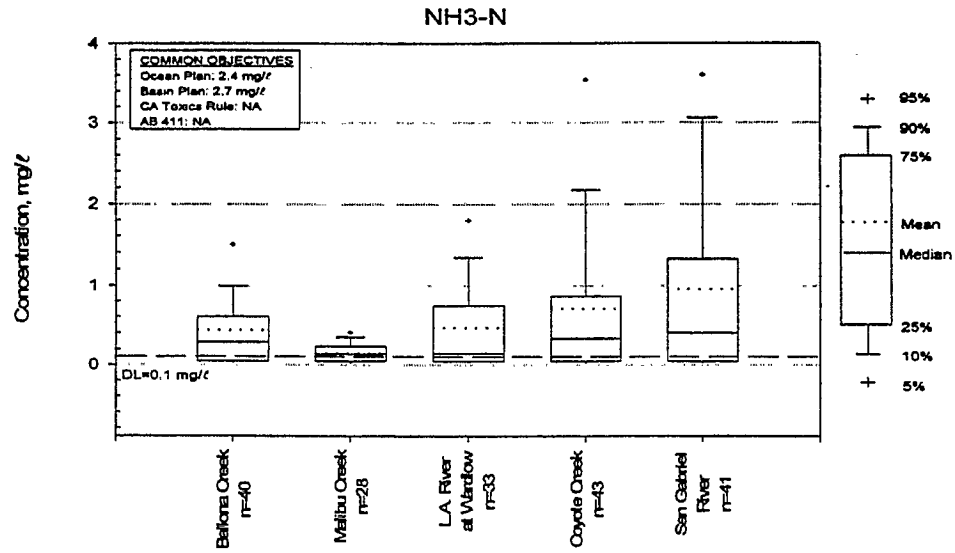


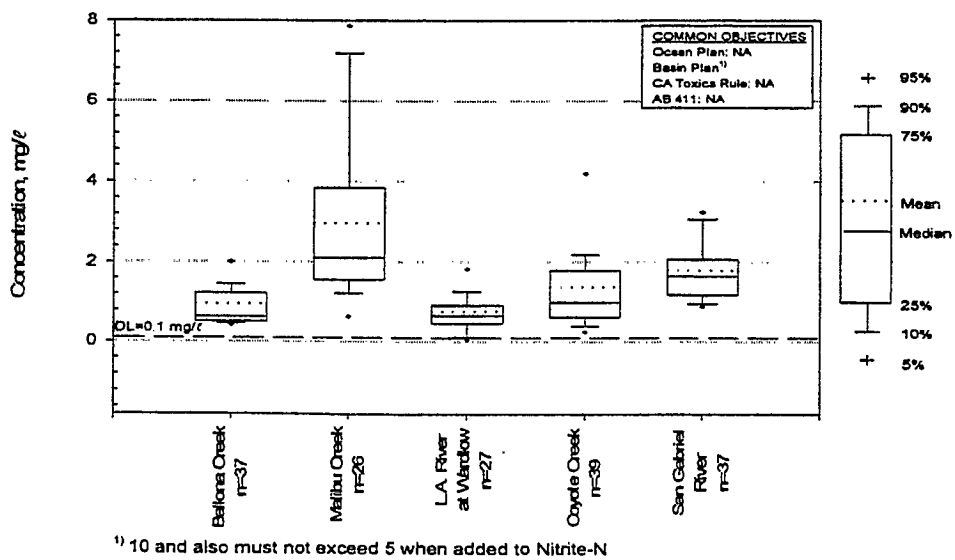
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2





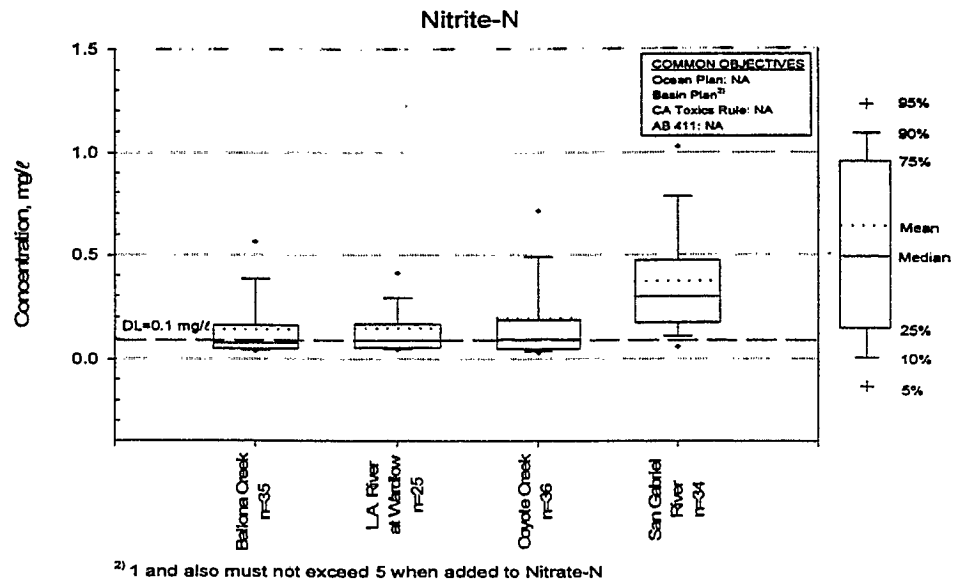
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2



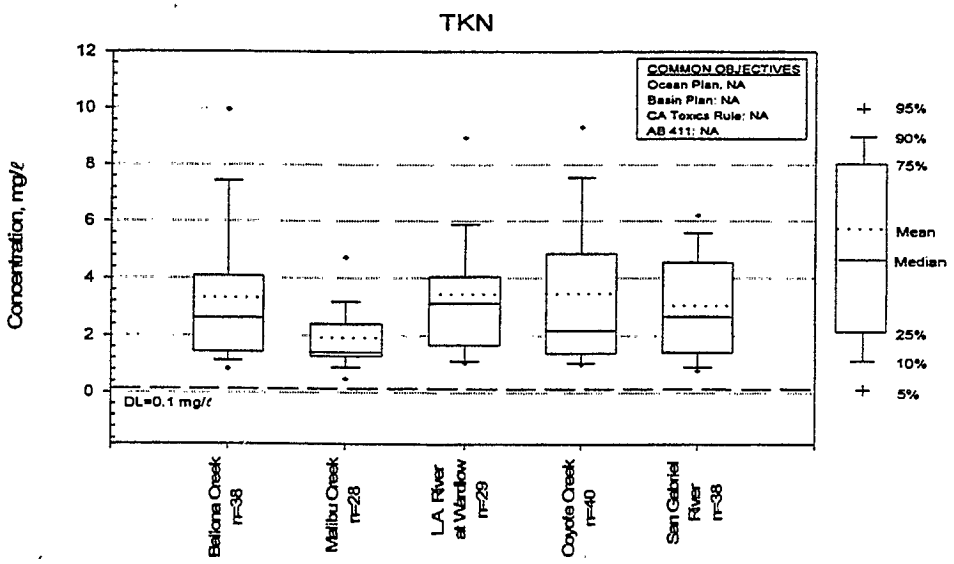


[1] 10 and also must not exceed 5 when added to Nitrite-N

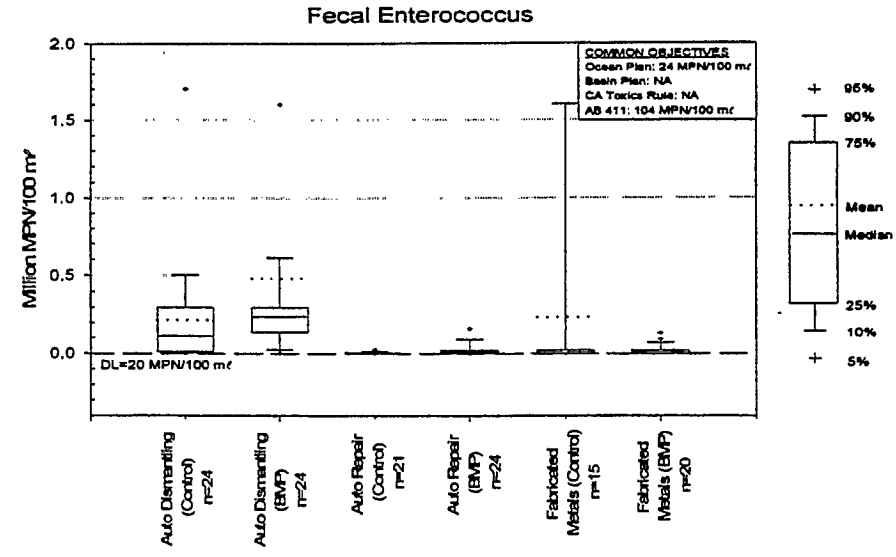
Mass Emission Box Plots
1994-2000 STORM SEASONS
Figure 4-2

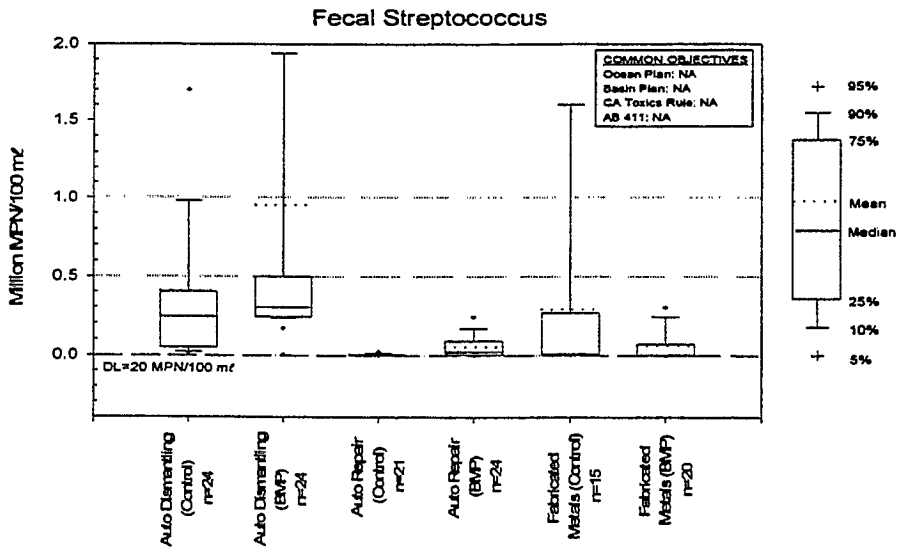


[2] 1 and also must not exceed 5 when added to Nitrate-N

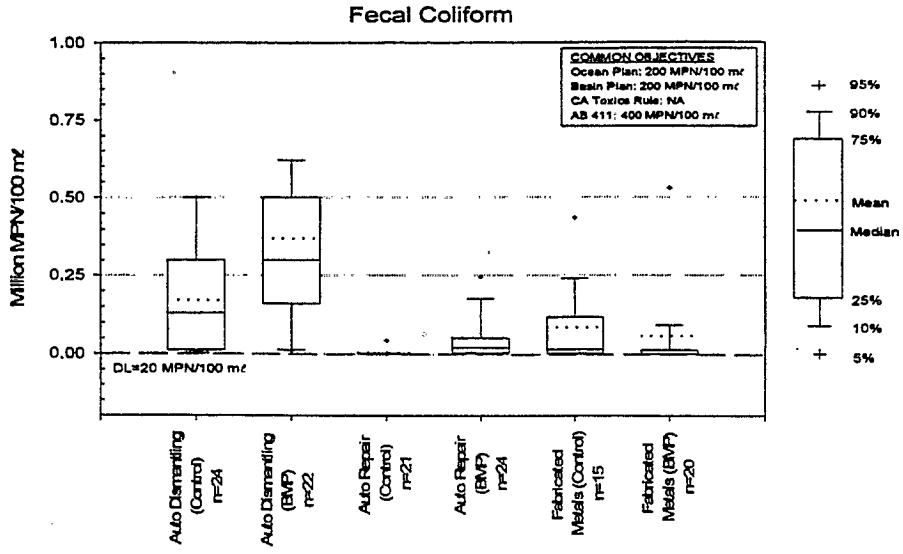


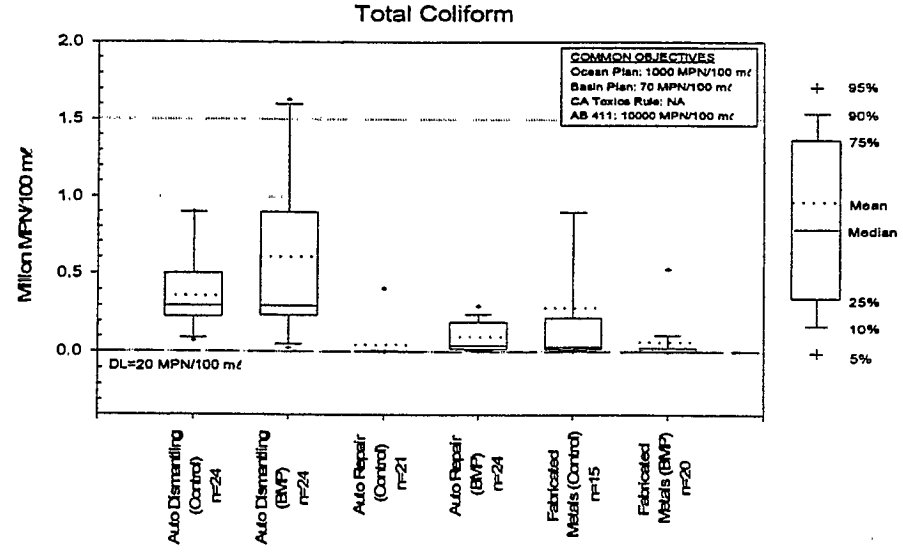
Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3



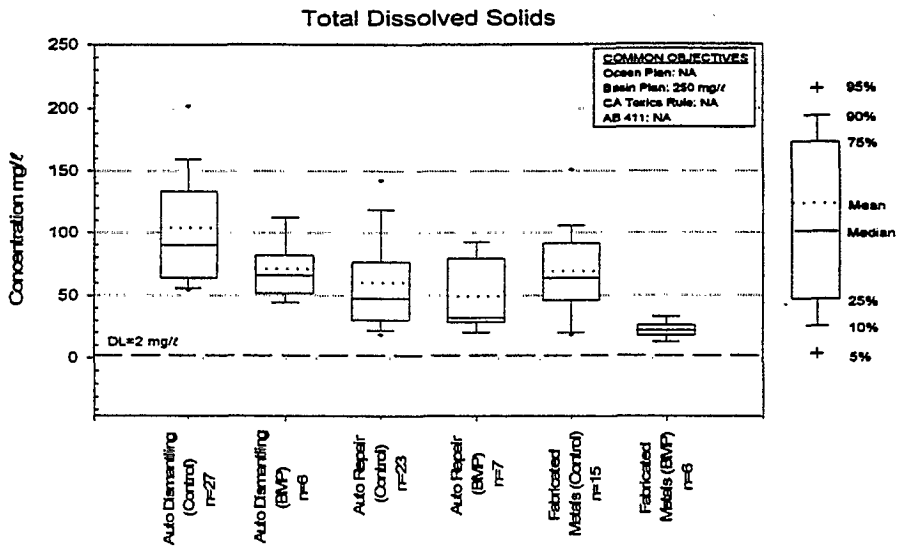


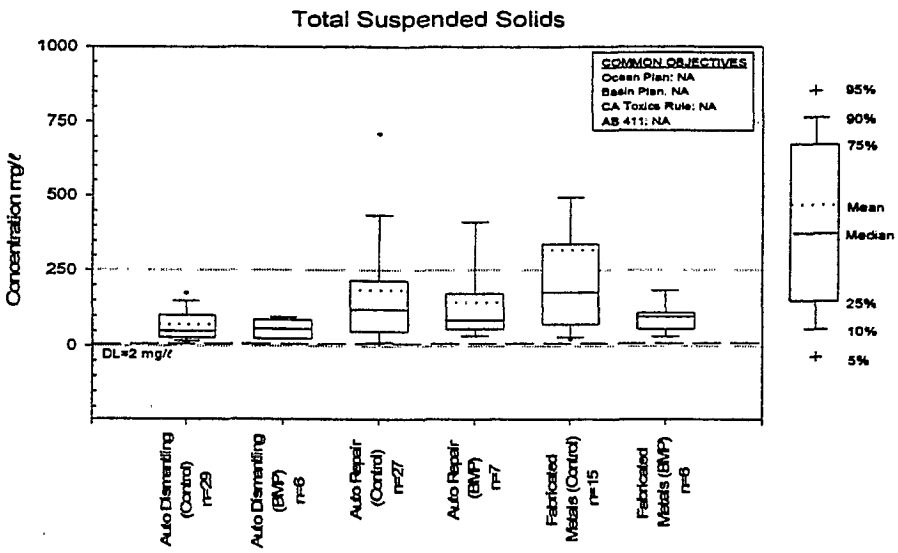
Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3



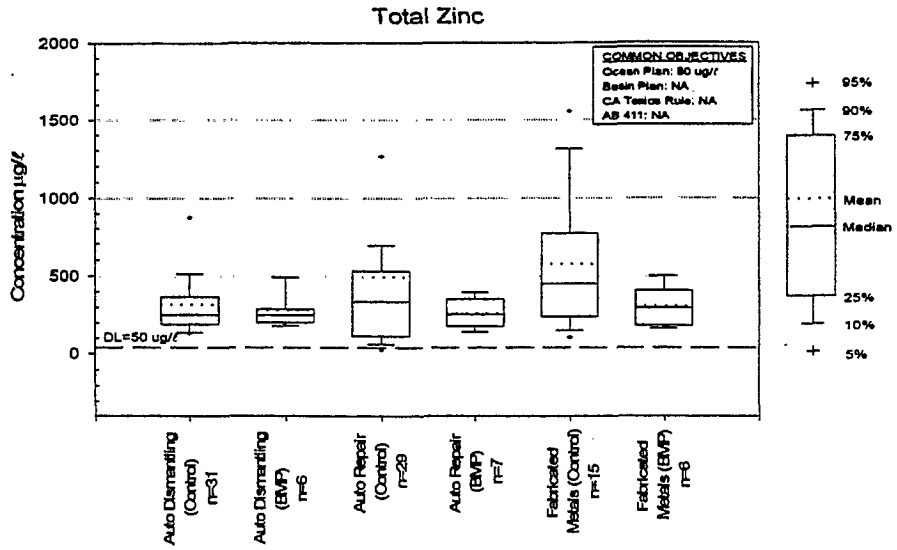


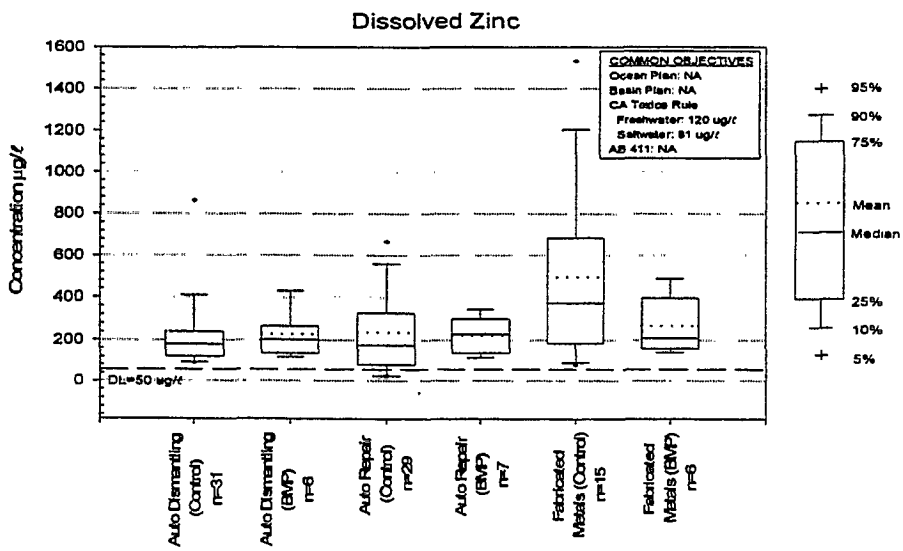
Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3



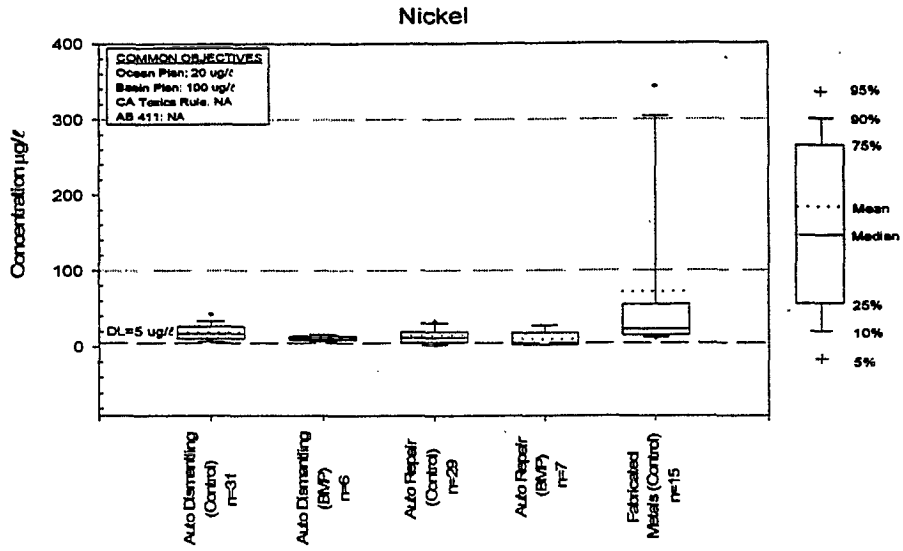


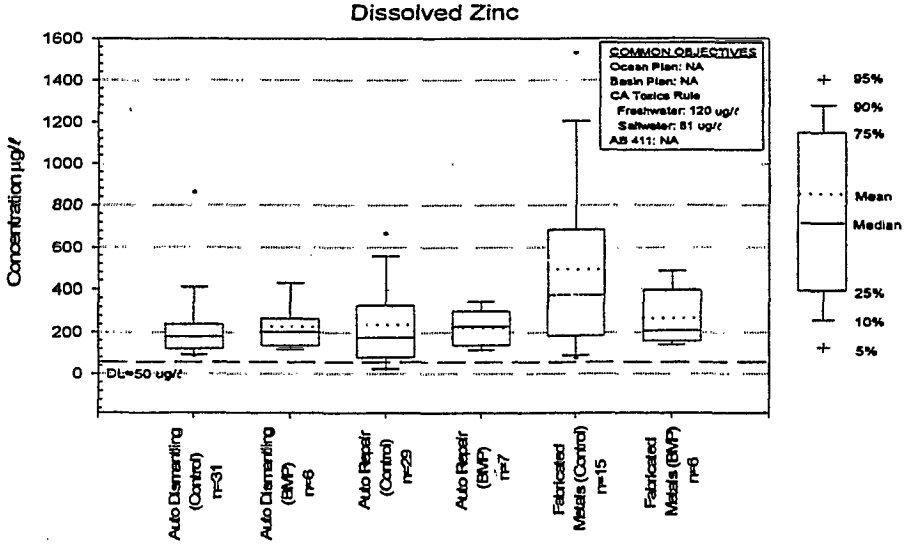
Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3



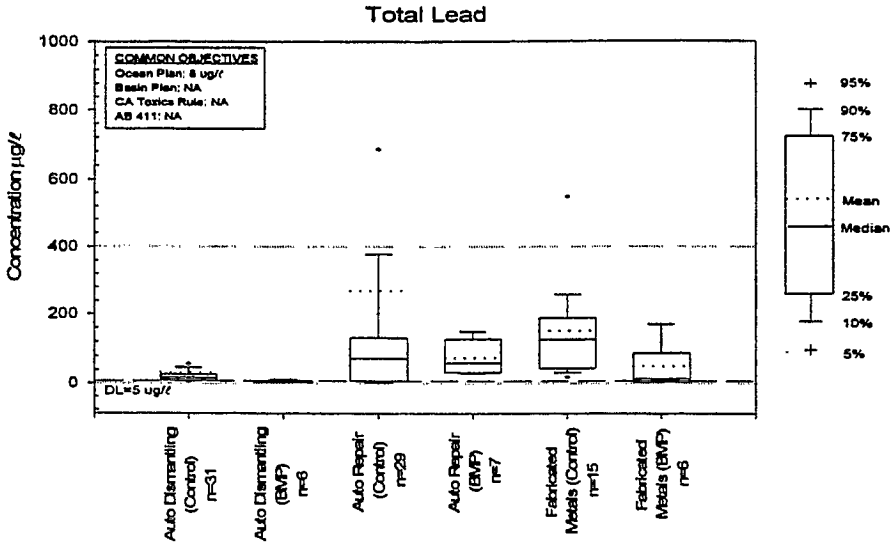


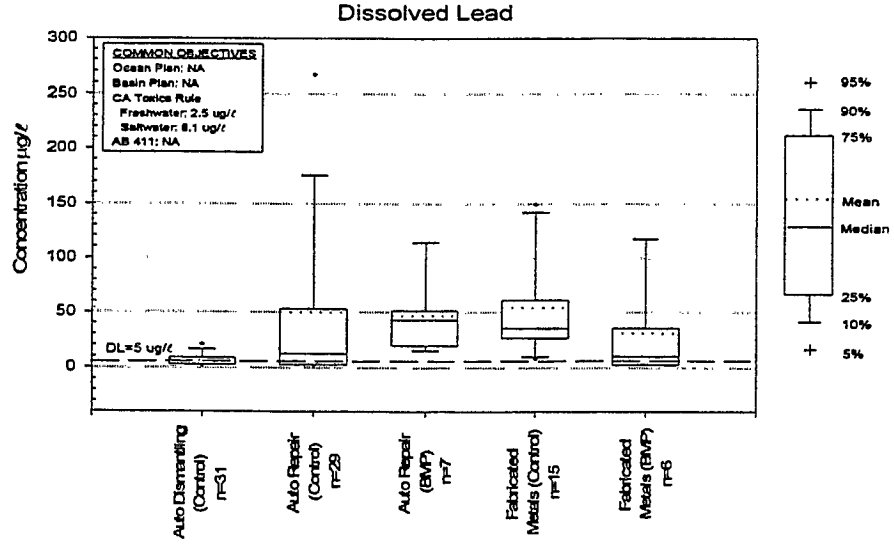
Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3





Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3





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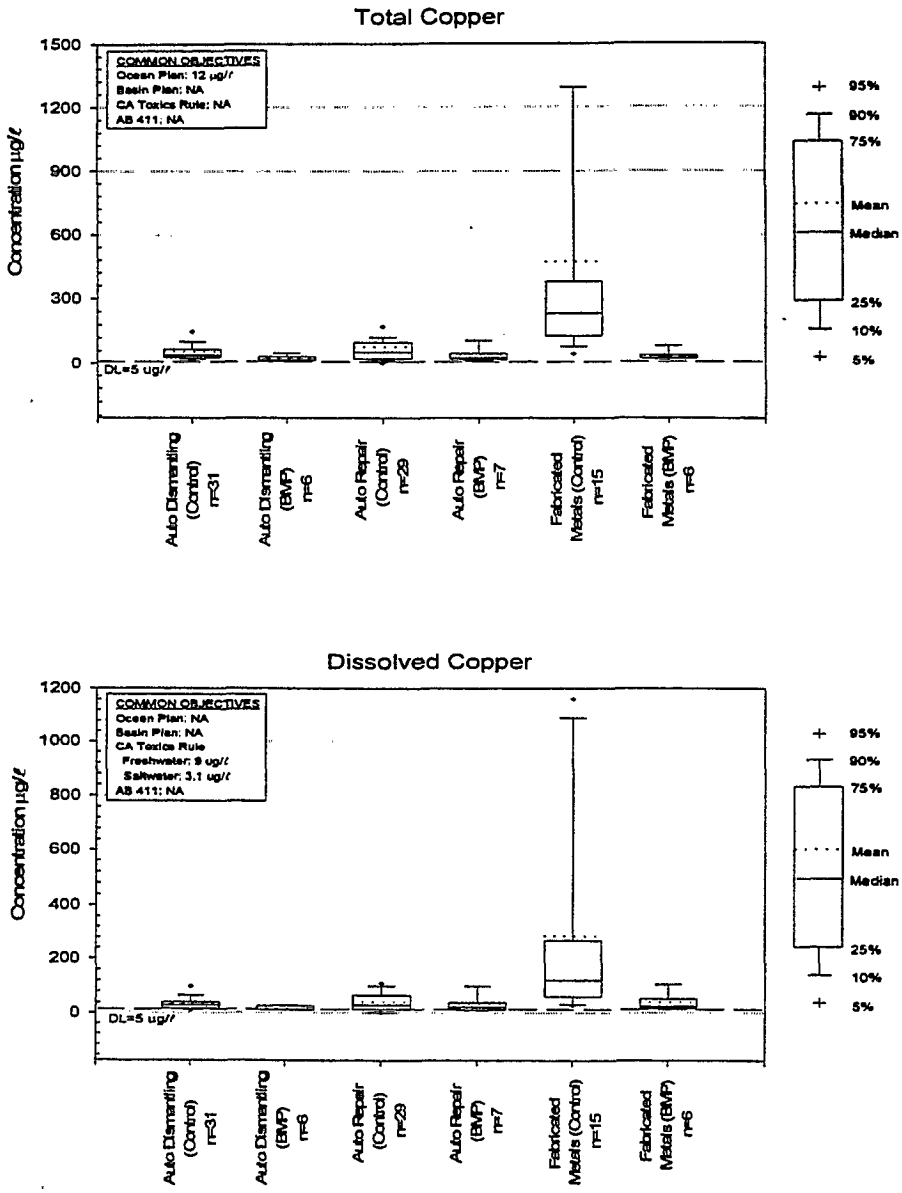
Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3



Critical Sources Box Plots
1997-2000 STORM SEASONS
Figure 4-3

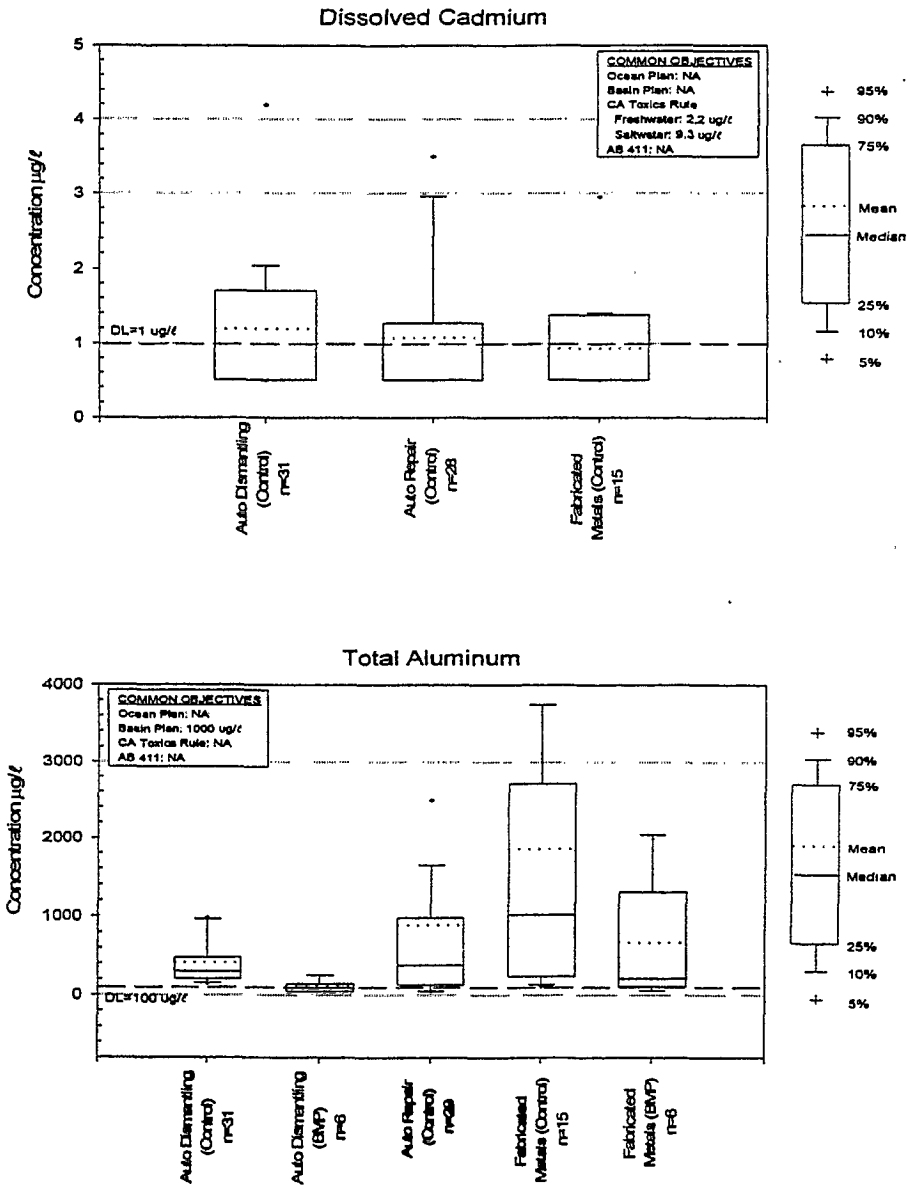
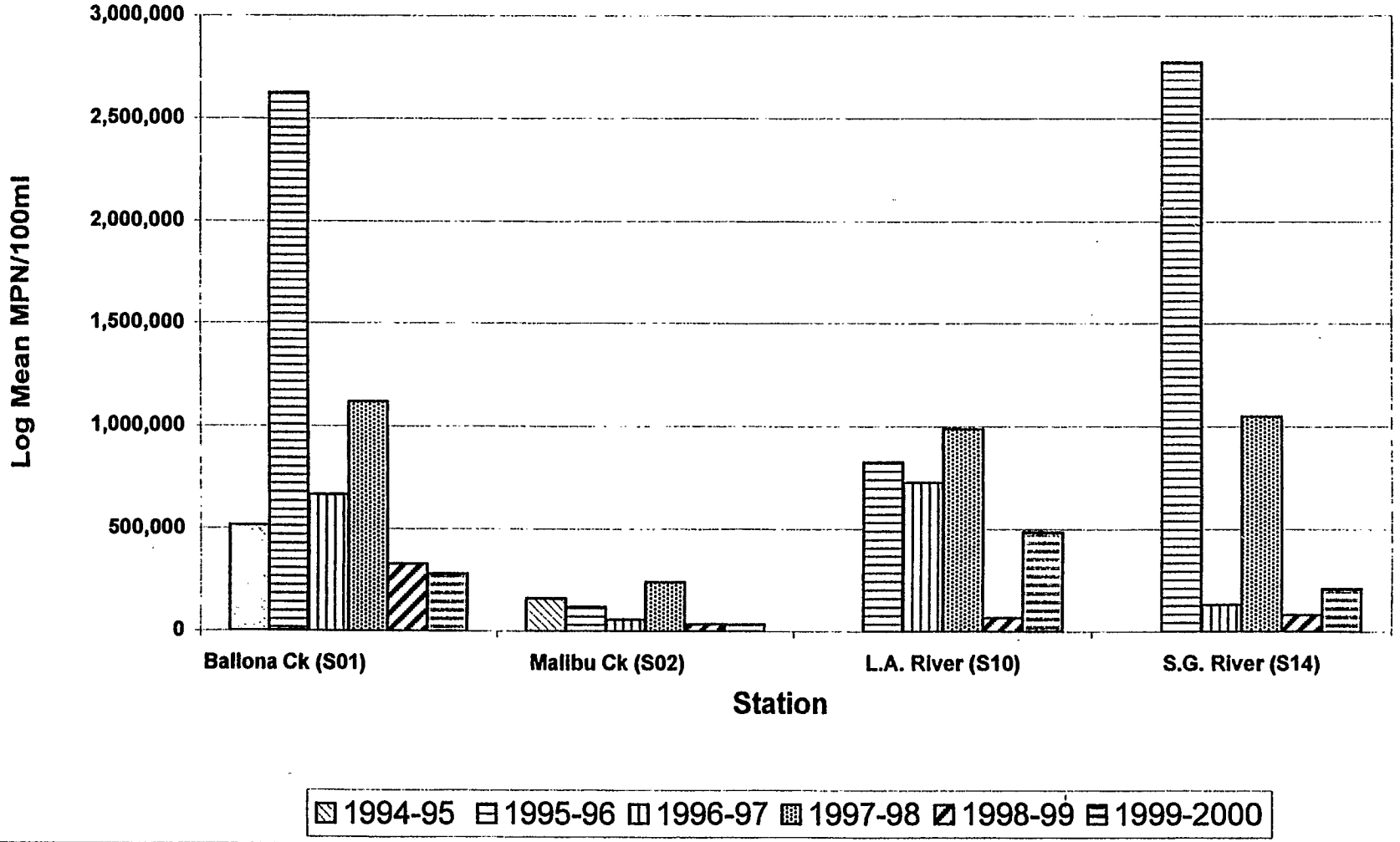


Figure 4-4a. STORMWATER BACTERIA COUNTS
TOTAL COLIFORM



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TJ Bacteria_94-00.xls

7/24/00

Figure 4-4b. STORMWATER BACTERIA COUNTS
FECAL COLIFORM

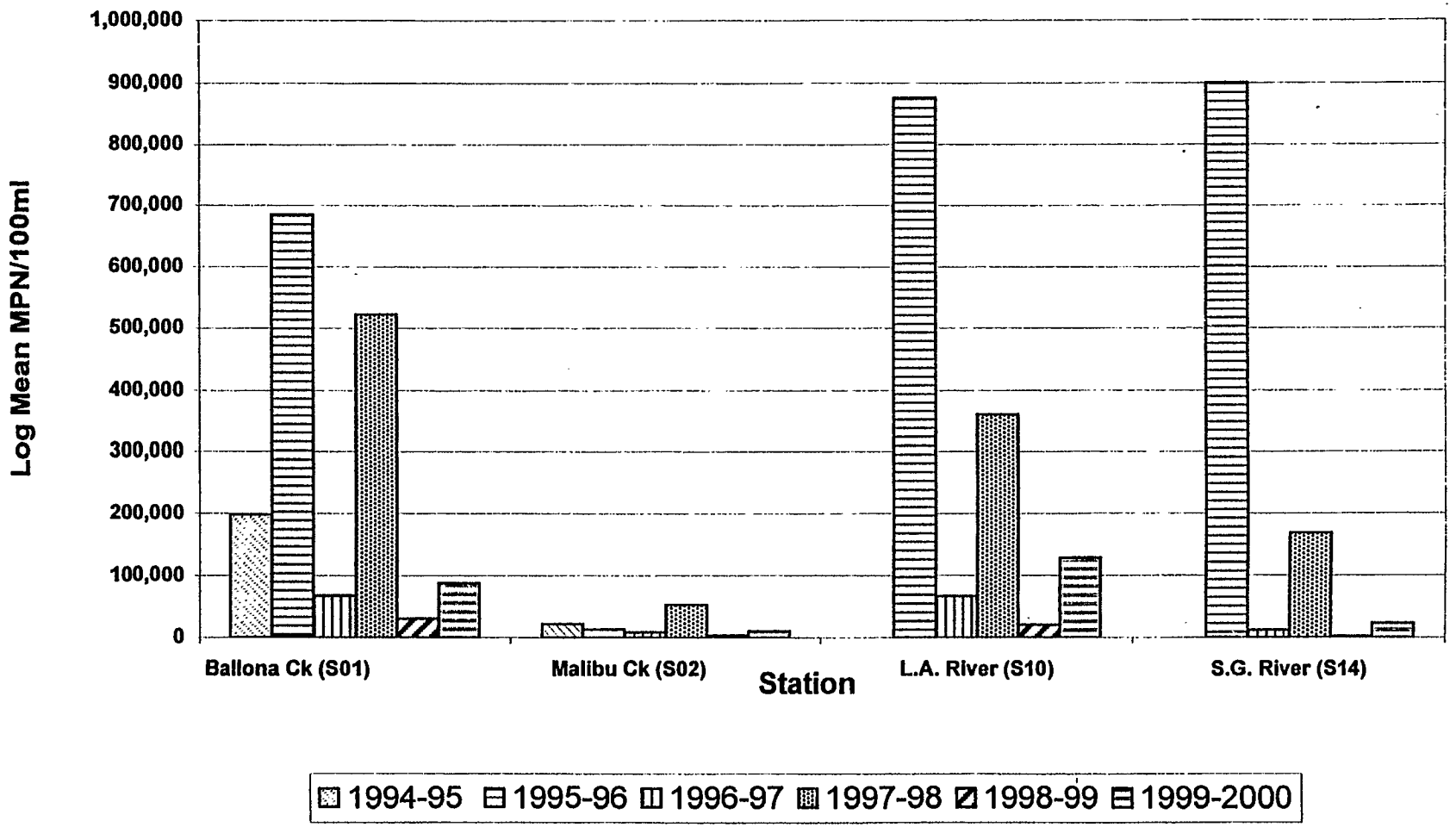

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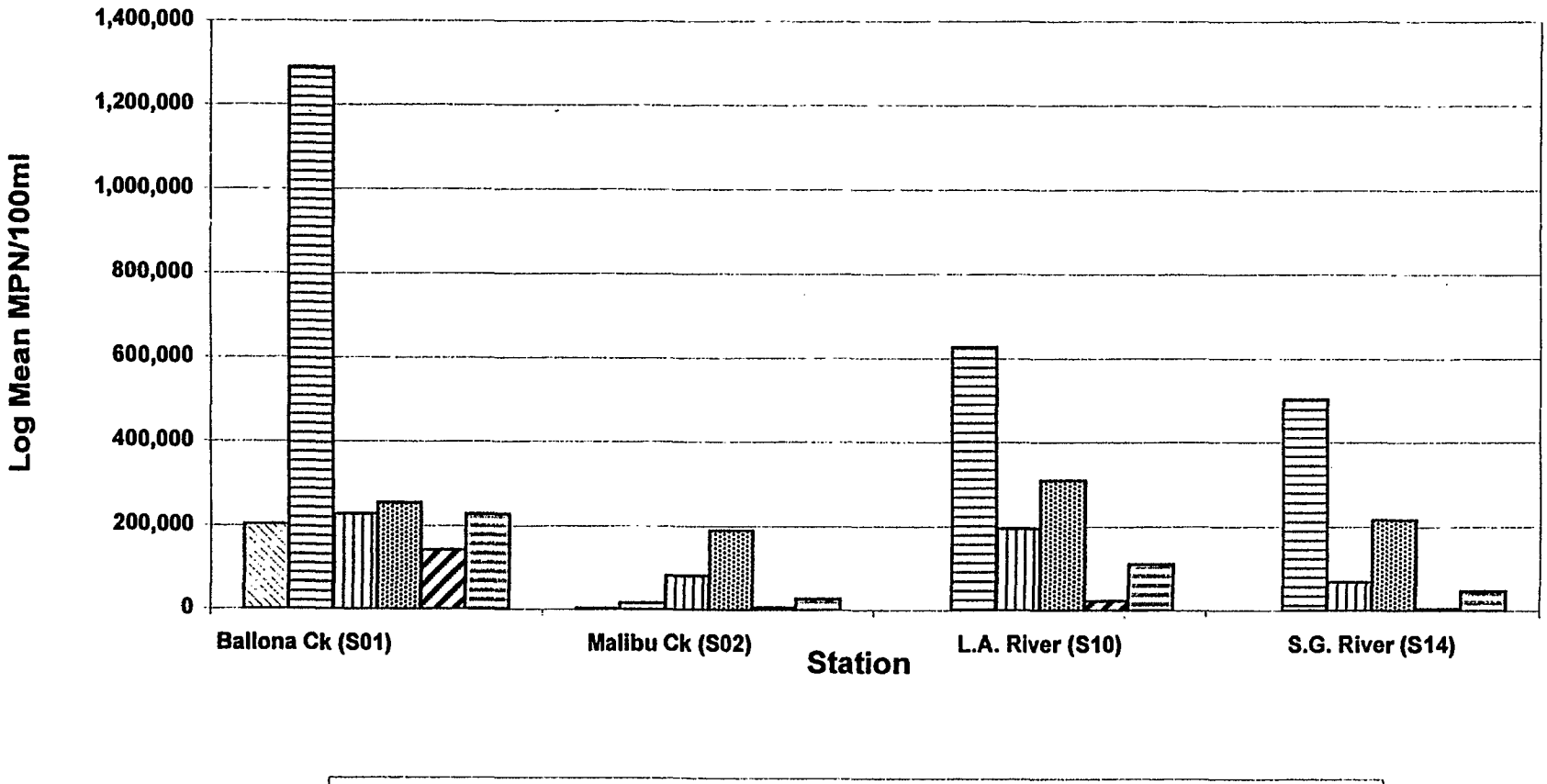
Figure 4-4c. STORMWATER BACTERIA COUNTS
FECAL STREPTOCOCCUS



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7/24/00

Figure 4-4d. STORMWATER BACTERIA COUNTS
FECAL ENTEROCOCCUS

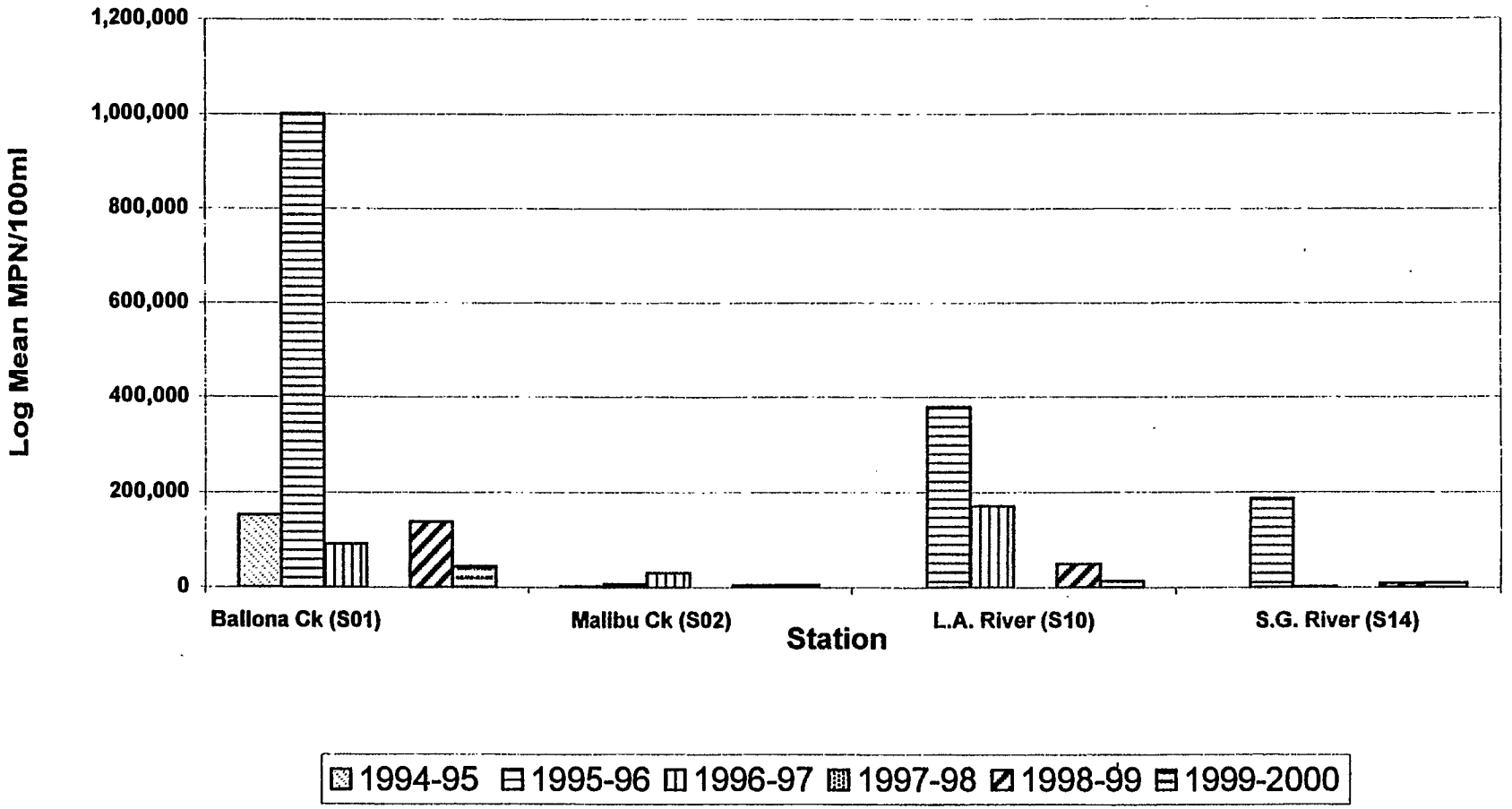

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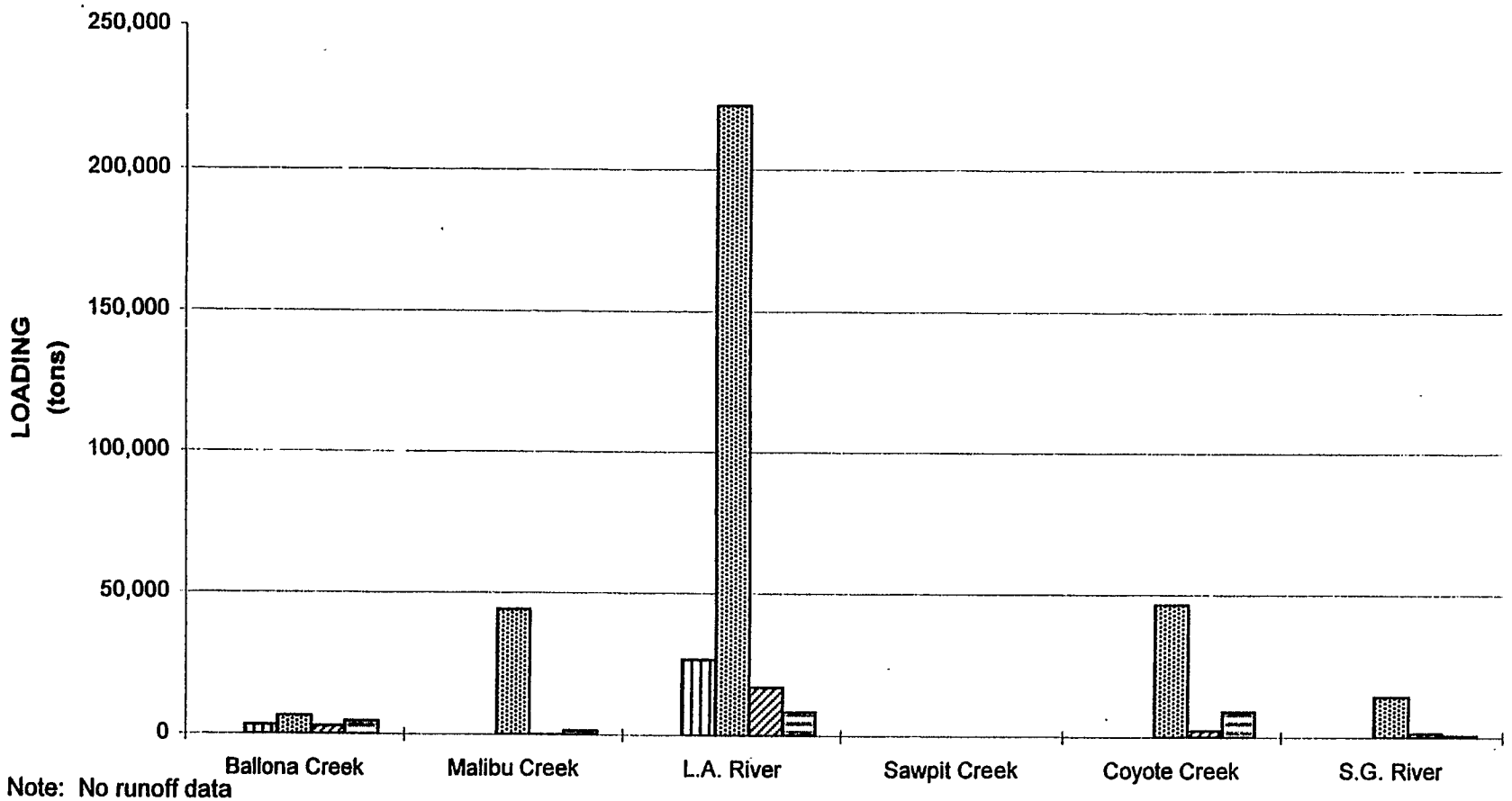
Figure 4-5a. MASS EMISSION LOADINGS TOTAL SUSPENDED SOLIDS



Note: No runoff data from 1995-96. No runoff data during Feb. 1998 for Ballona Creek.

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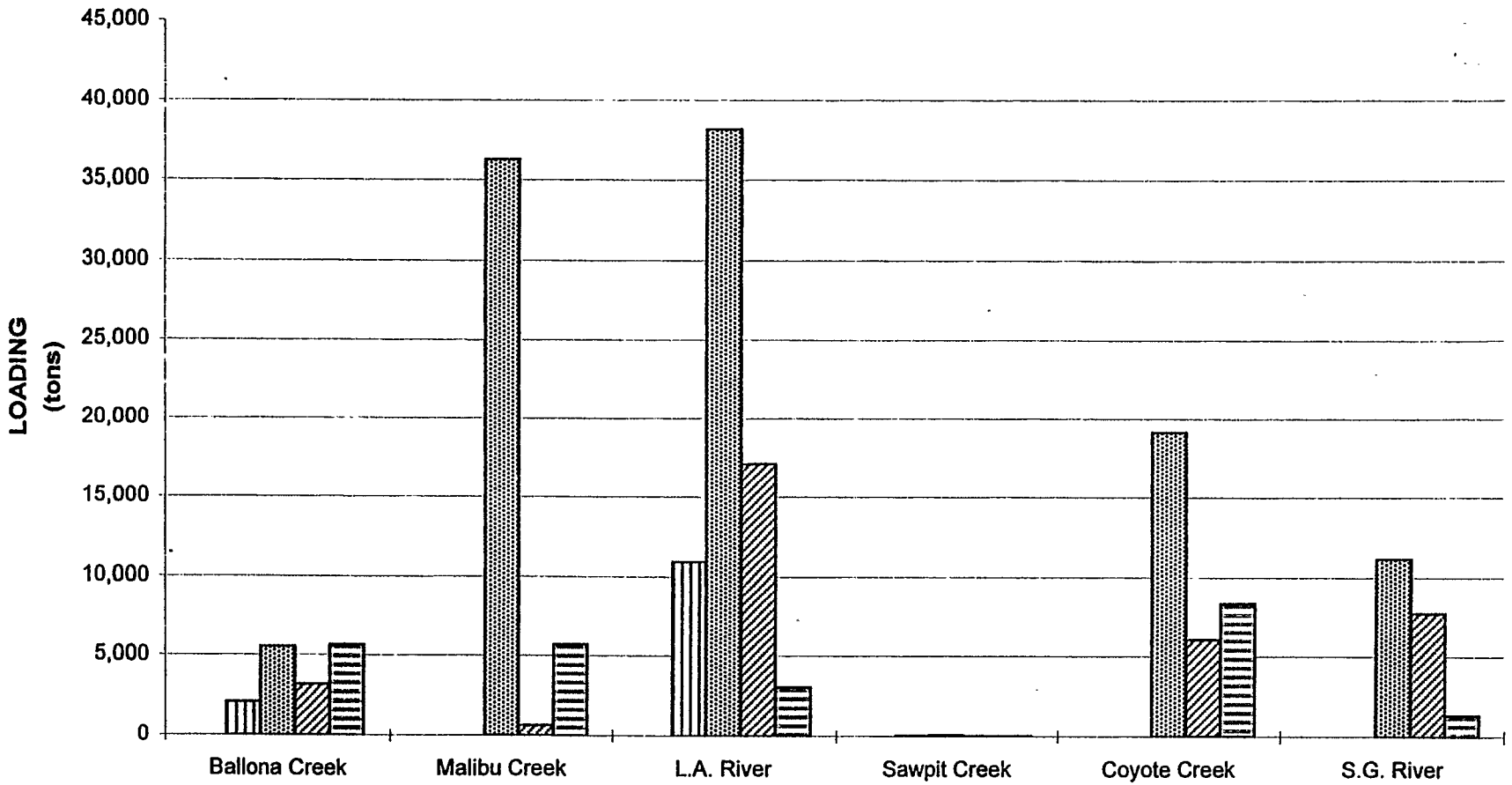
Figure 4-5b. MASS EMISSION LOADINGS
TOTAL DISSOLVED SOLIDS



Note: No runoff data from 1995-96.
No runoff data during Feb. 1998 for Ballona Creek.

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Figure 4-5c

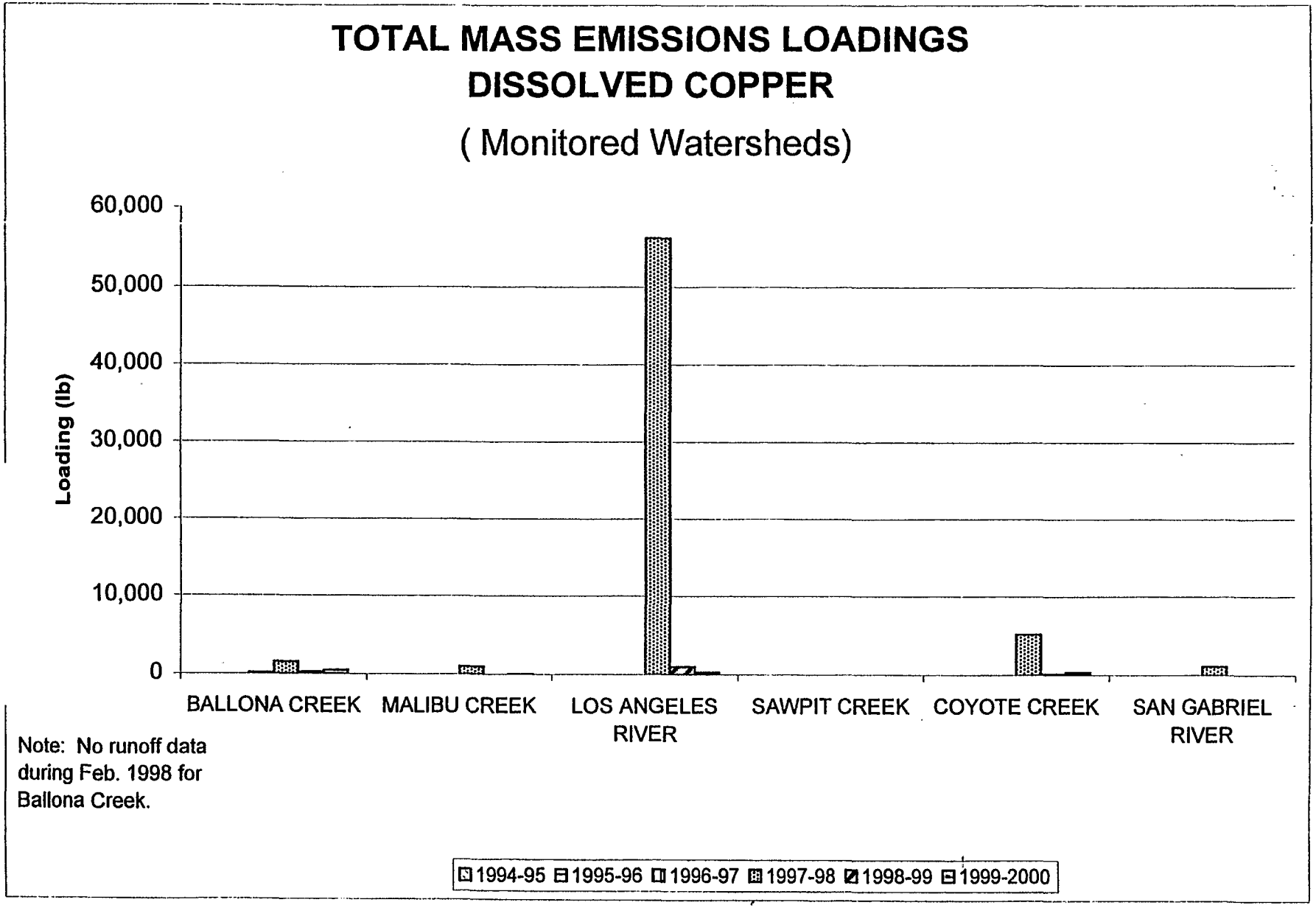

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Figure 4-5d

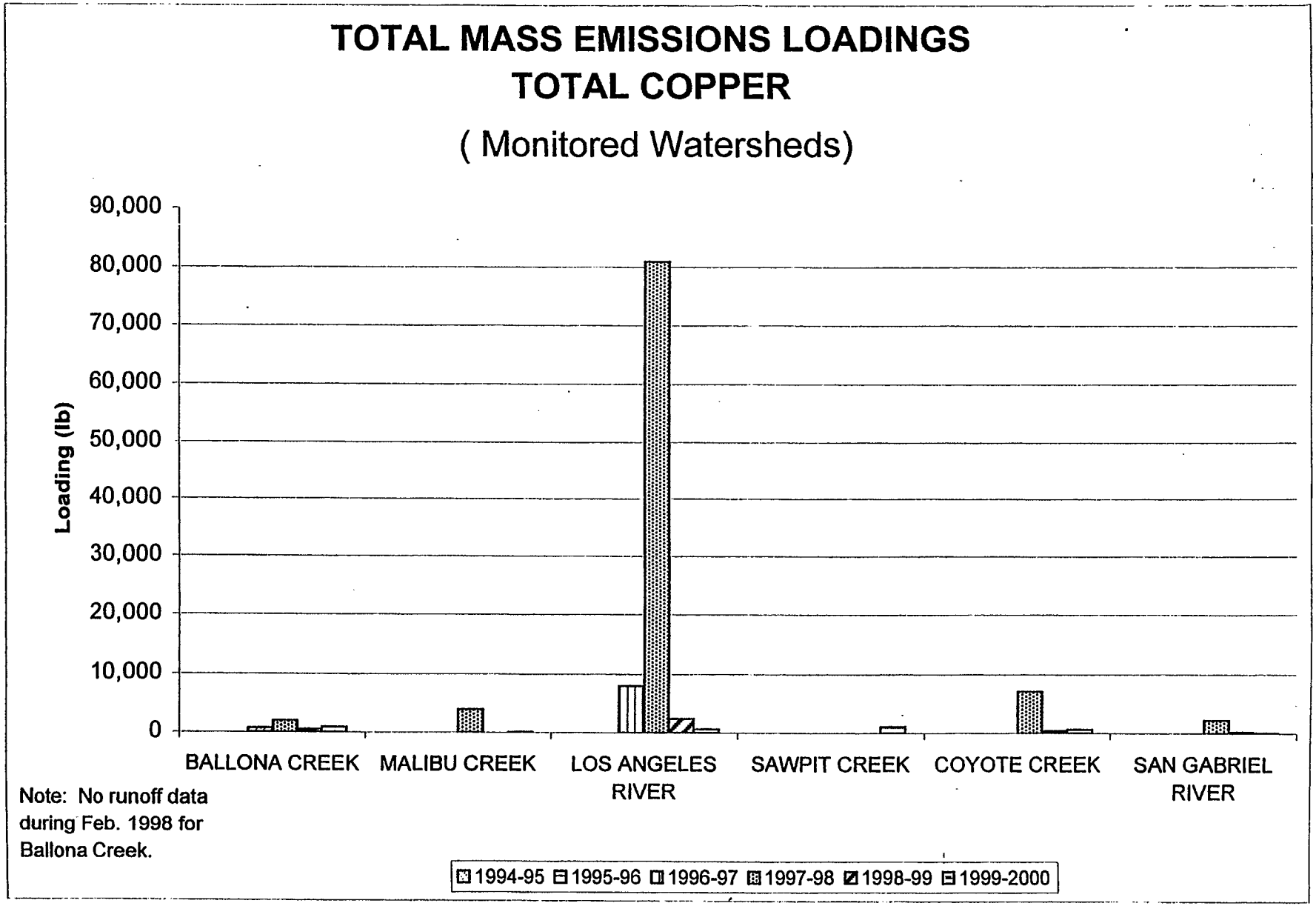

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Figure 4-5e

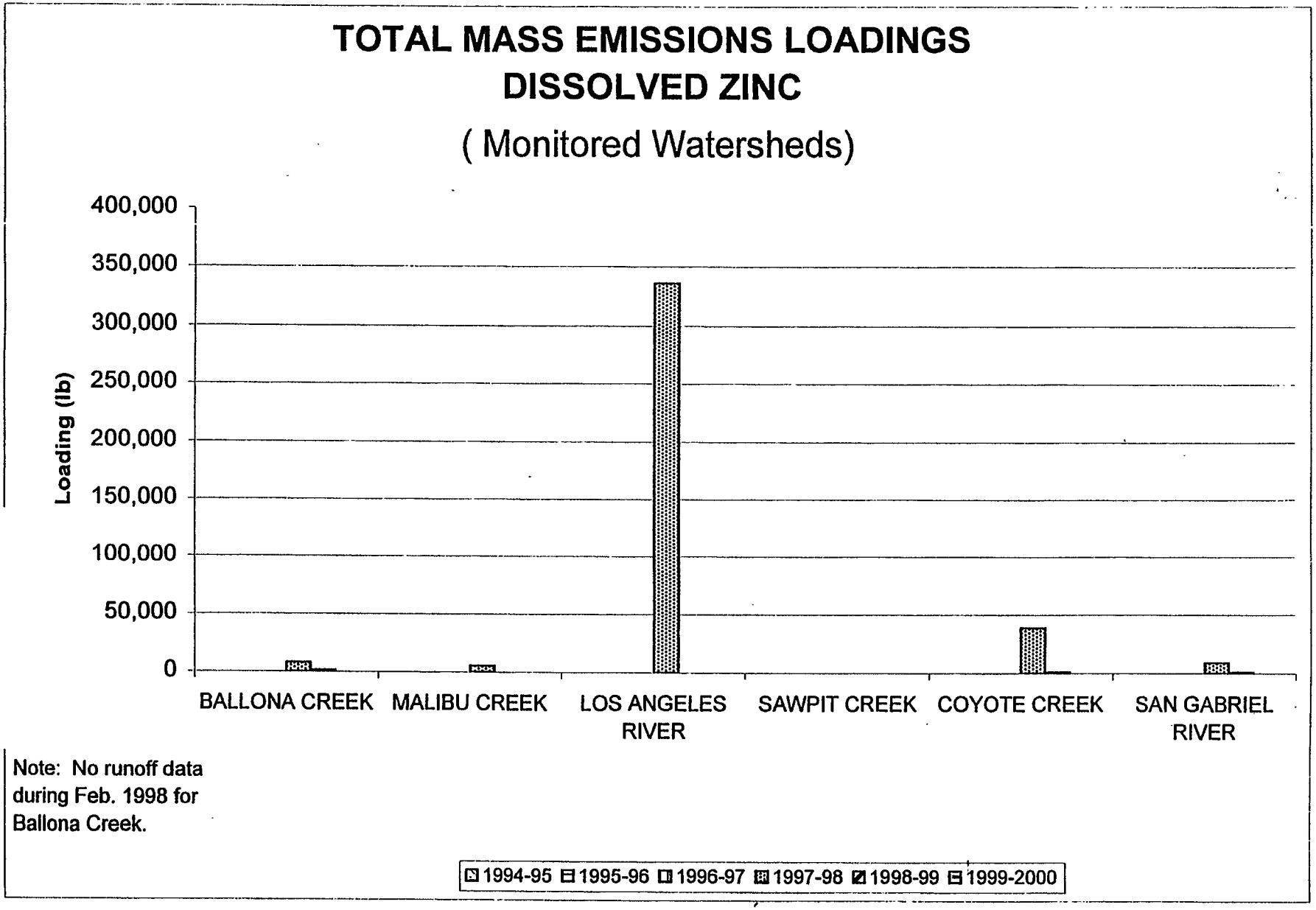

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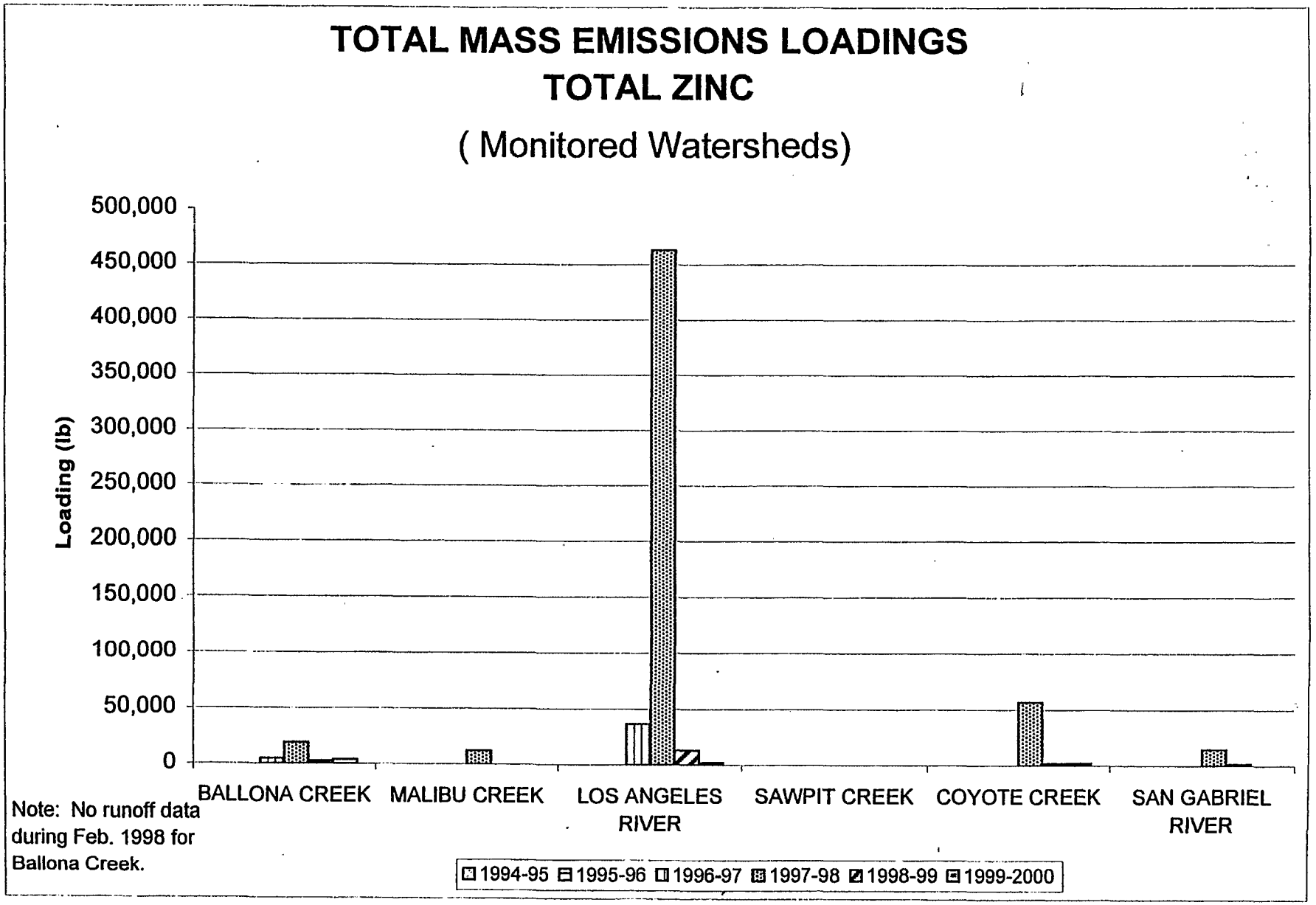
Figure 4-5f



Note: No runoff data during Feb. 1998 for Ballona Creek.

R0012141

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Figure 4-6. MASS EMISSION MEAN TURBIDITY

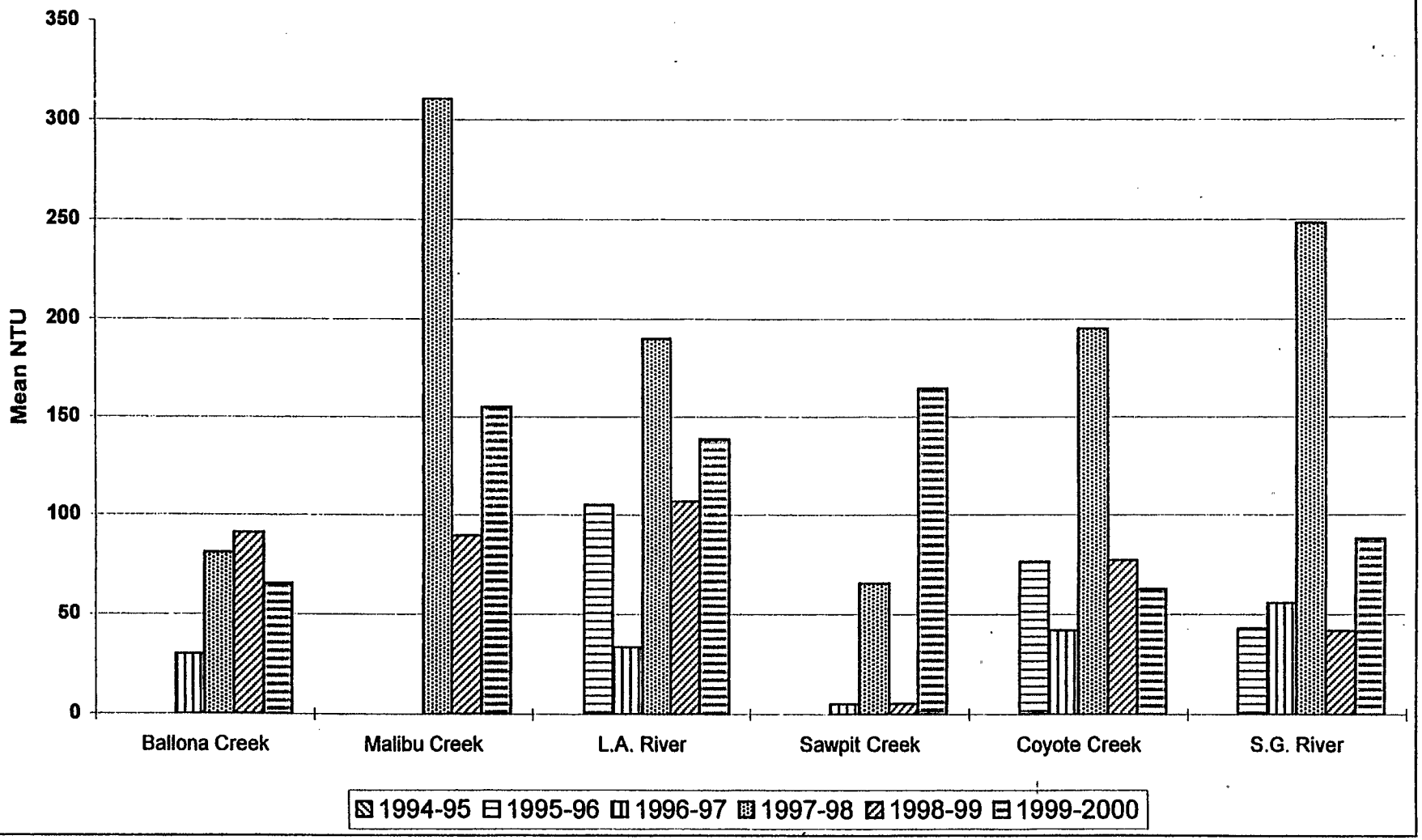

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Figure 4-7. TOTAL MASS EMISSION LOADINGS BALLONA CREEK

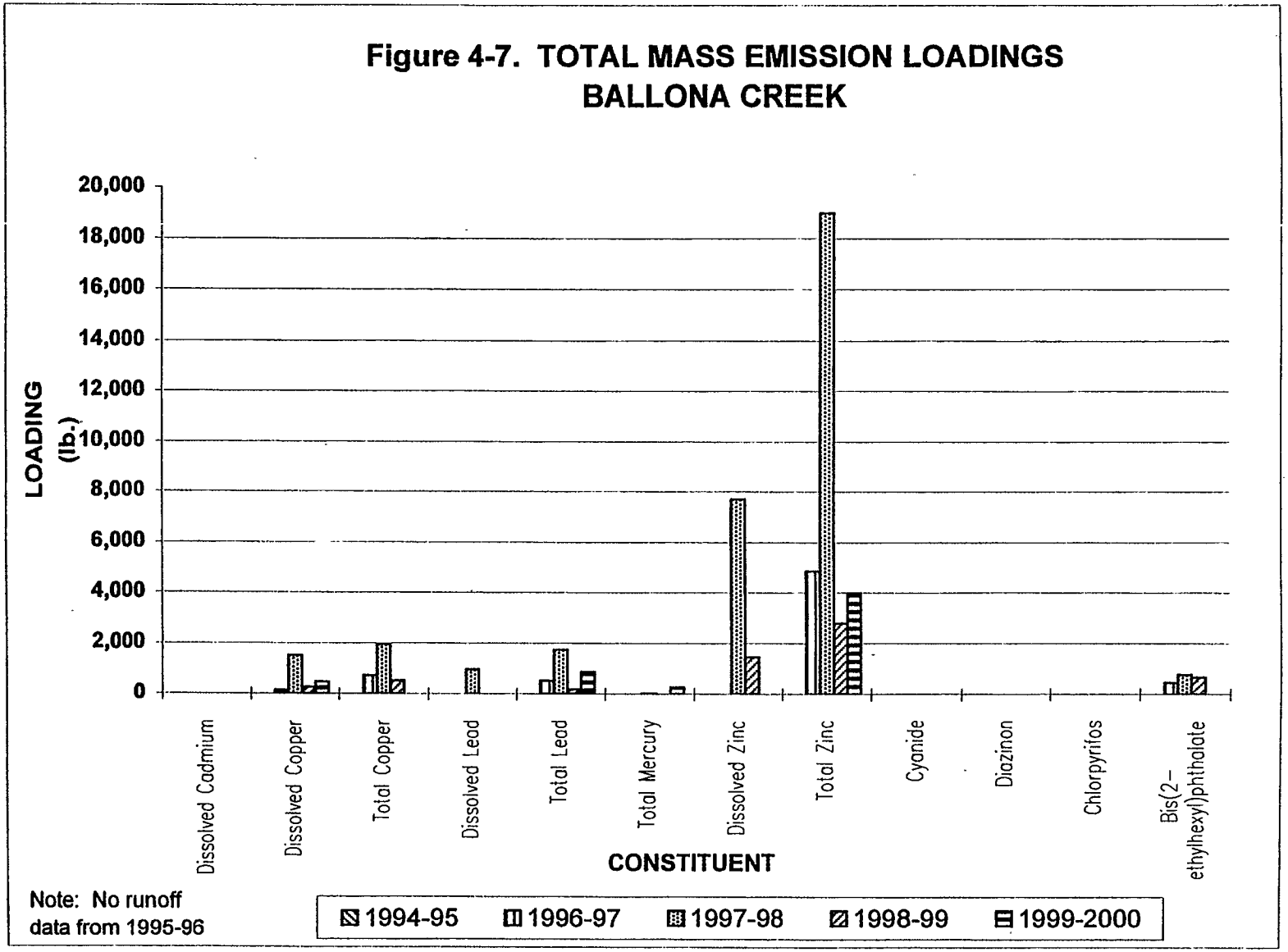

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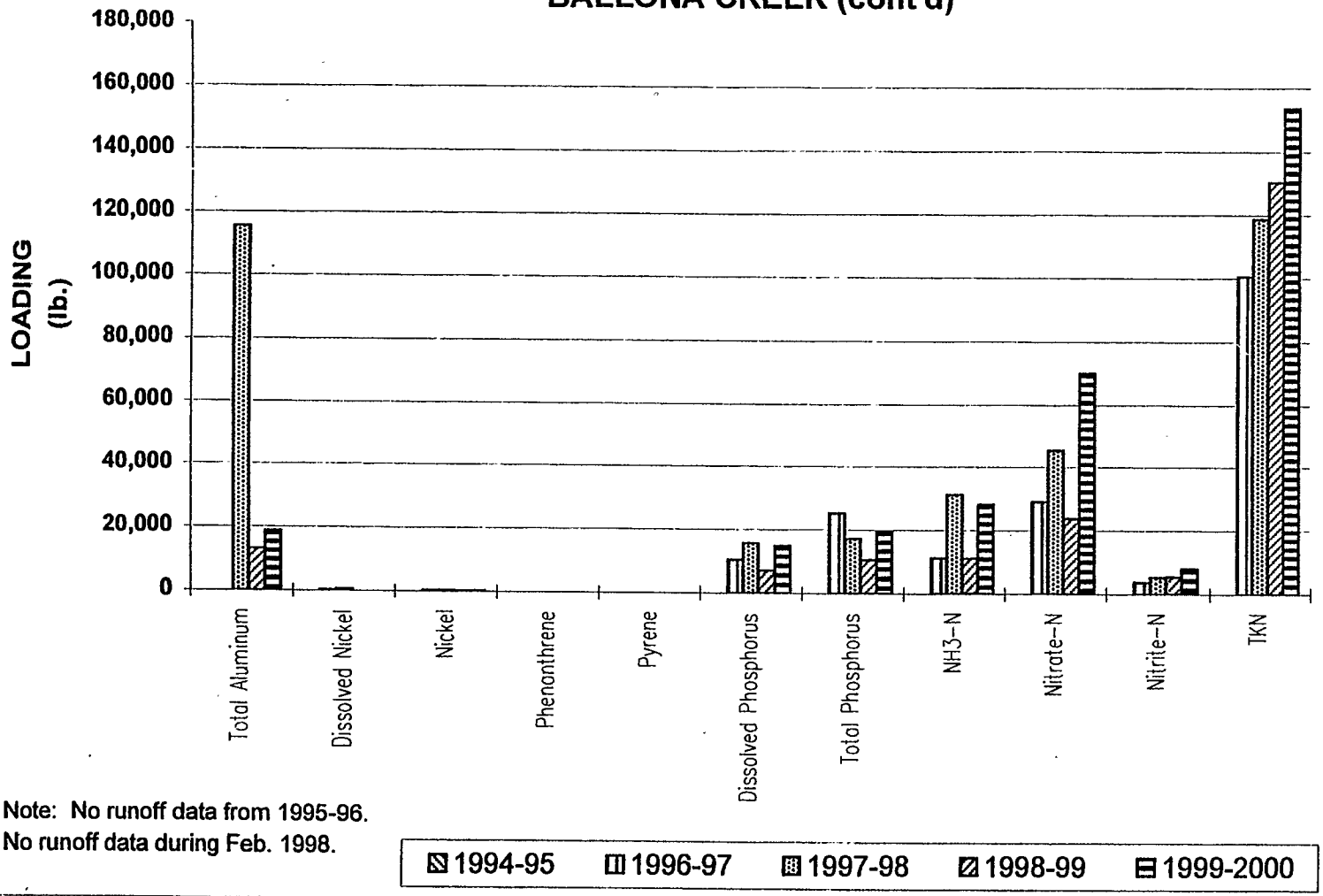
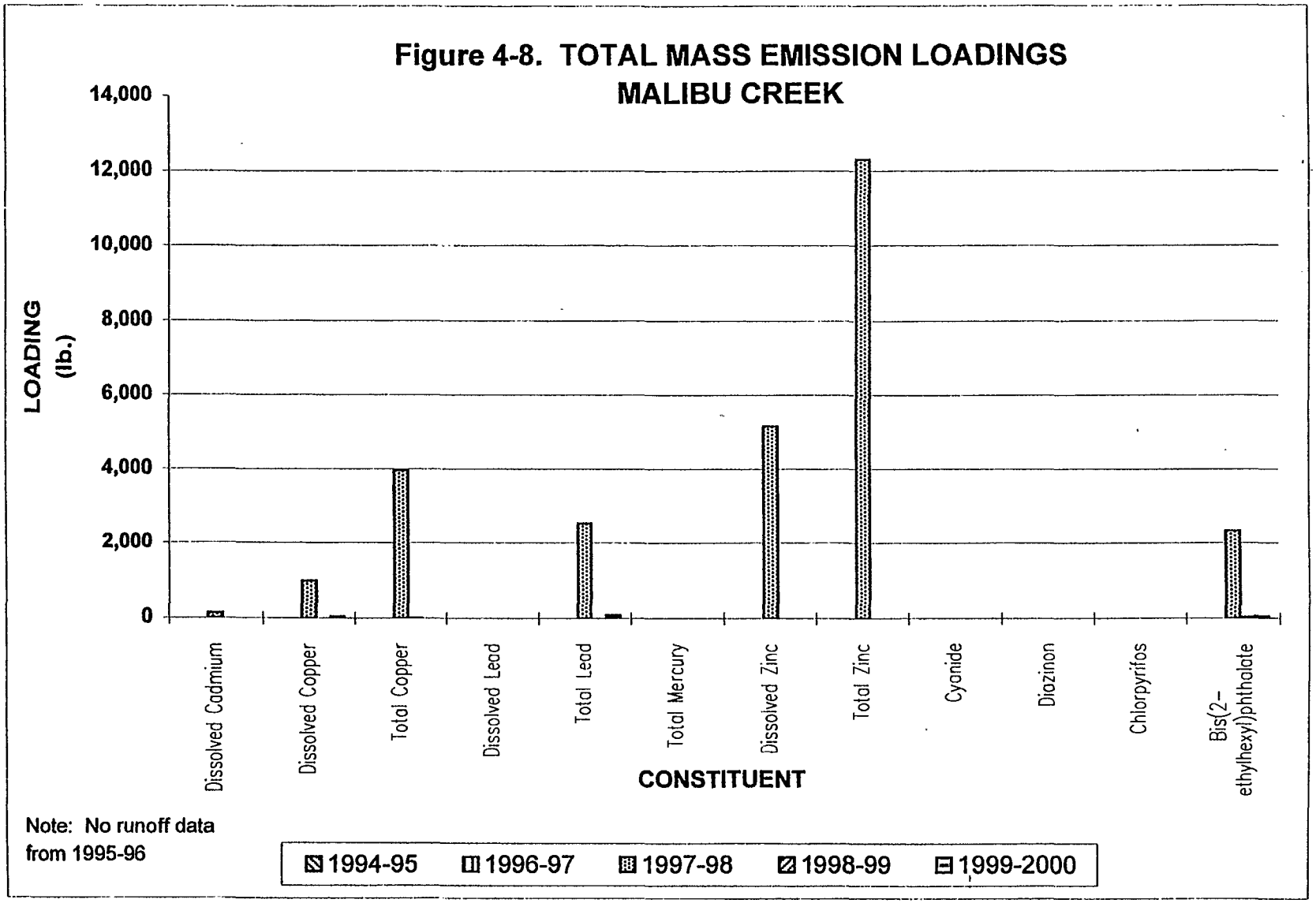
Figure 4-7. TOTAL MASS EMISSION LOADINGS BALLONA CREEK (cont'd)



Note: No runoff data from 1995-96.
No runoff data during Feb. 1998.

R0012144



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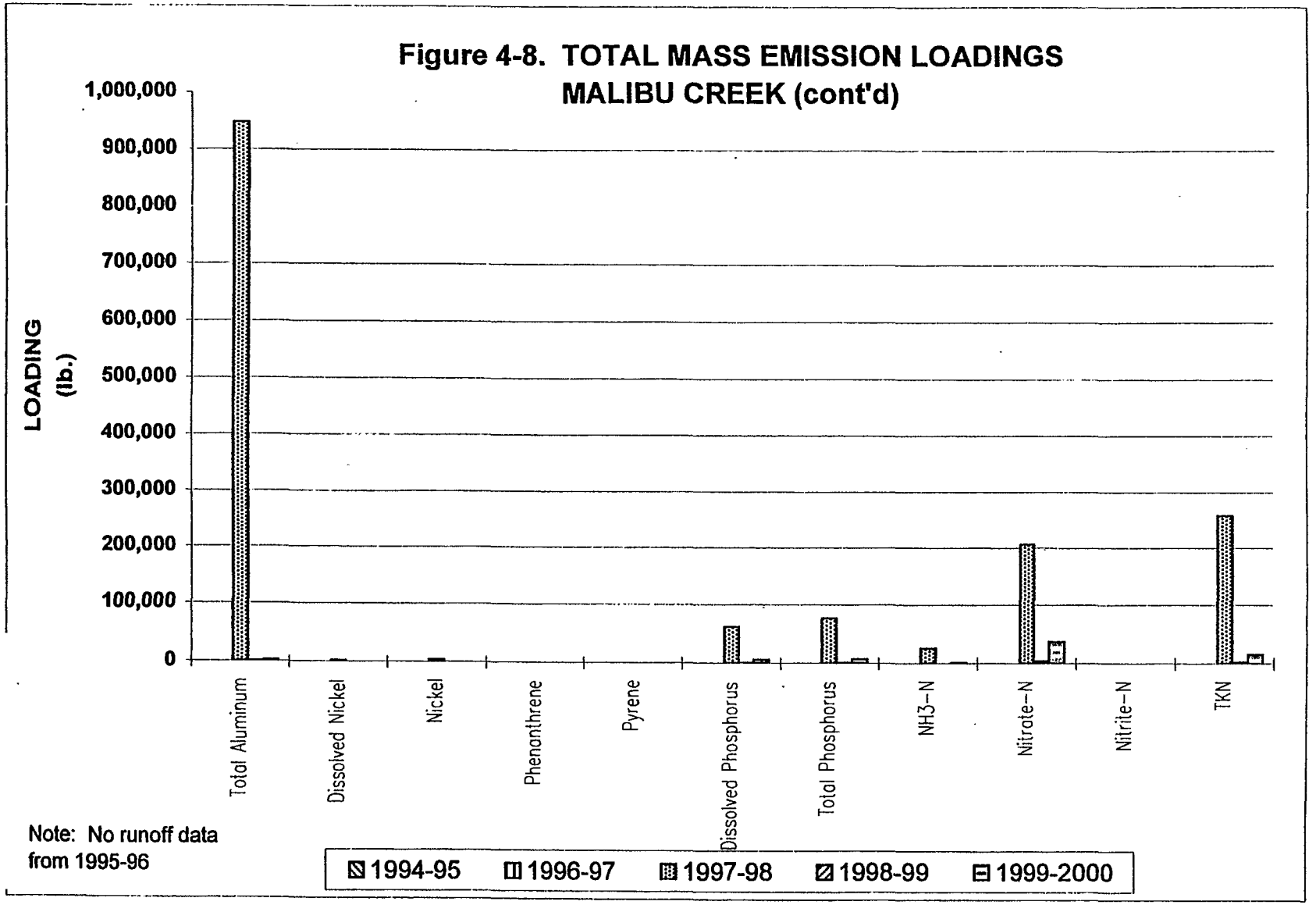
tw ME_load.xls

Figure 4-8. TOTAL MASS EMISSION LOADINGS MALIBU CREEK (cont'd)



Note: No runoff data from 1995-96

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Figure 4-9. TOTAL MASS EMISSION LOADINGS LOS ANGELES RIVER

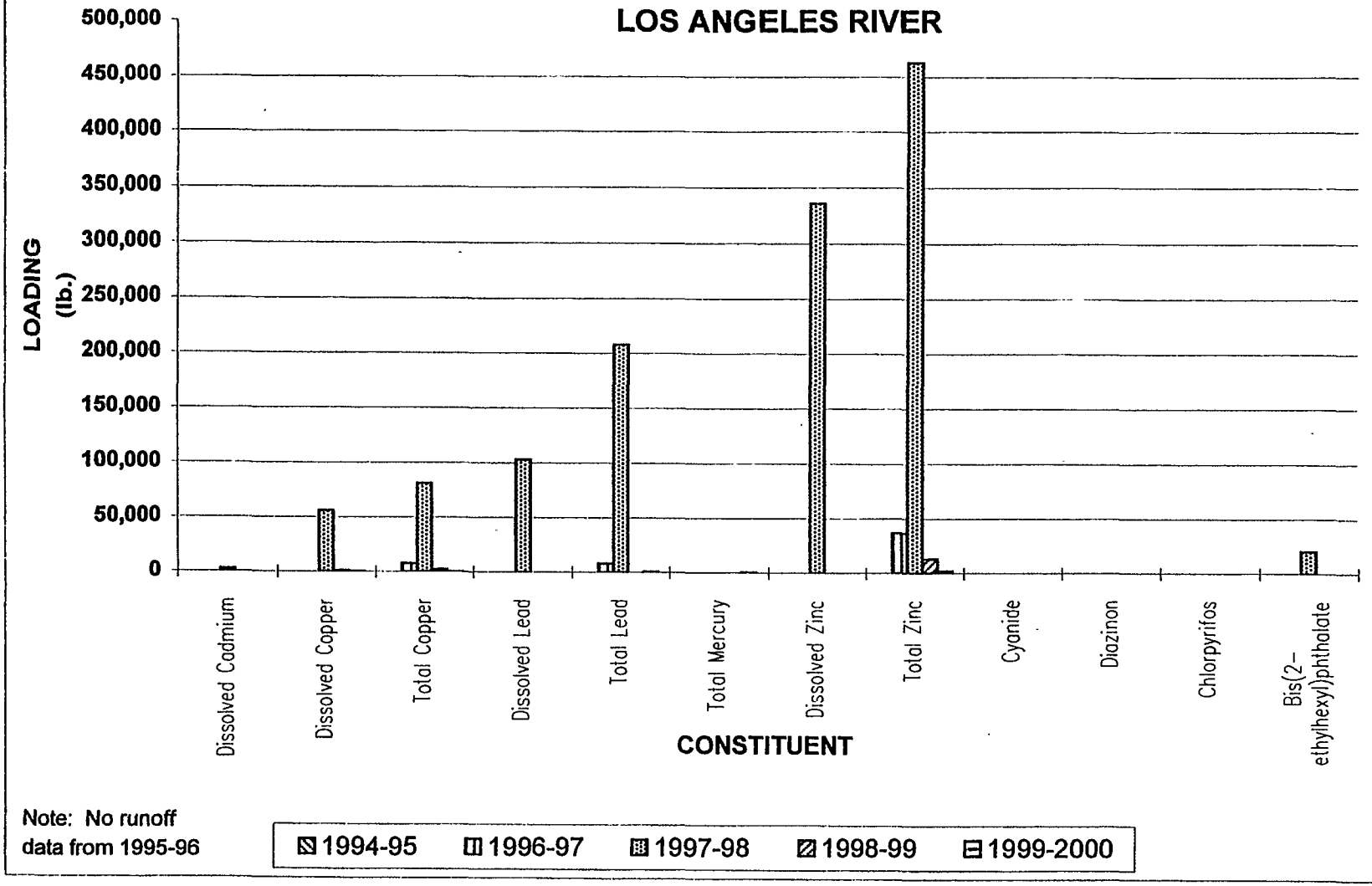

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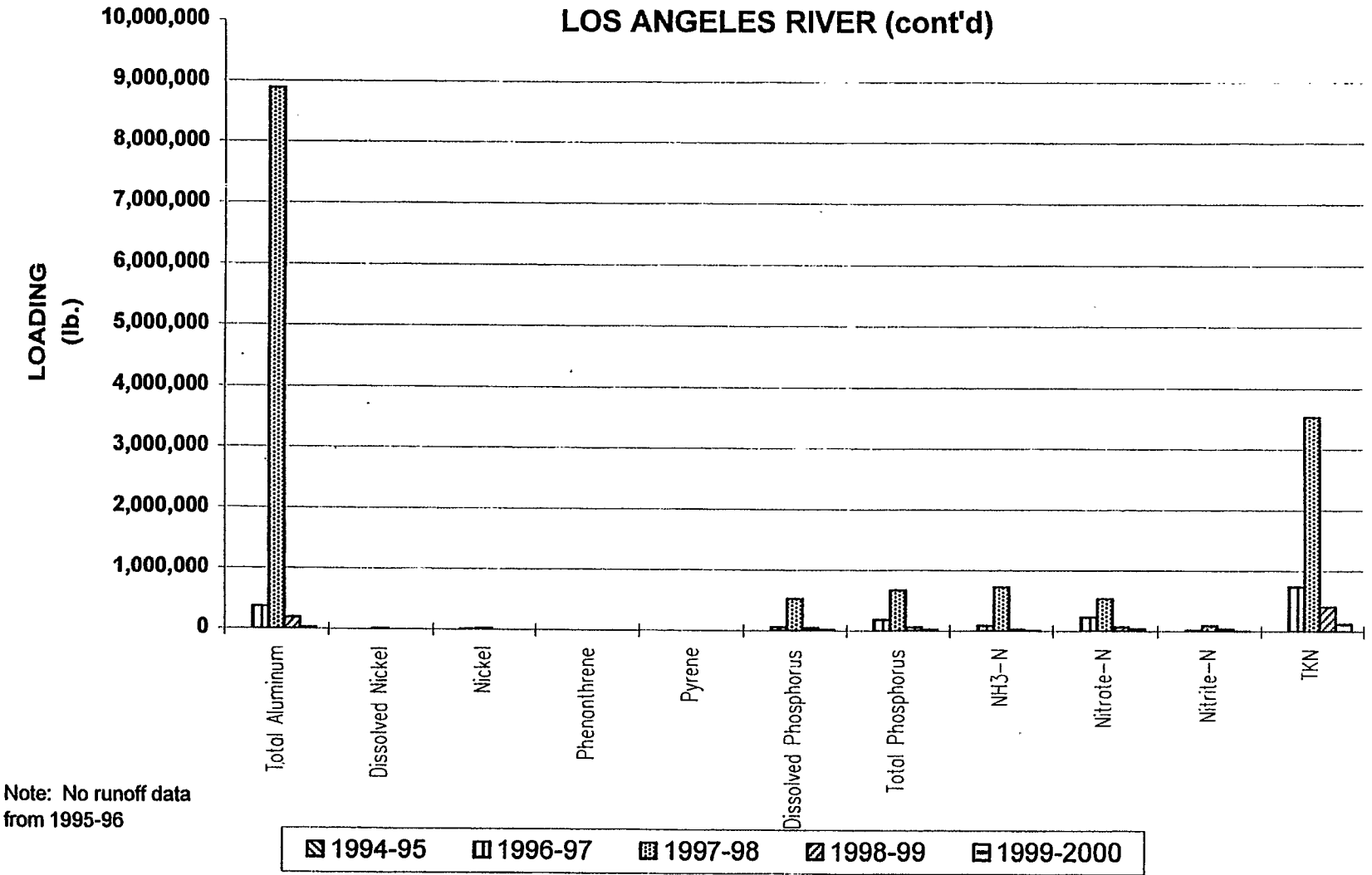
Figure 4-9. TOTAL MASS EMISSION LOADINGS LOS ANGELES RIVER (cont'd)



Note: No runoff data from 1995-96

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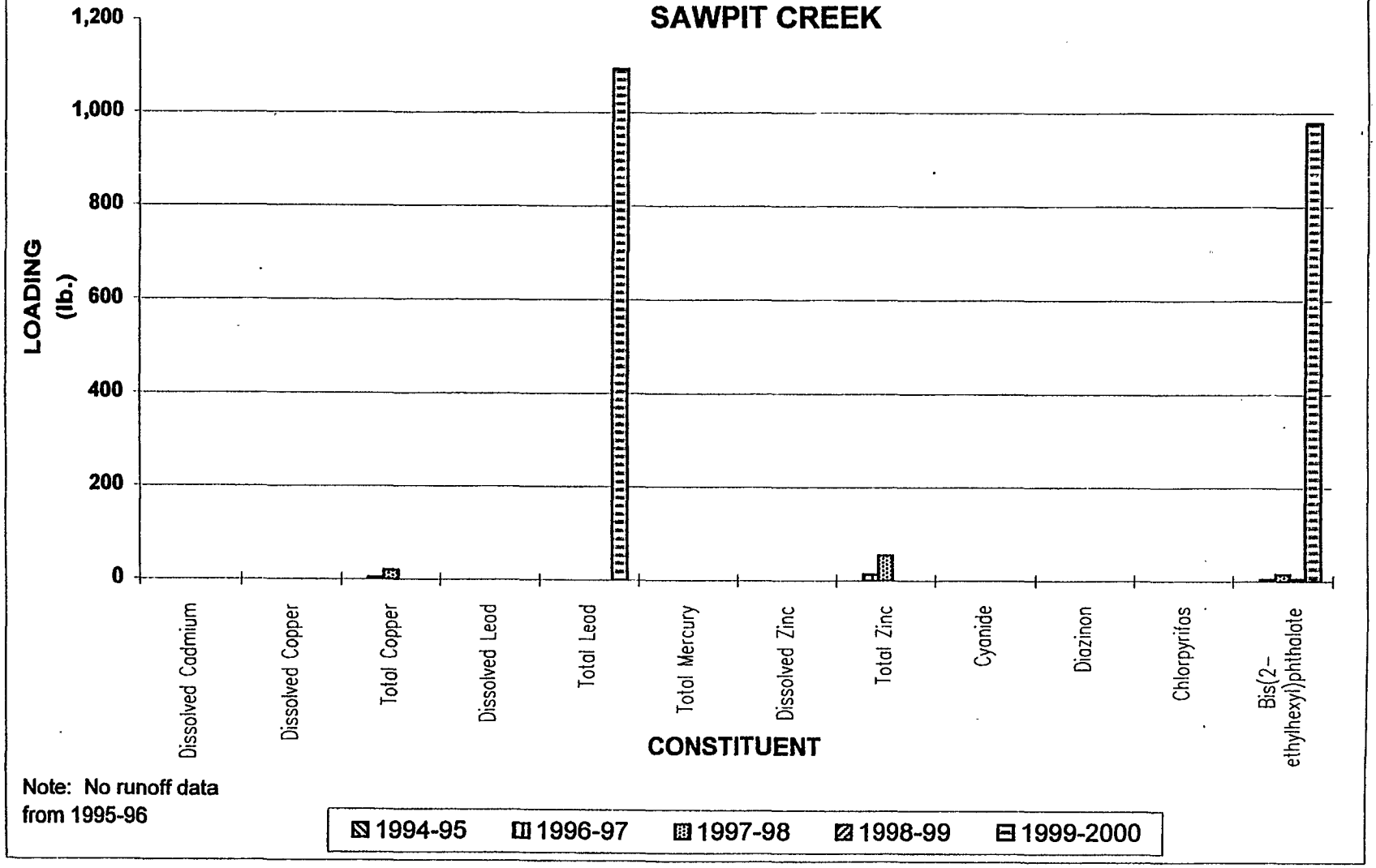
Figure 4-10. TOTAL MASS EMISSION LOADINGS
SAWPIT CREEK



Note: No runoff data from 1995-96

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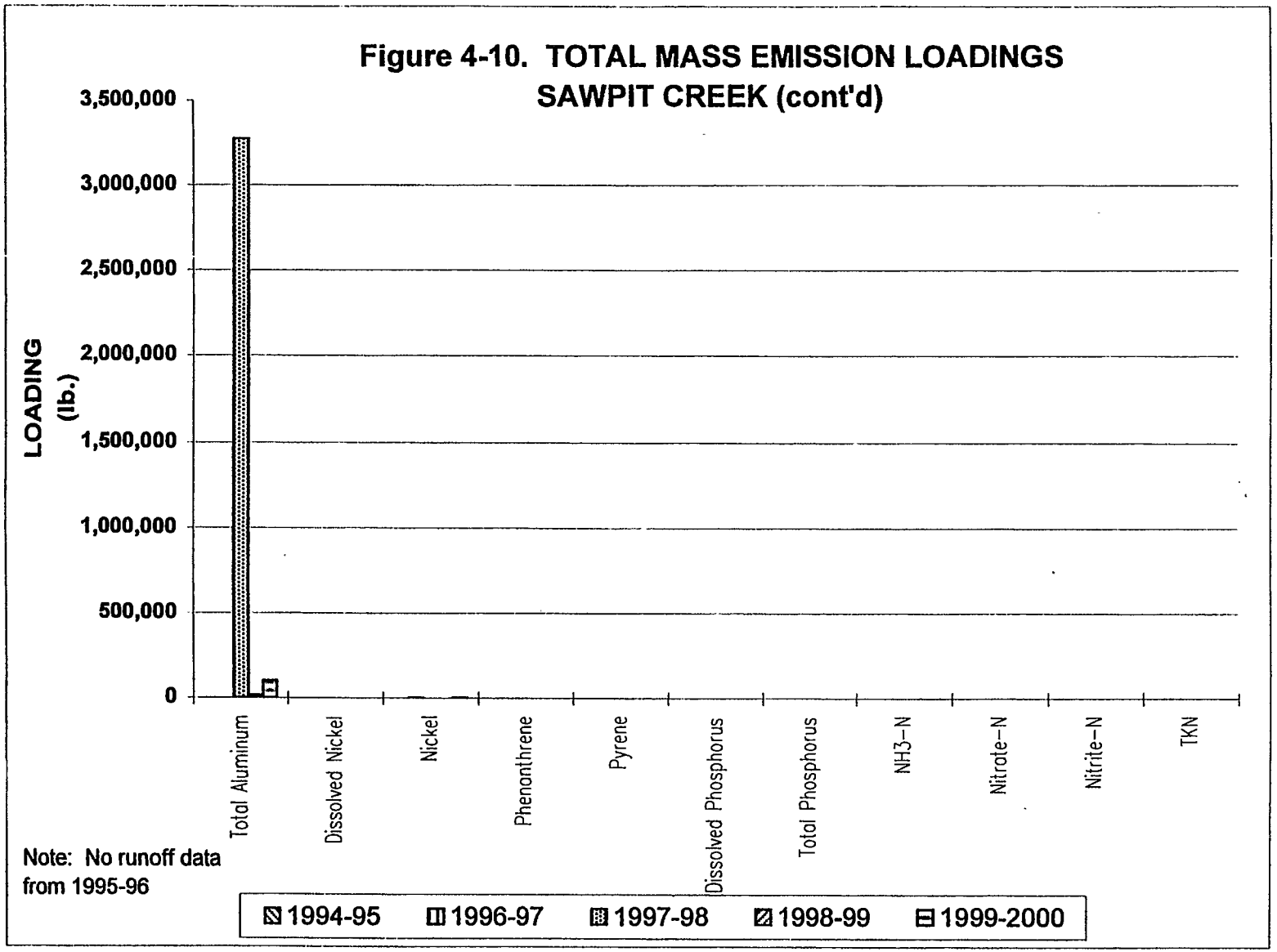
Figure 4-10. TOTAL MASS EMISSION LOADINGS SAWPIT CREEK (cont'd)



Note: No runoff data from 1995-96

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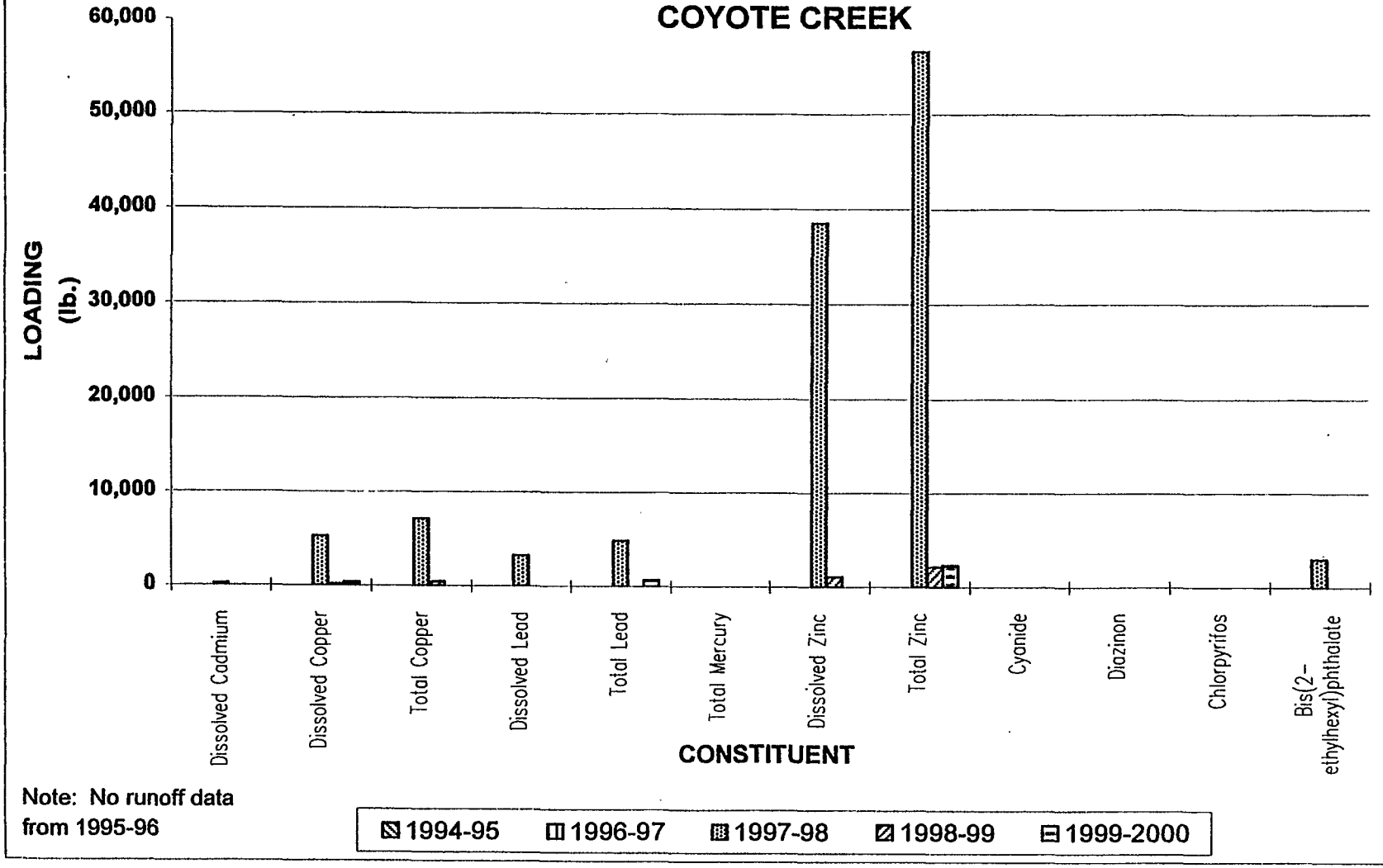
Figure 4-11. TOTAL MASS EMISSION LOADINGS
COYOTE CREEK



Note: No runoff data from 1995-96

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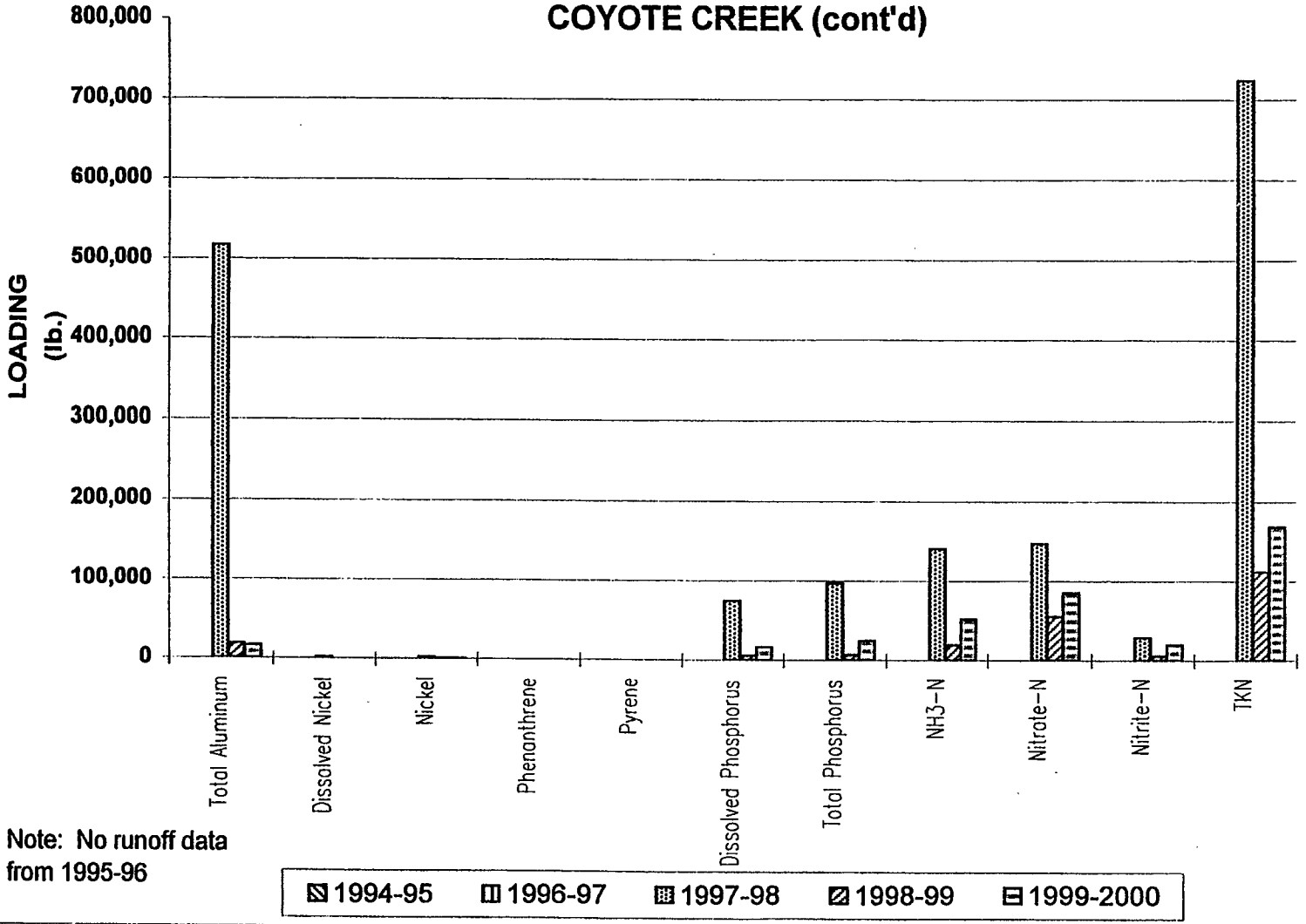
tw ME_load.xls

Figure 4-11. TOTAL MASS EMISSION LOADINGS COYOTE CREEK (cont'd)

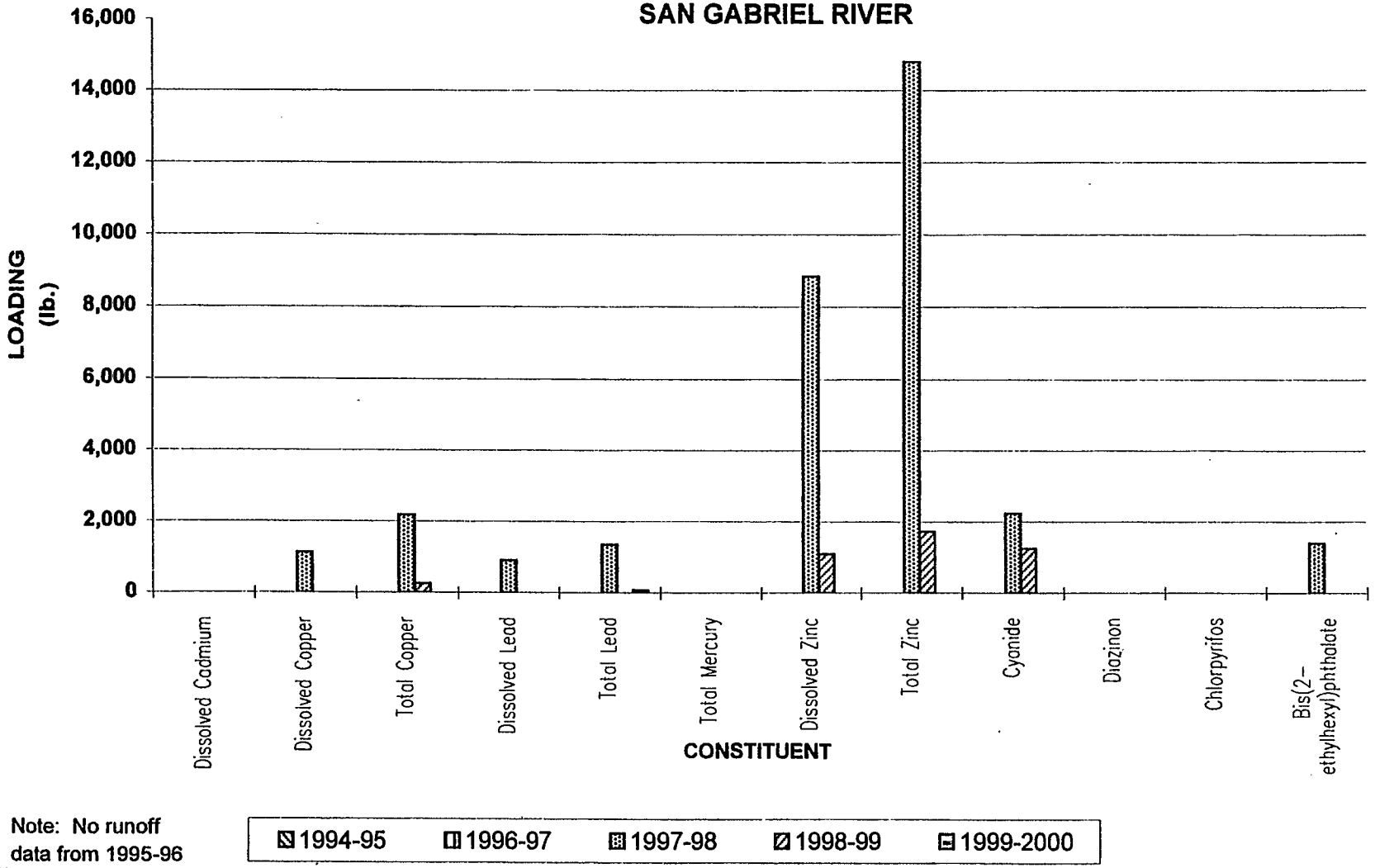


Note: No runoff data from 1995-96

R0012152

tw ME_load.xls

Figure 4-12. TOTAL MASS EMISSION LOADINGS
SAN GABRIEL RIVER

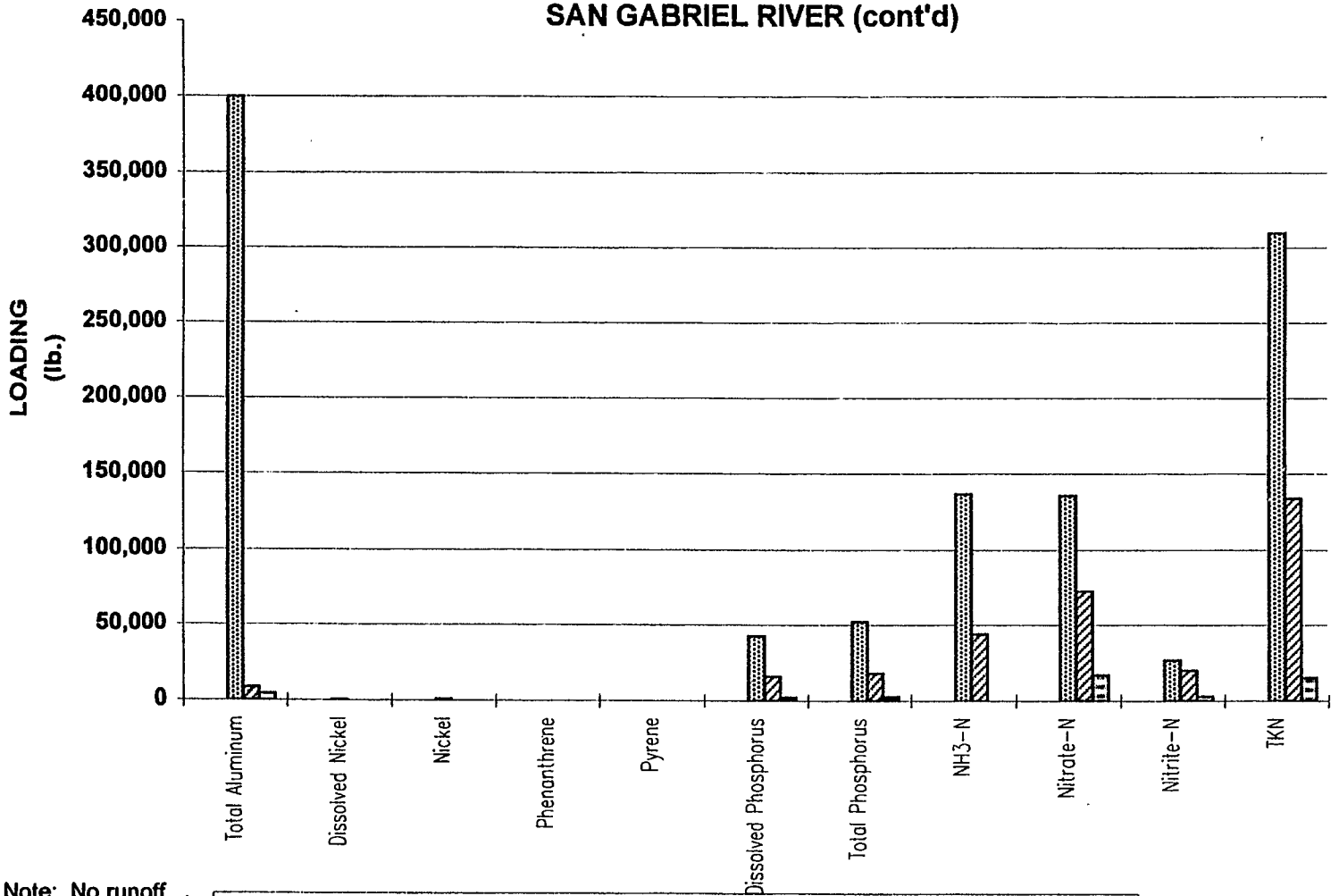


Note: No runoff data from 1995-96

R0012153

tw ME_load.xls

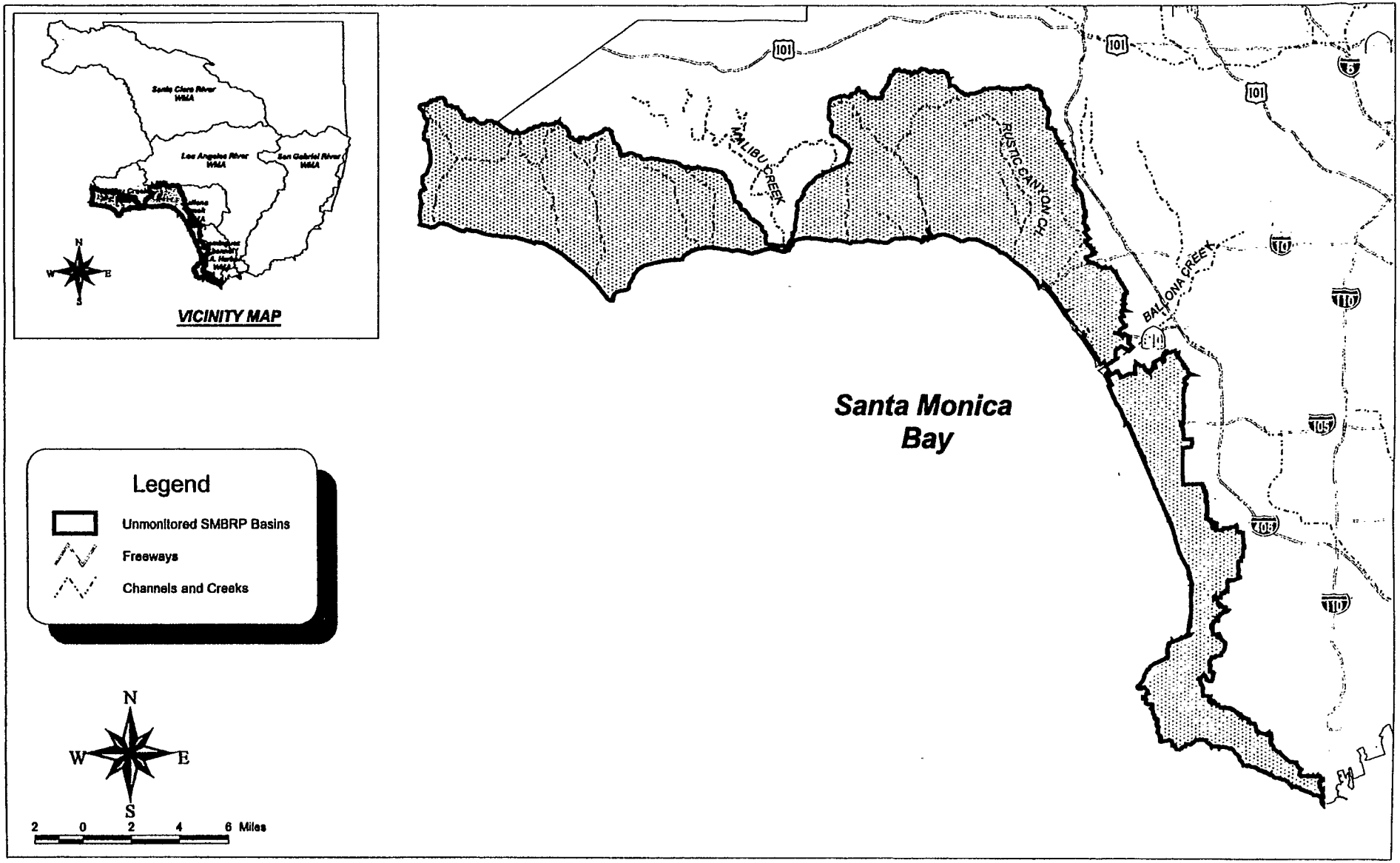
Figure 4-12. TOTAL MASS EMISSION LOADINGS SAN GABRIEL RIVER (cont'd)



Note: No runoff data from 1995-96

R0012154

tw ME_load.xls



R0012155

LOS ANGELES COUNTY PUBLIC WORKS
Public Service That Works

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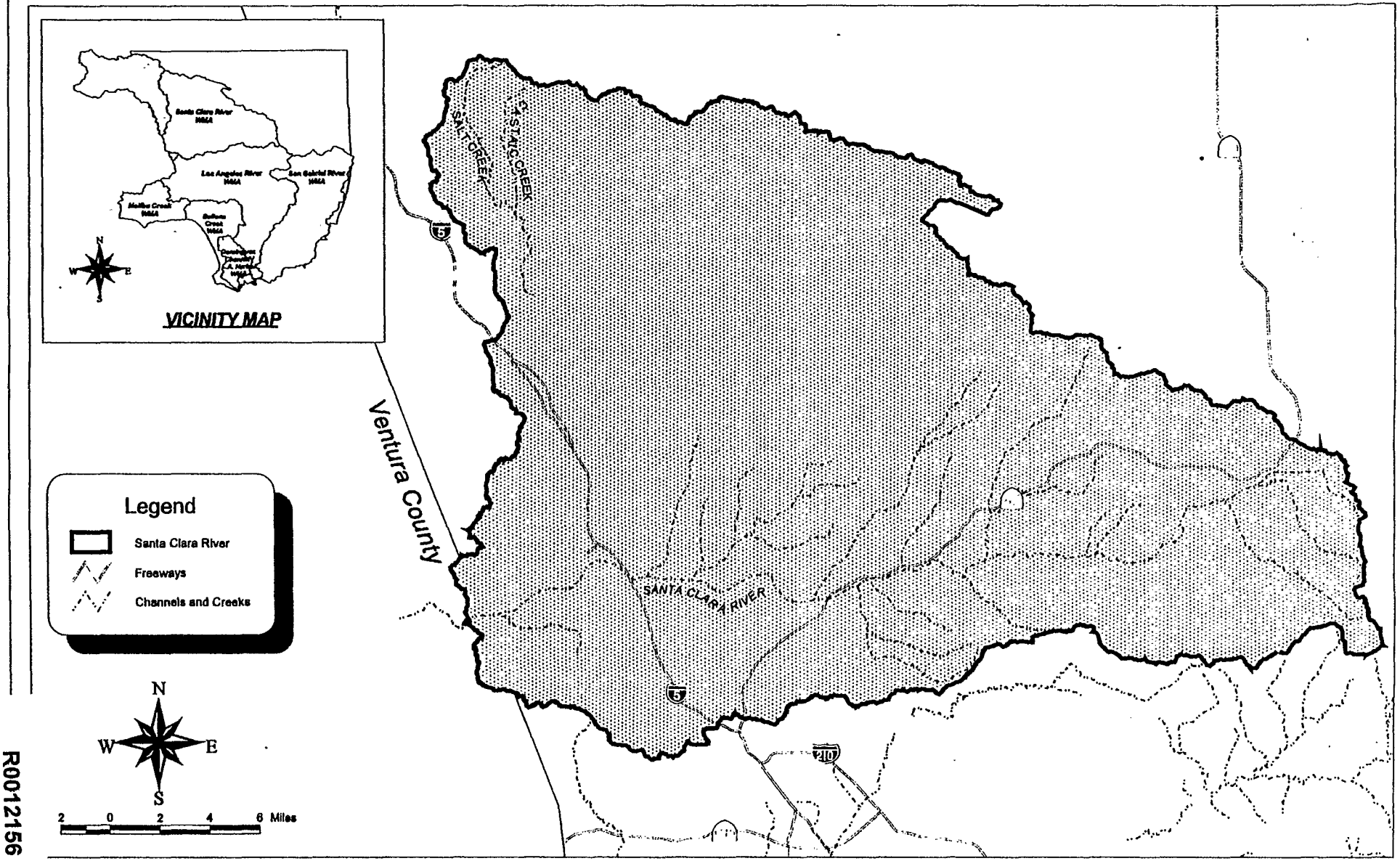
Figure 4-13

UNMONITORED SANTA MONICA BAY BASINS (Unmonitored Watersheds)

Land Use Distribution	Area (Acres)	Percent
High Density Residential	48,817	14.0%
Light Industrial	1,049	0.3%
Vacant	251,445	72.4%
Retail/Commercial	2,360	0.7%
Multi-Family Residential	5,572	1.6%
Transportation	19,725	5.7%
Education	1,591	0.5%
Mixed Residential	1,229	0.4%
Other	15,214	4.4%
Total	347,003	100.0%



R0012156

Figure 4-14

SANTA CLARA RIVER (Unmonitored Watershed)

Land Use Distribution	Area (Acres)	Percent
High Density Residential	7,669	1.0%
Light Industrial	1,155	0.2%
Vacant	670,234	91.0%
Retail/Commercial	842	0.1%
Multi-Family Residential	1,139	0.2%
Transportation	7,730	1.0%
Education	653	0.1%
Mixed Residential	12	0.0%
Other	46,950	6.4%
Total	736,384	100.0%

LOS ANGELES COUNTY PUBLIC WORKS Public Service That Works

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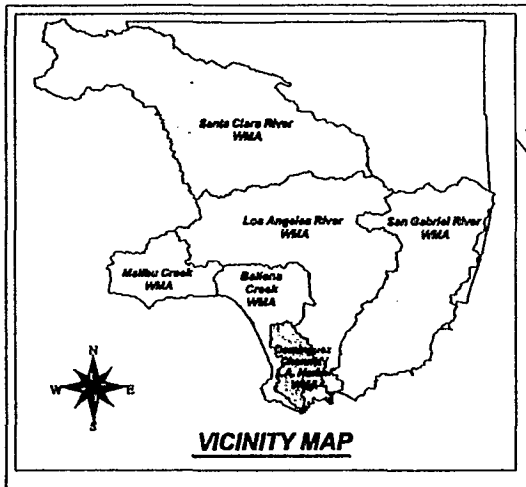
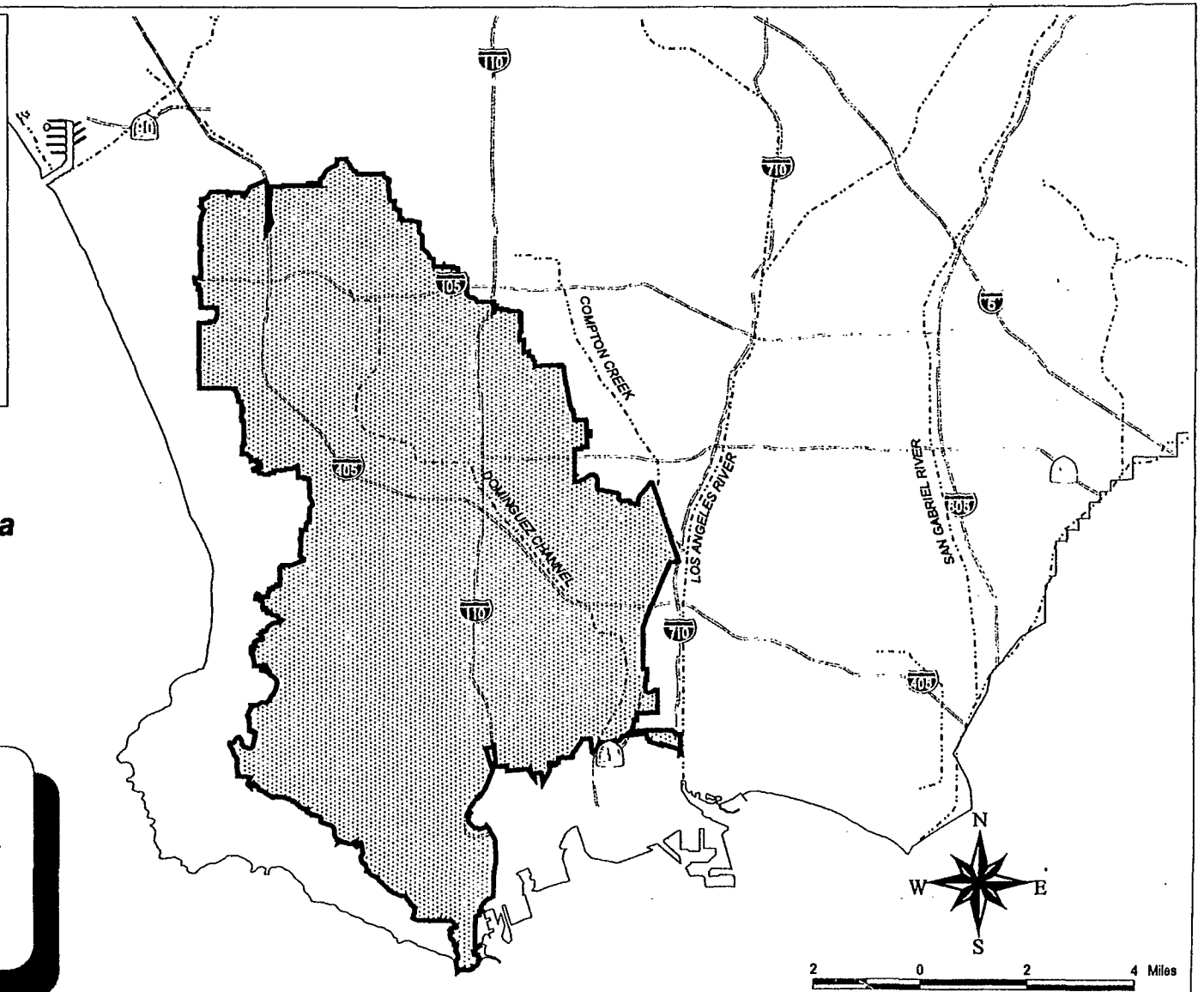


VICINITY MAP

Santa Monica Bay



Legend

- Dominguez Channel/L.A. Harbor WMA
- Freeways
- Channels and Creeks

R0012157

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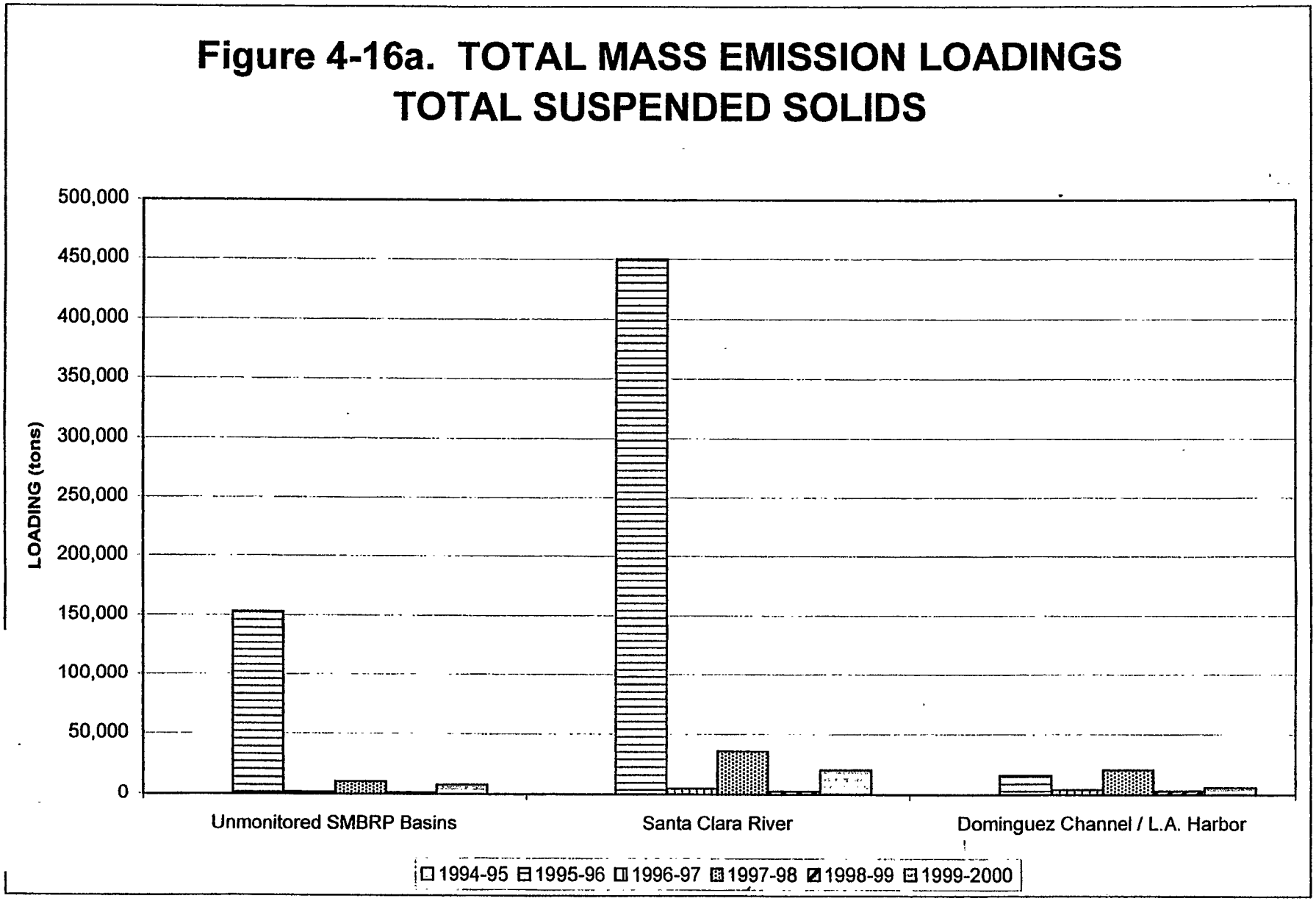
Figure 4-15

DOMINGUEZ CHANNEL/L.A. HARBOR WMA (Unmonitored Watershed)

Land Use Distribution	Area (Acres)	Percent
High Density Residential	76,067	45.7%
Light Industrial	10,689	6.4%
Vacant	6,946	4.2%
Retail/Commercial	4,914	3.0%
Multi-Family Residential	4,384	2.6%
Transportation	35,878	21.6%
Education	2,644	1.6%
Mixed Residential	4,035	2.4%
Other	20,826	12.5%
Total	166,383	100.0%

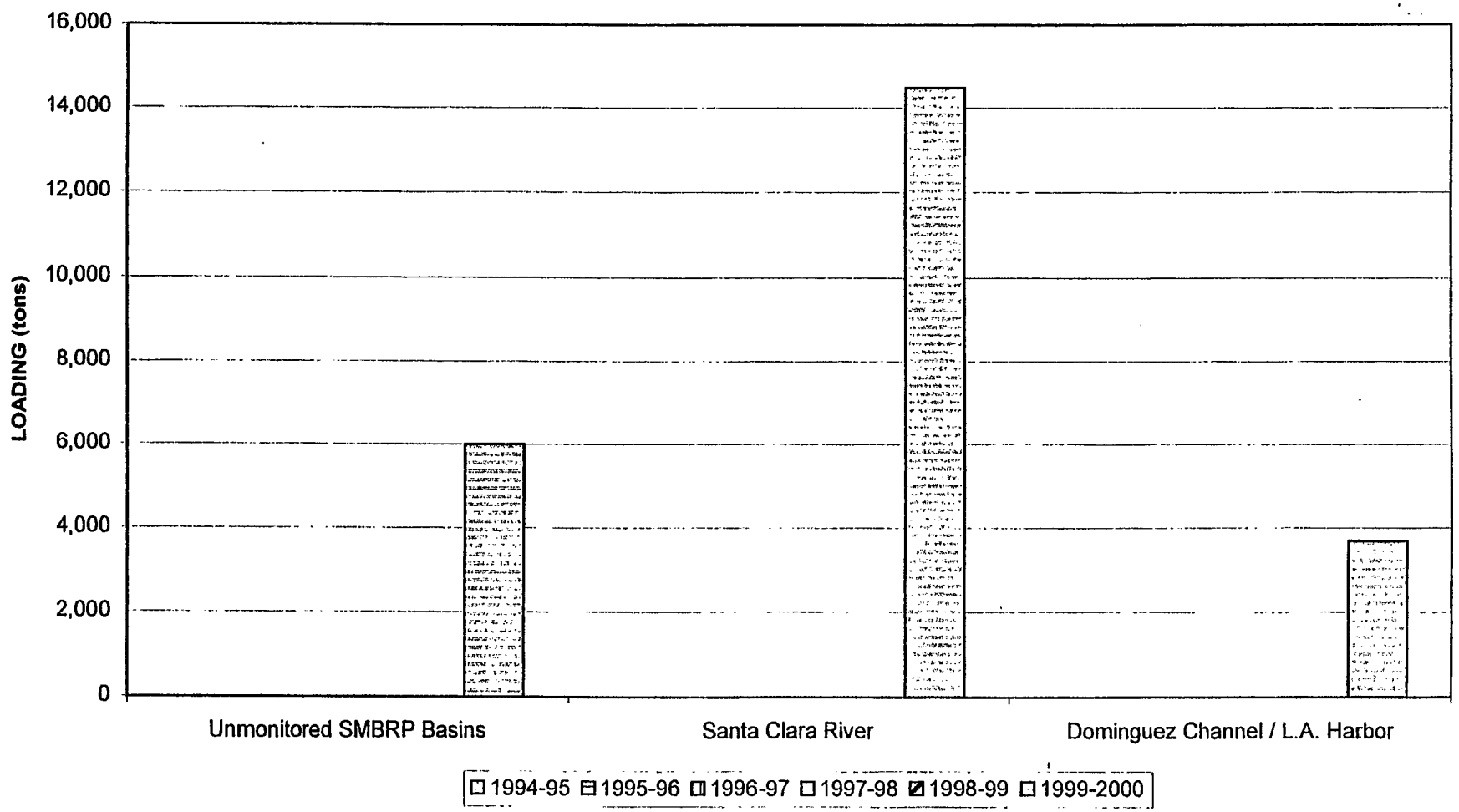
Figure 4-16a. TOTAL MASS EMISSION LOADINGS TOTAL SUSPENDED SOLIDS



R0012158

ee/tw Figure 4-16a.xls

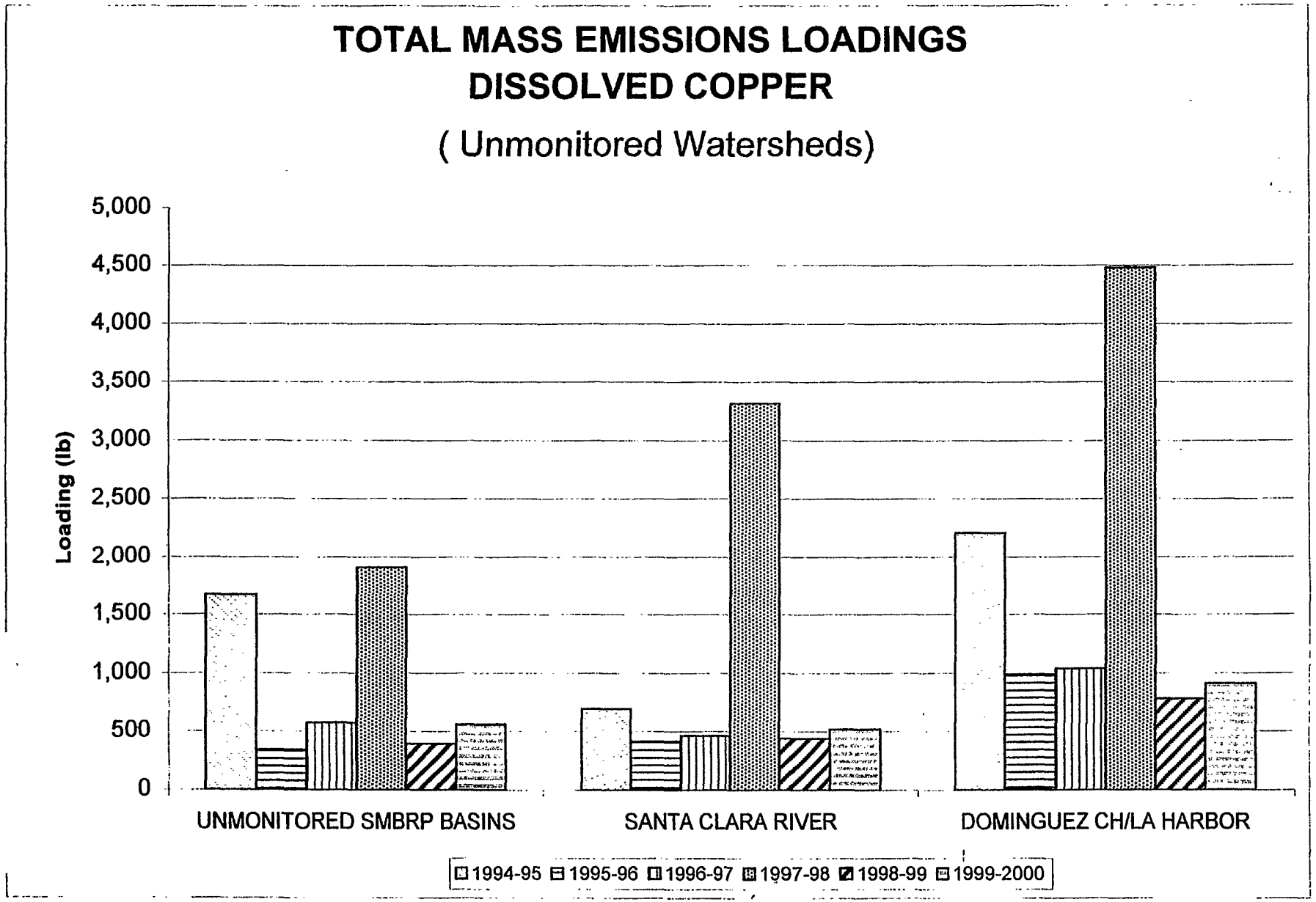
Figure 4-16b. TOTAL MASS EMISSION LOADINGS
TOTAL DISSOLVED SOLIDS



R0012159

ee/tw Figure 4-16b.xls

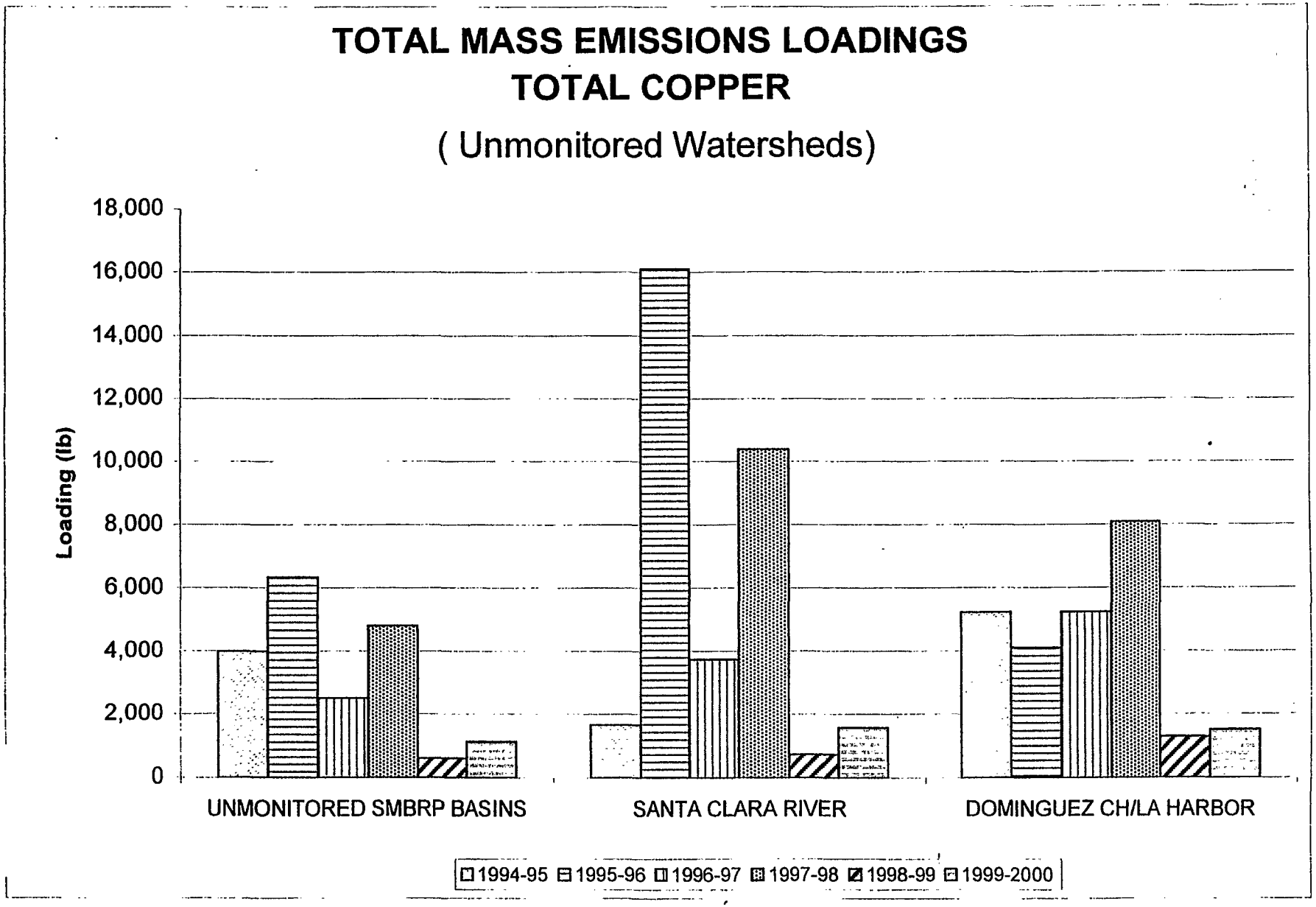
Figure 4-16c



R0012160

EE Figure 4-16c.xls

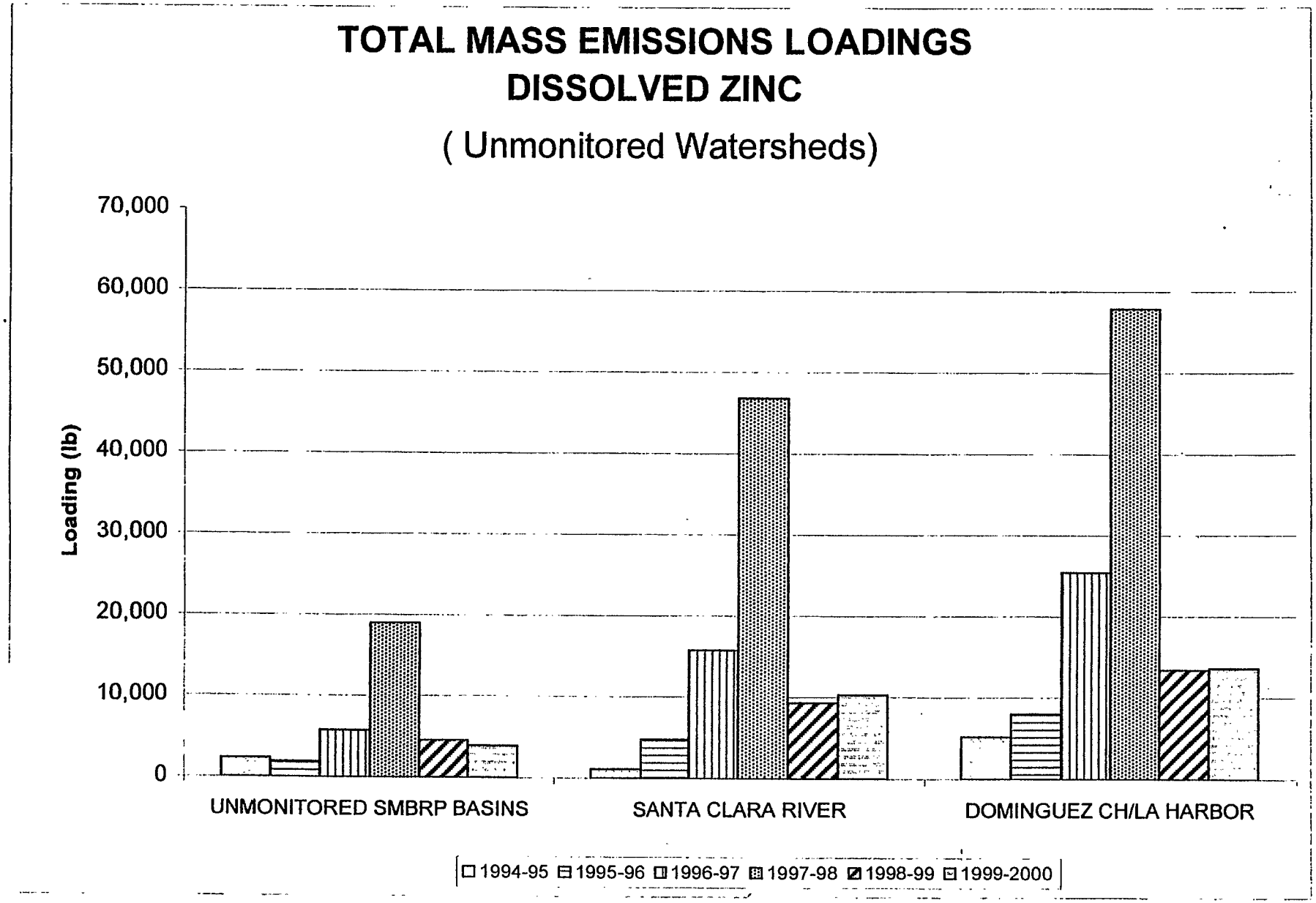
Figure 4-16d



R0012161

EE Figure 4-16d

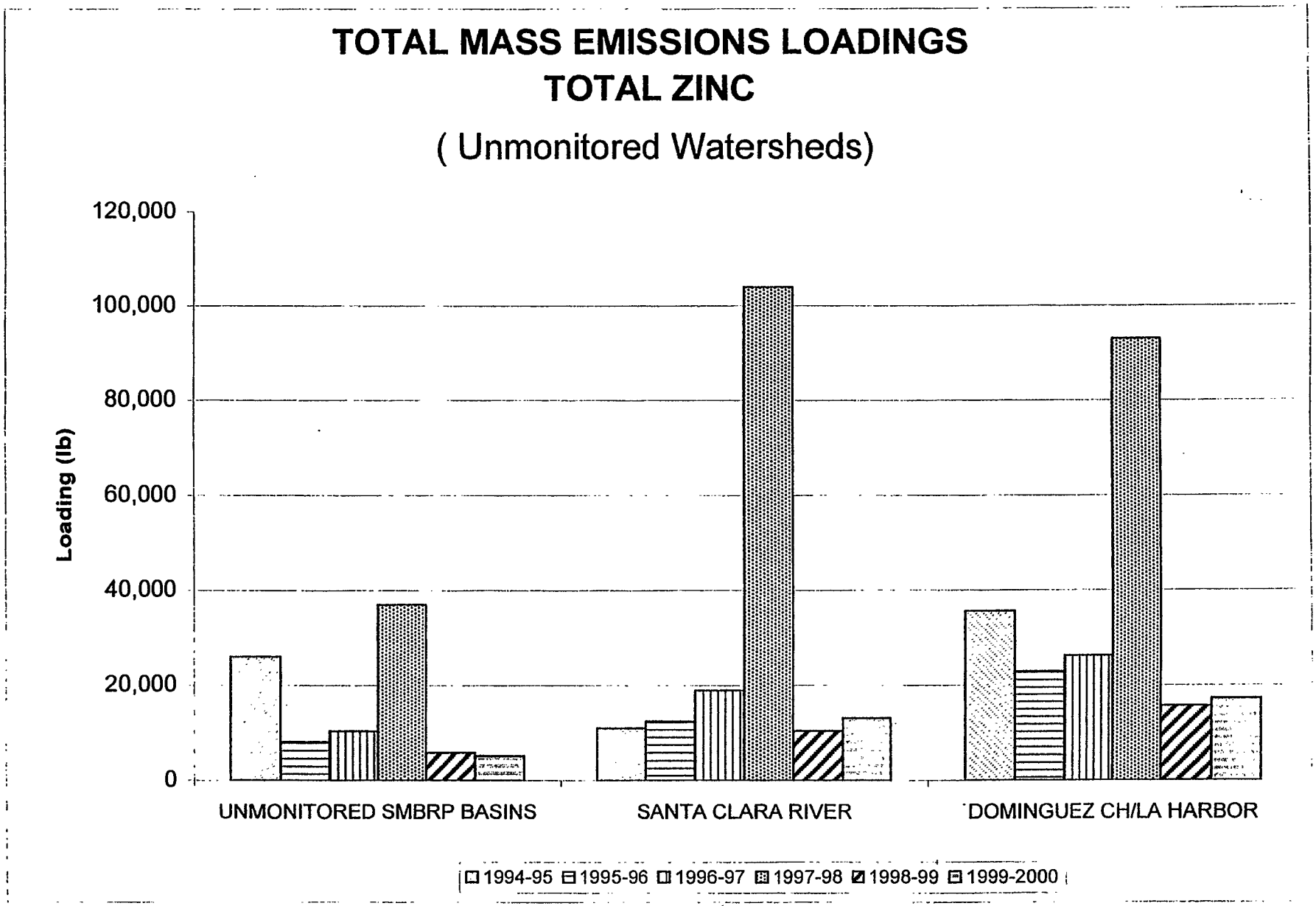
Figure 4-16e



R0012162

EE Figure 4-16e.xls

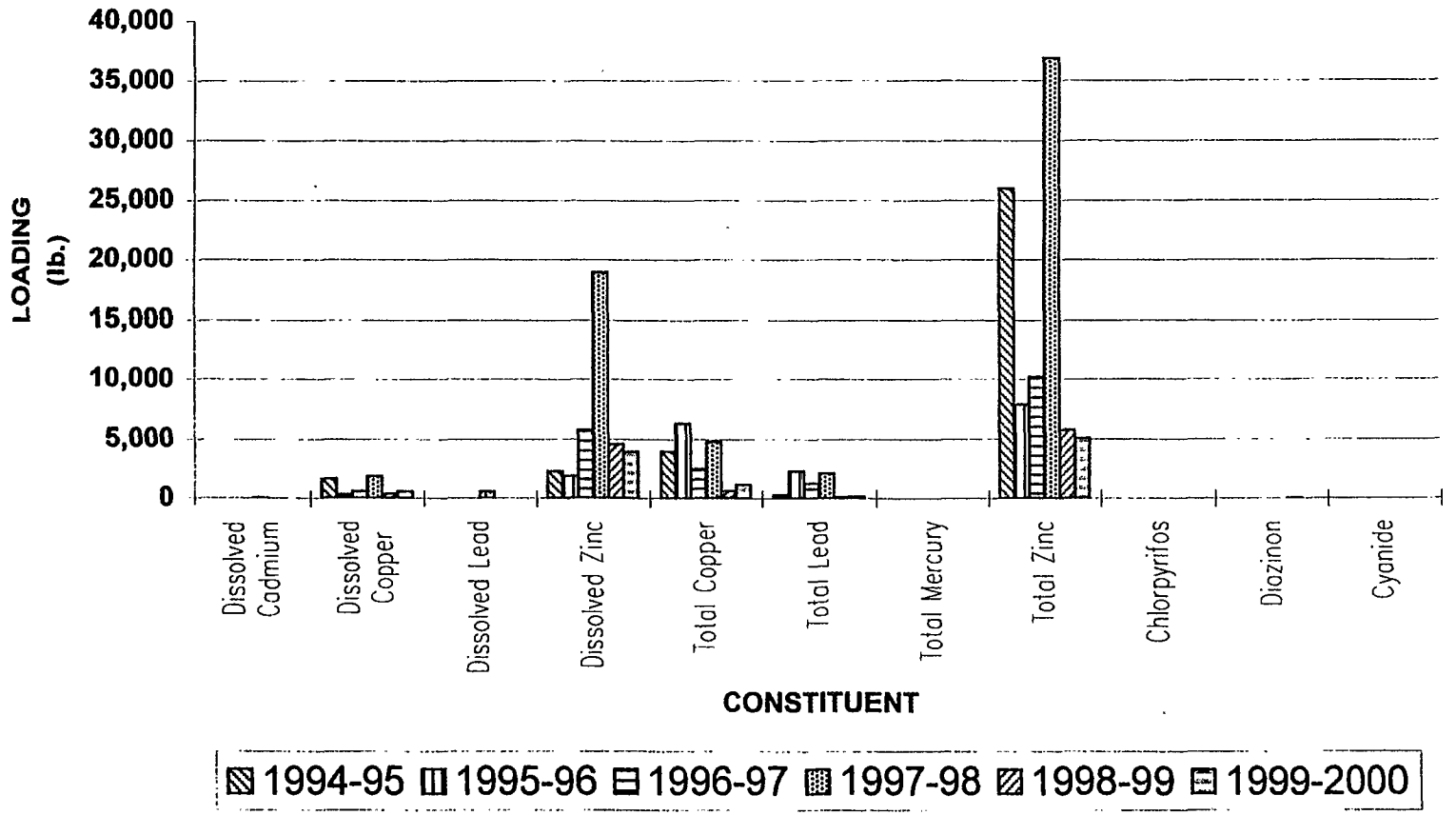
Figure 4-16f



R0012163

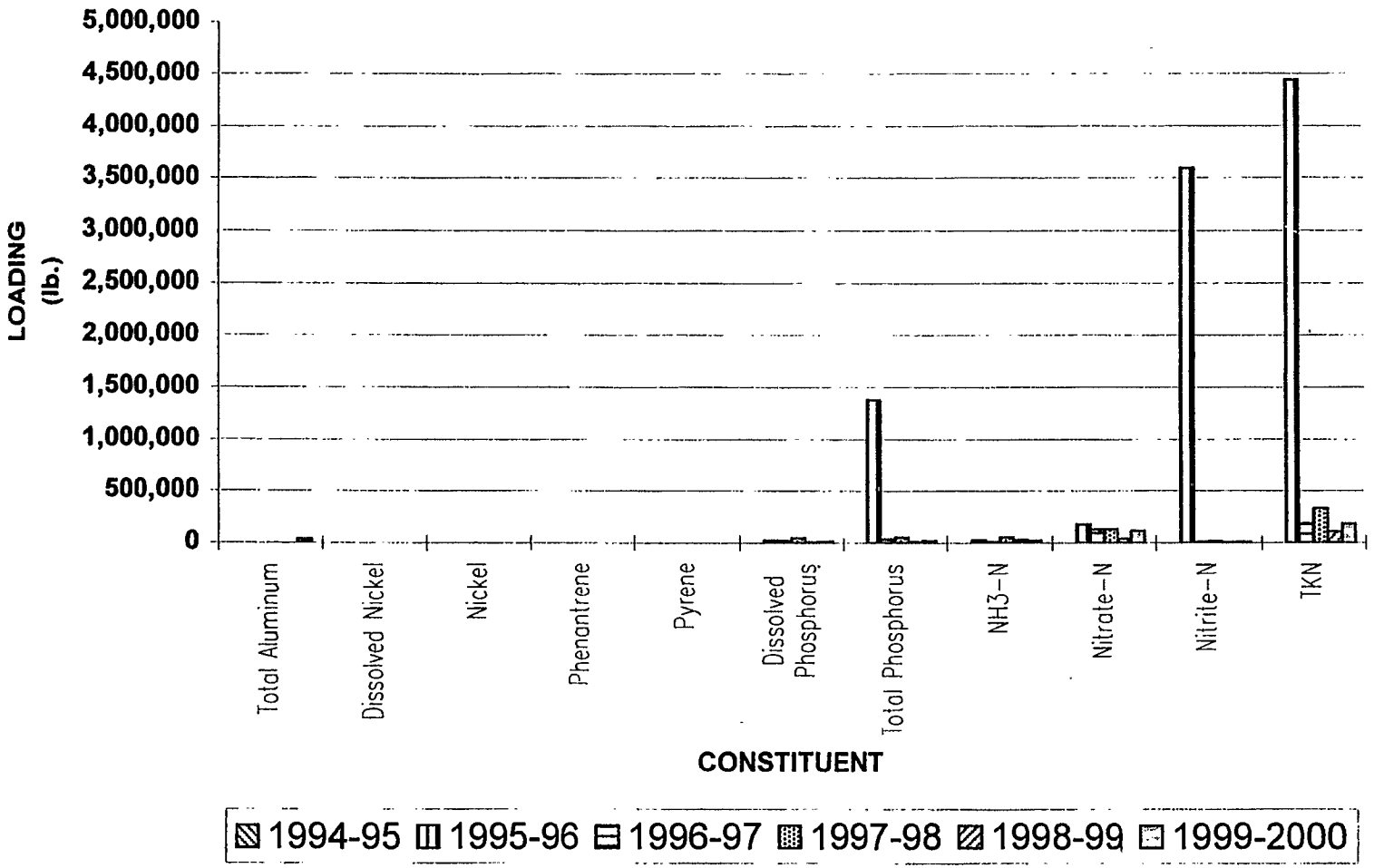
EE Fig 4-16f.xls

Figure 4-17. TOTAL MASS EMISSION LOADINGS UNMONITORED SMBRP BASINS



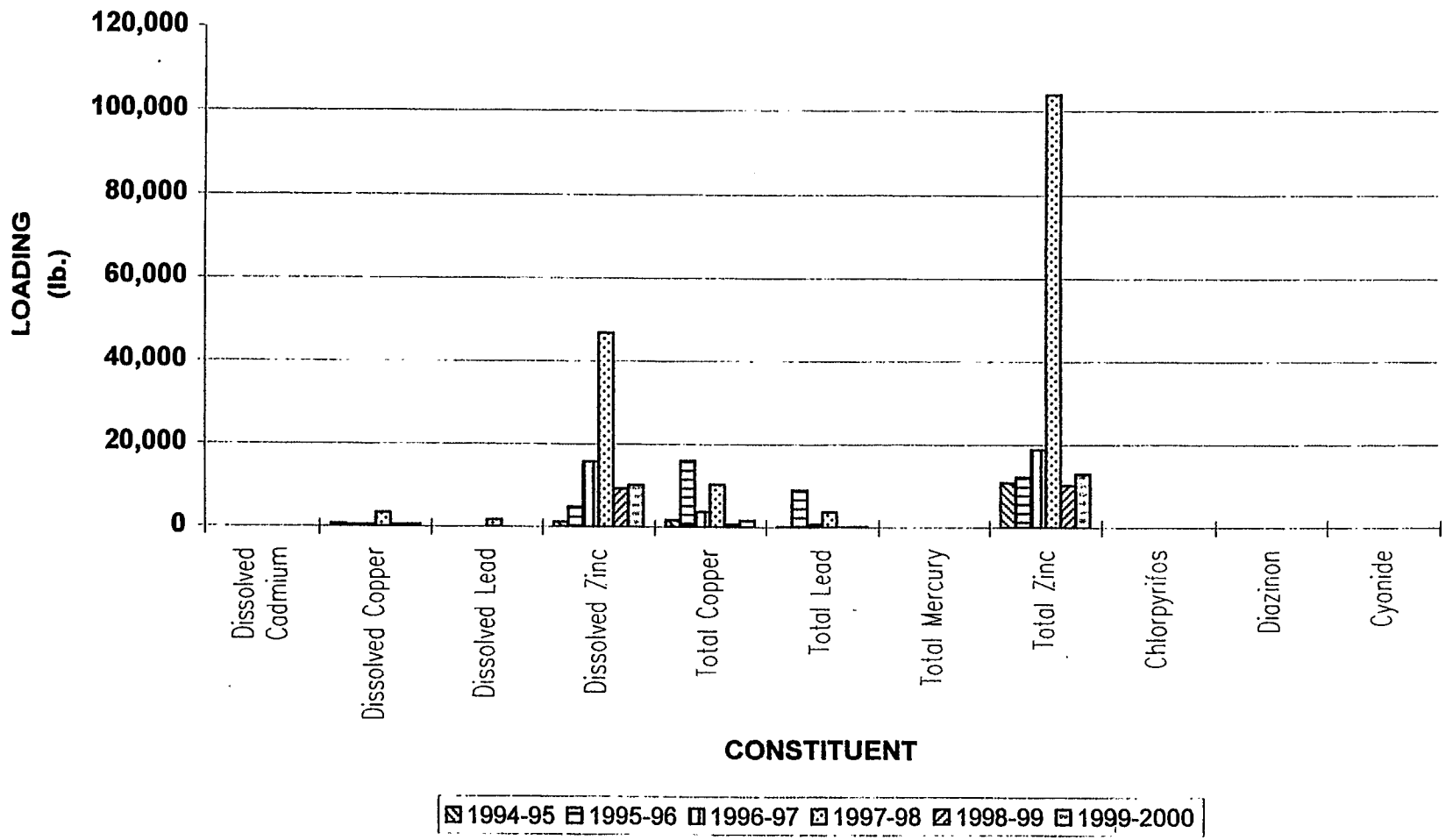
R0012164

Figure 4-17. TOTAL MASS EMISSION LOADINGS UNMONITORED SMBRP BASINS (cont'd)



R0012165

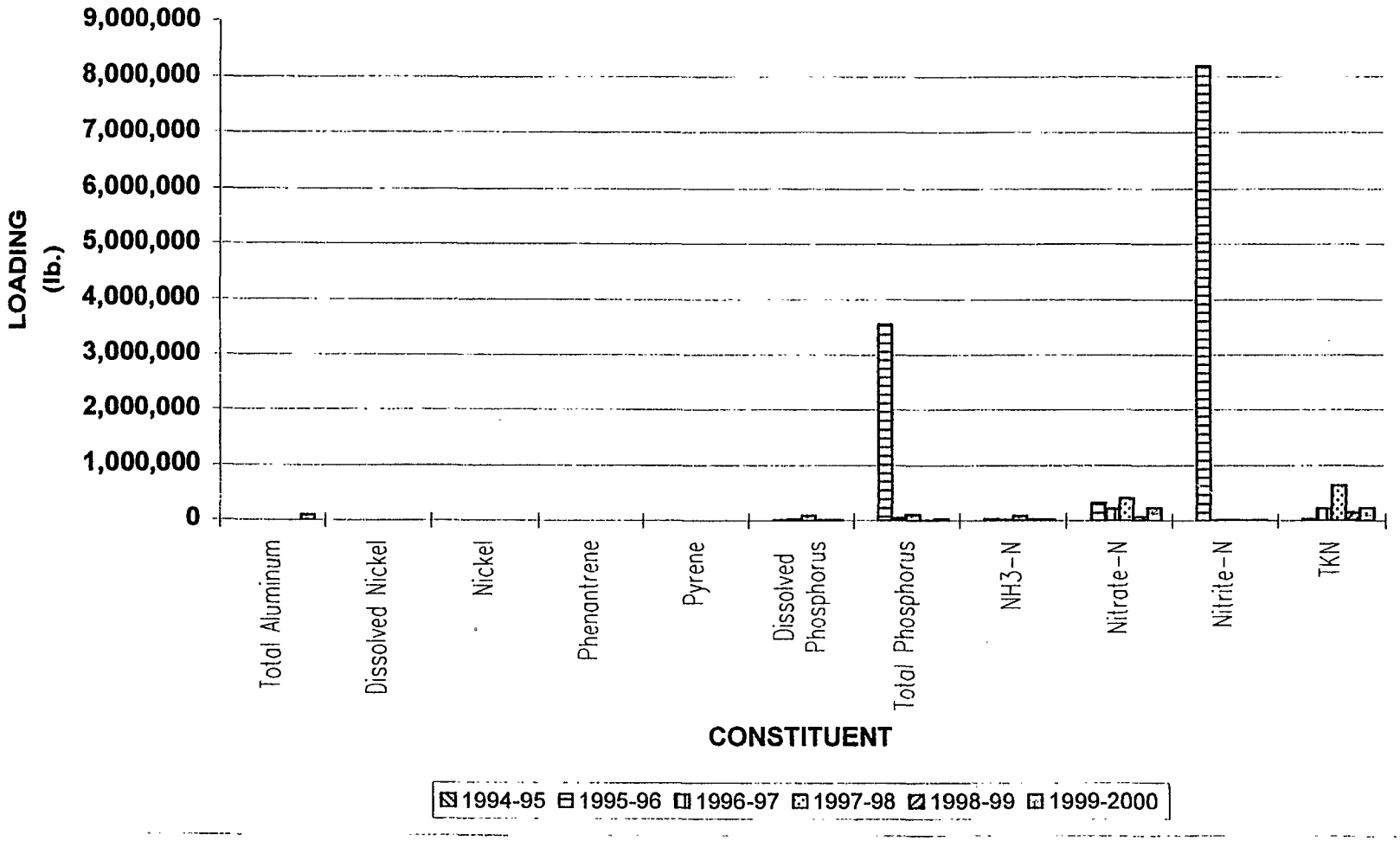
Figure 4-18. TOTAL MASS EMISSION LOADINGS SANTA CLARA RIVER



R0012166

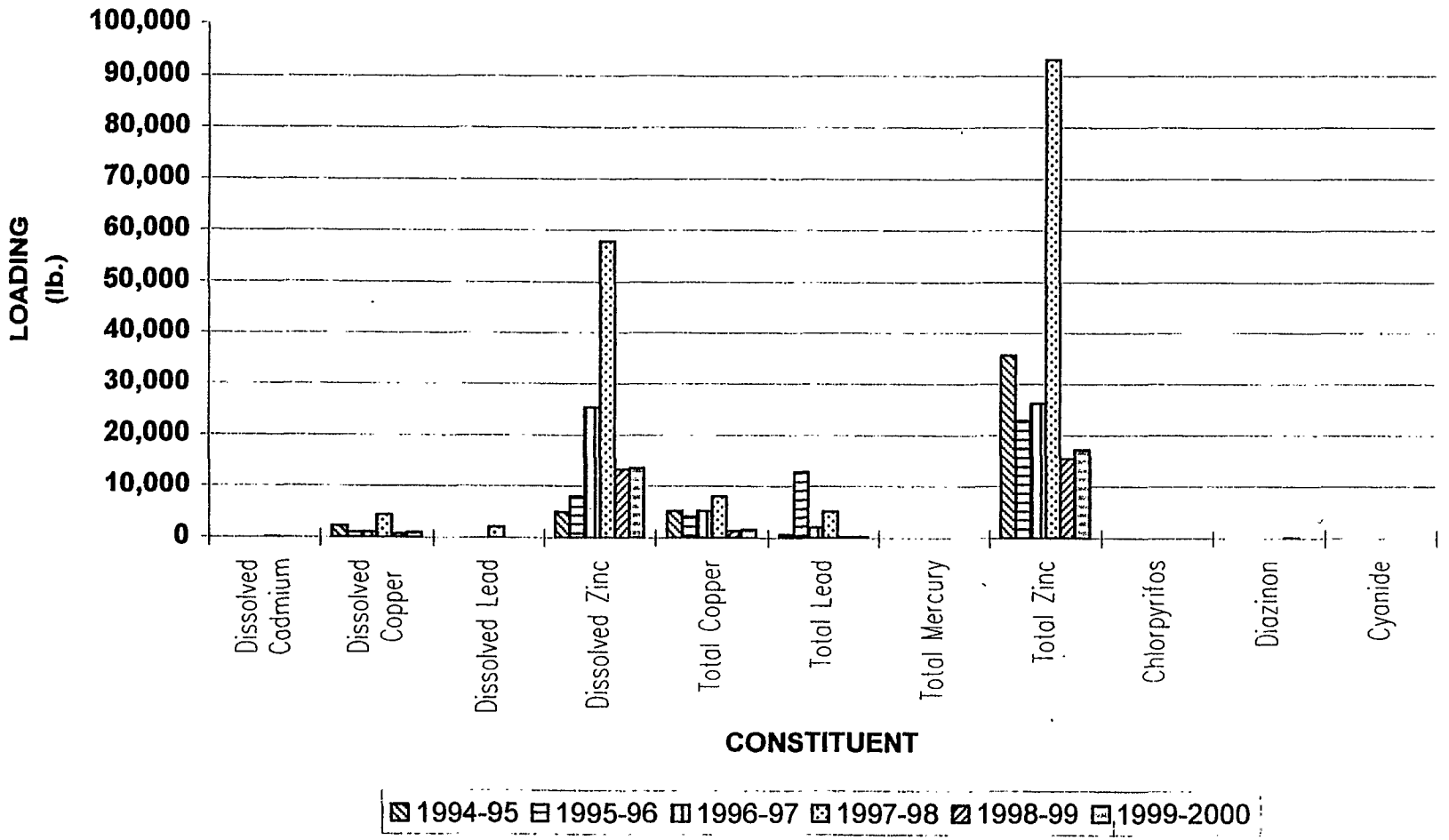
ee/tw Figure 4-18.xls

Figure 4-18. TOTAL MASS EMISSION LOADINGS SANTA CLARA RIVER (cont'd)



R0012167

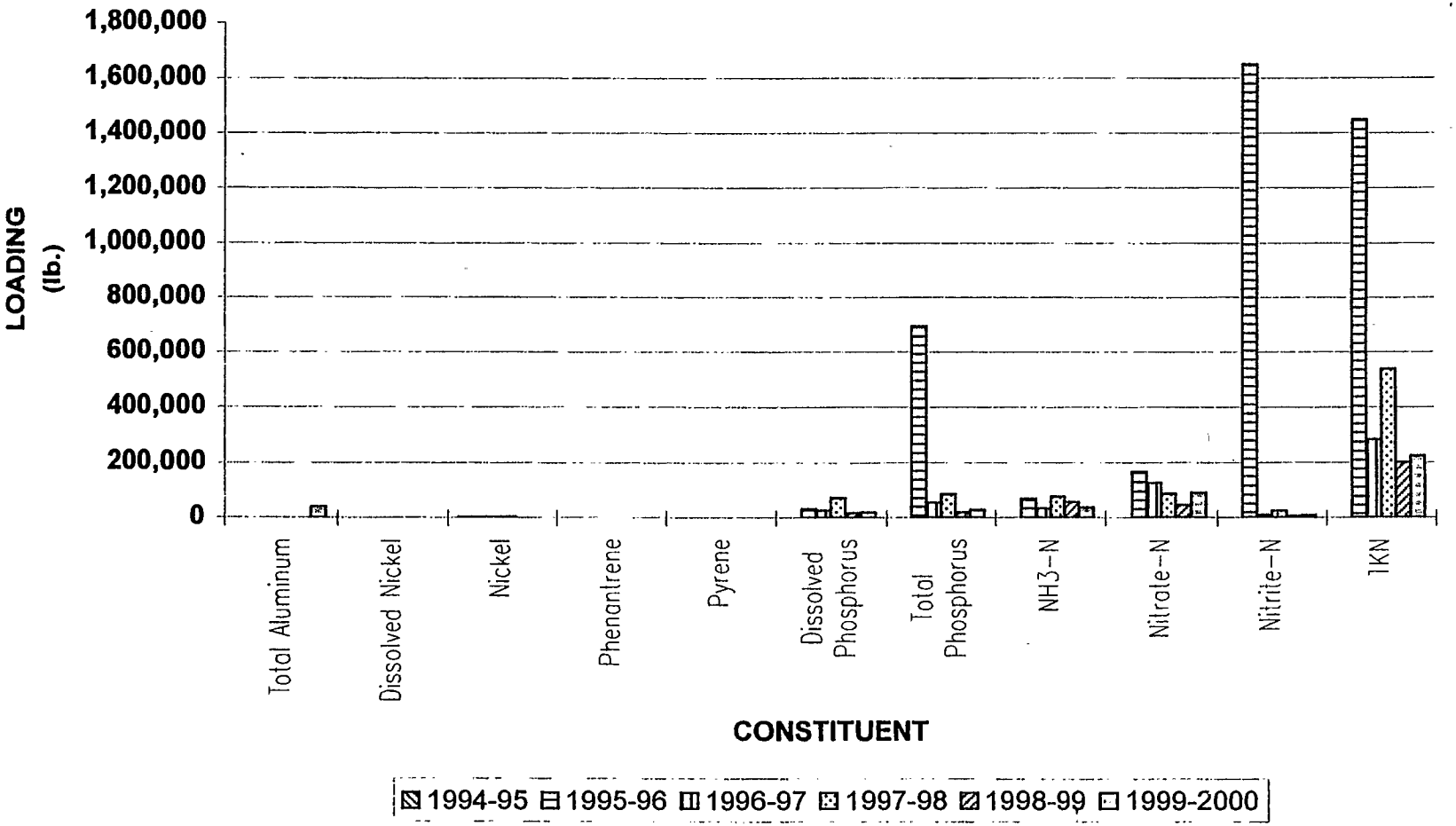
Figure 4-19. TOTAL MASS EMISSION LOADINGS DOMINGUEZ CHANNEL / L.A. HARBOR WMA



R0012168

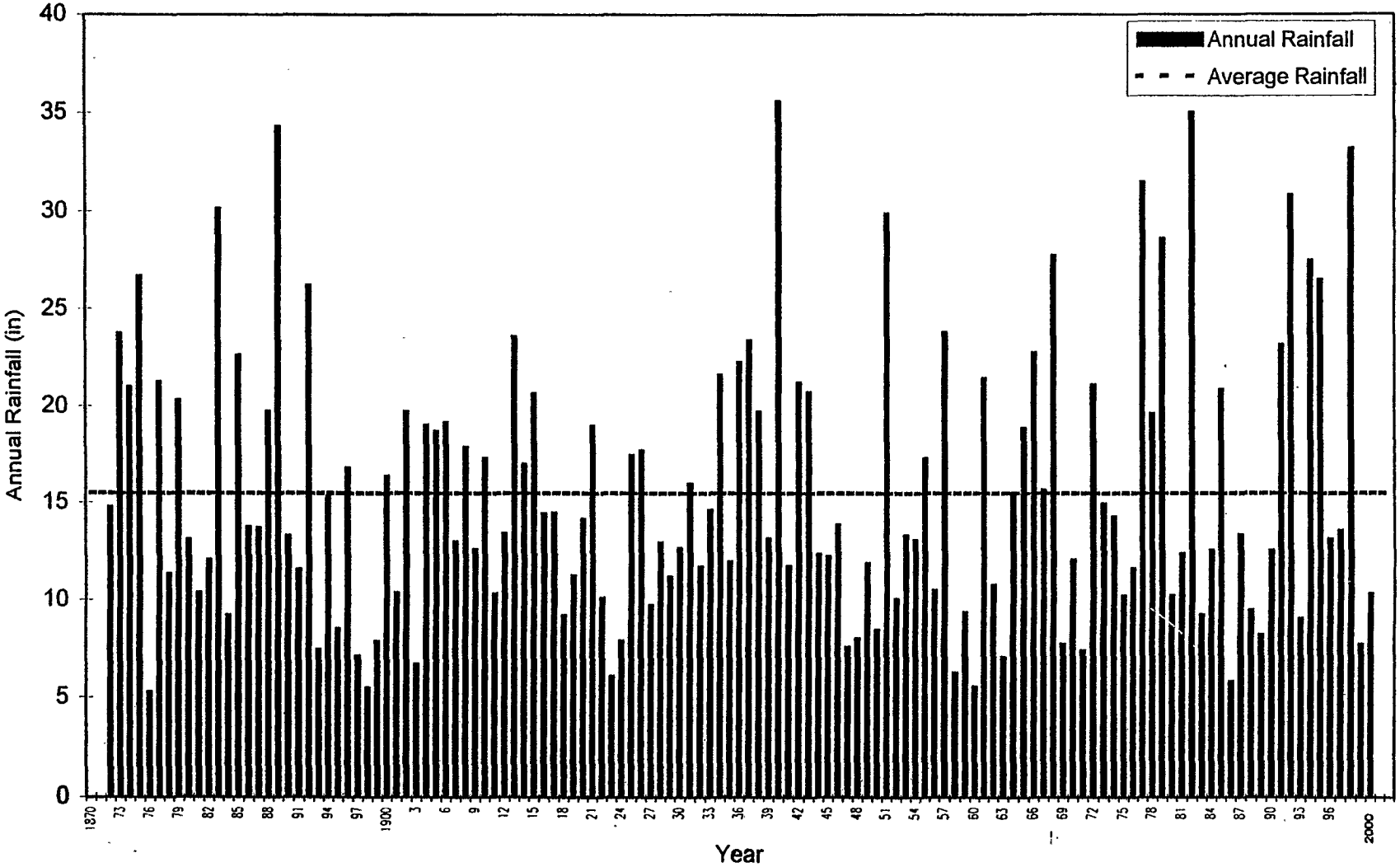
ee/tw Figure 4-19.xls

Figure 4-19. TOTAL MASS EMISSION LOADINGS DOMINGUEZ CHANNEL / L.A. HARBOR WMA (cont'd)



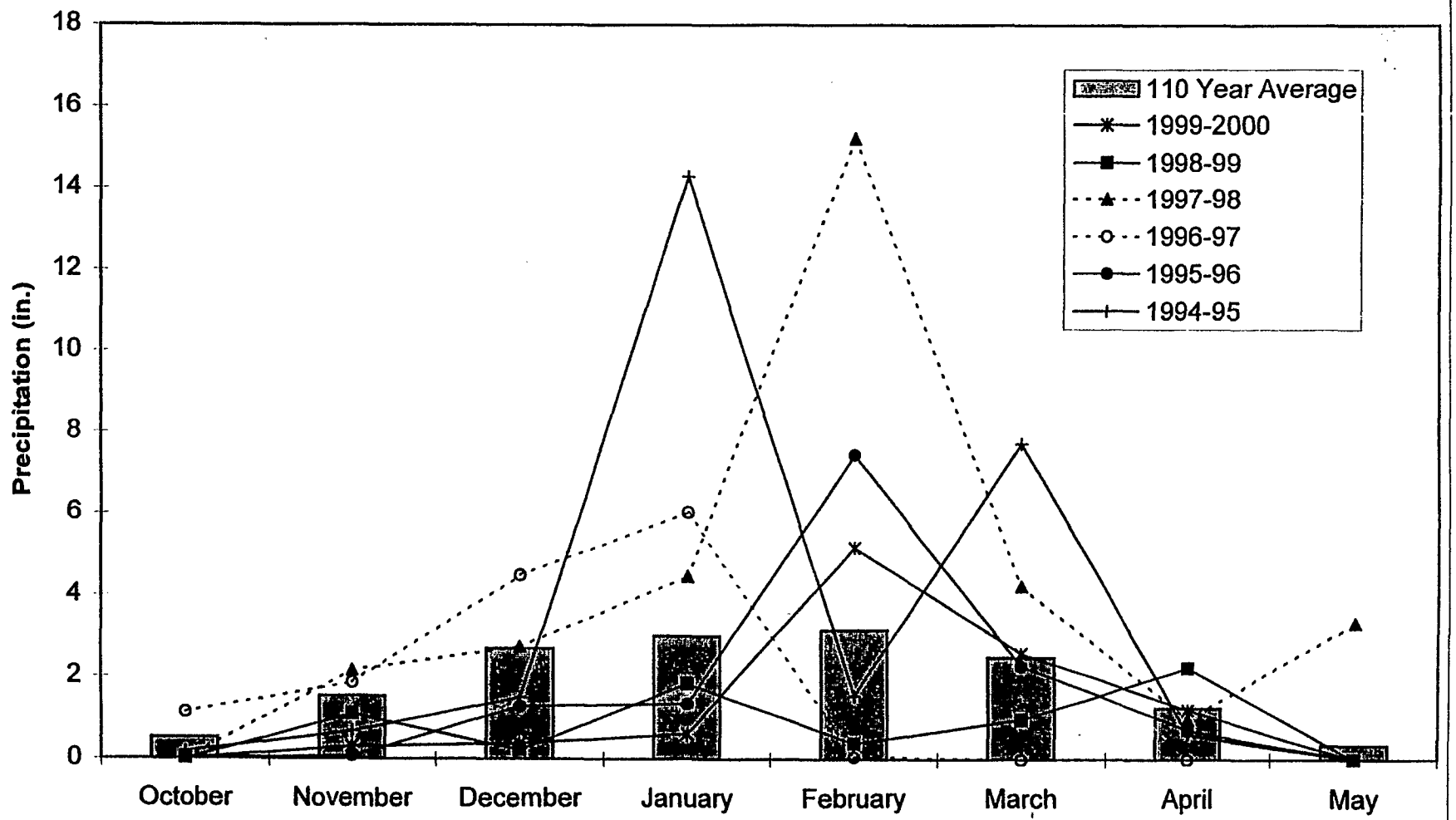
R0012169

Figure 4-20
Los Angeles Annual (Wet Season) Rainfall at Station #716, Ducommun St., Los Angeles



R0012170

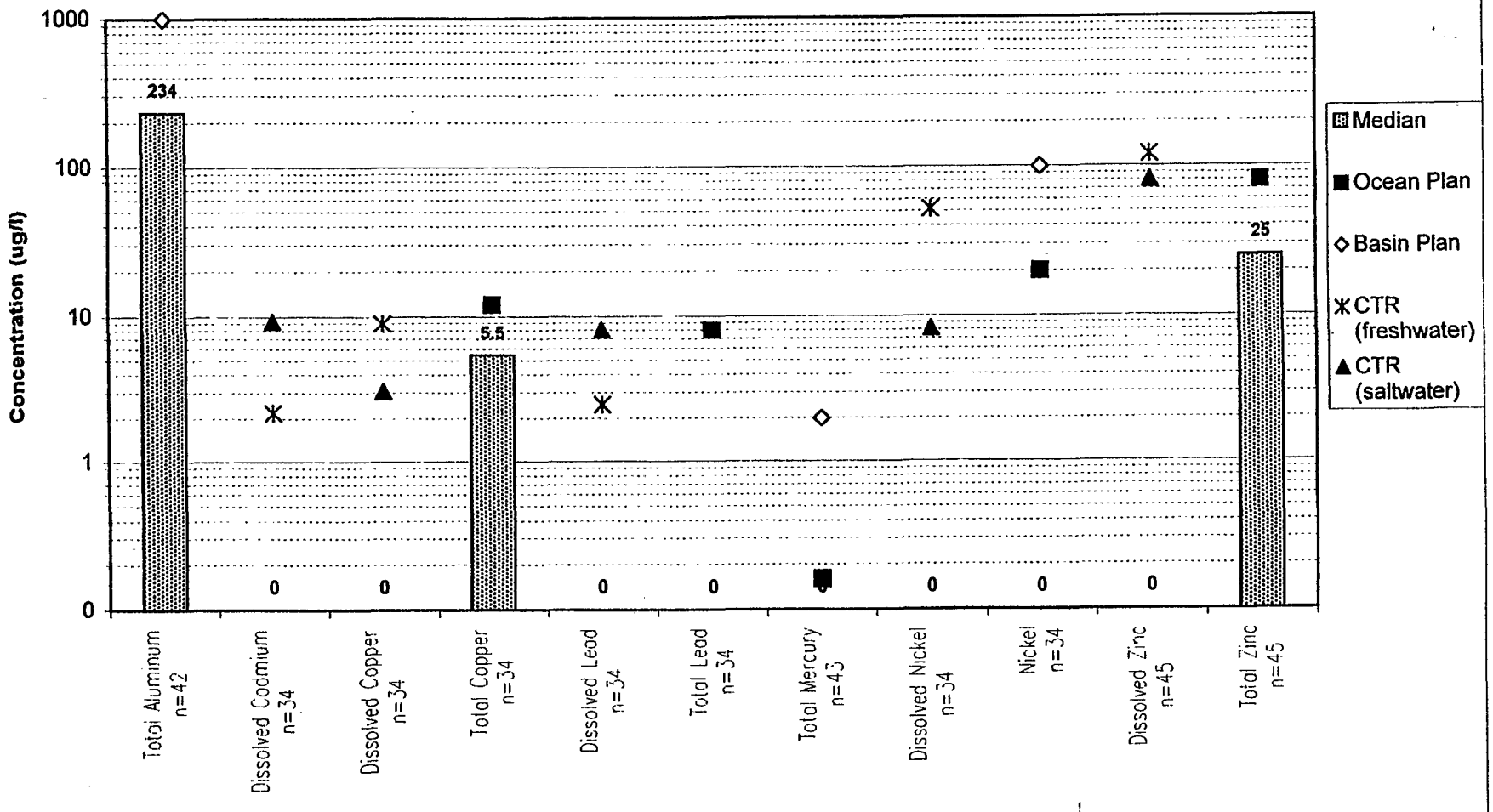
Figure 4-21
Historic Los Angeles Monthly Wet Season Rainfall at Station #716, Ducommun St., Los Angeles



R0012171

Figure 4-22a. LONG TERM MEDIAN CONCENTRATIONS
VACANT LAND USE
METALS

NOTE THE Y AXIS IS LOGARITHMIC

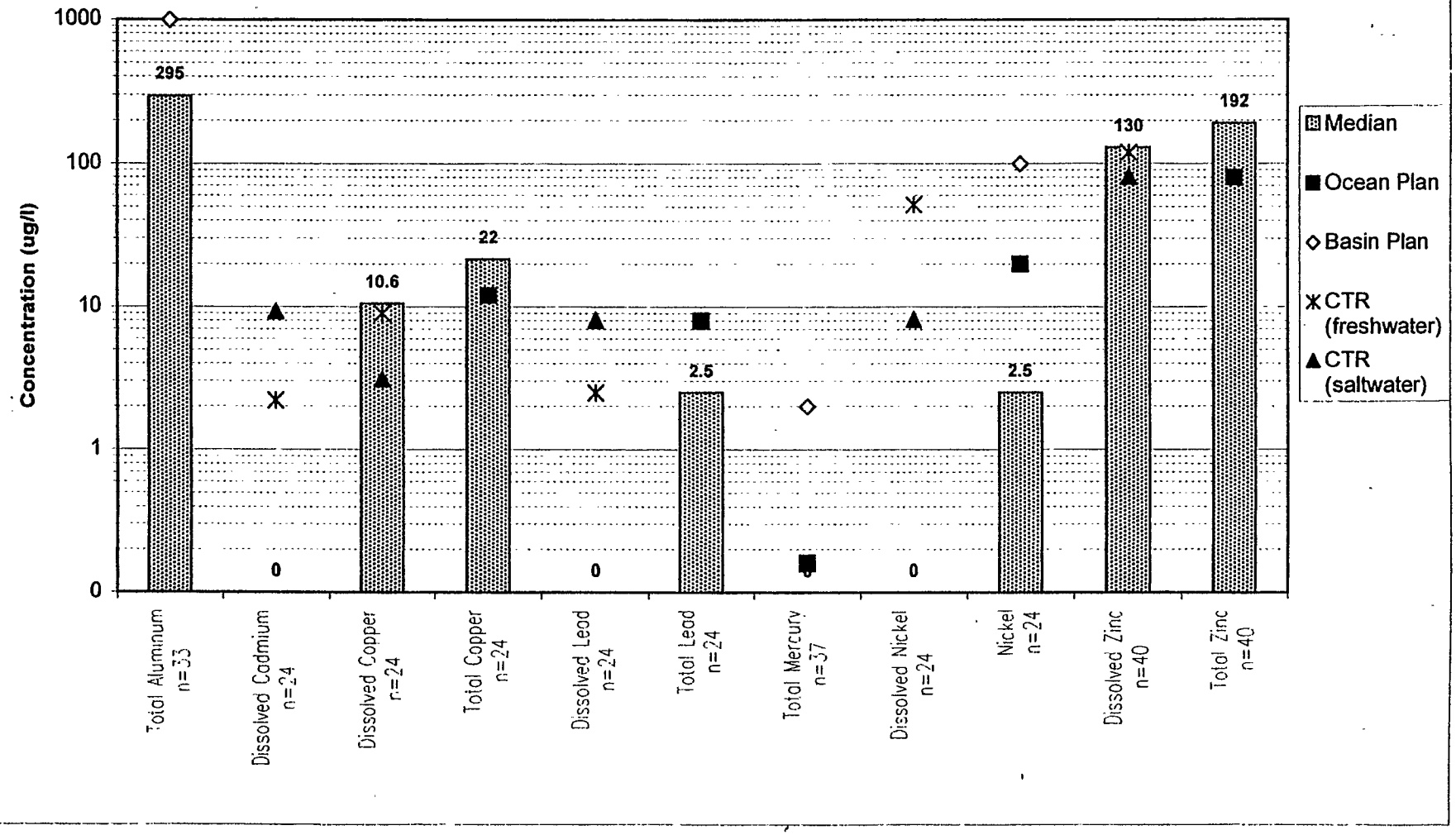


R0012172

LUmetalFigs.xls

Figure 4-22b. LONG TERM MEDIAN CONCENTRATIONS COMMERCIAL LAND USE METALS

NOTE THE Y AXIS IS LOGARITHMIC

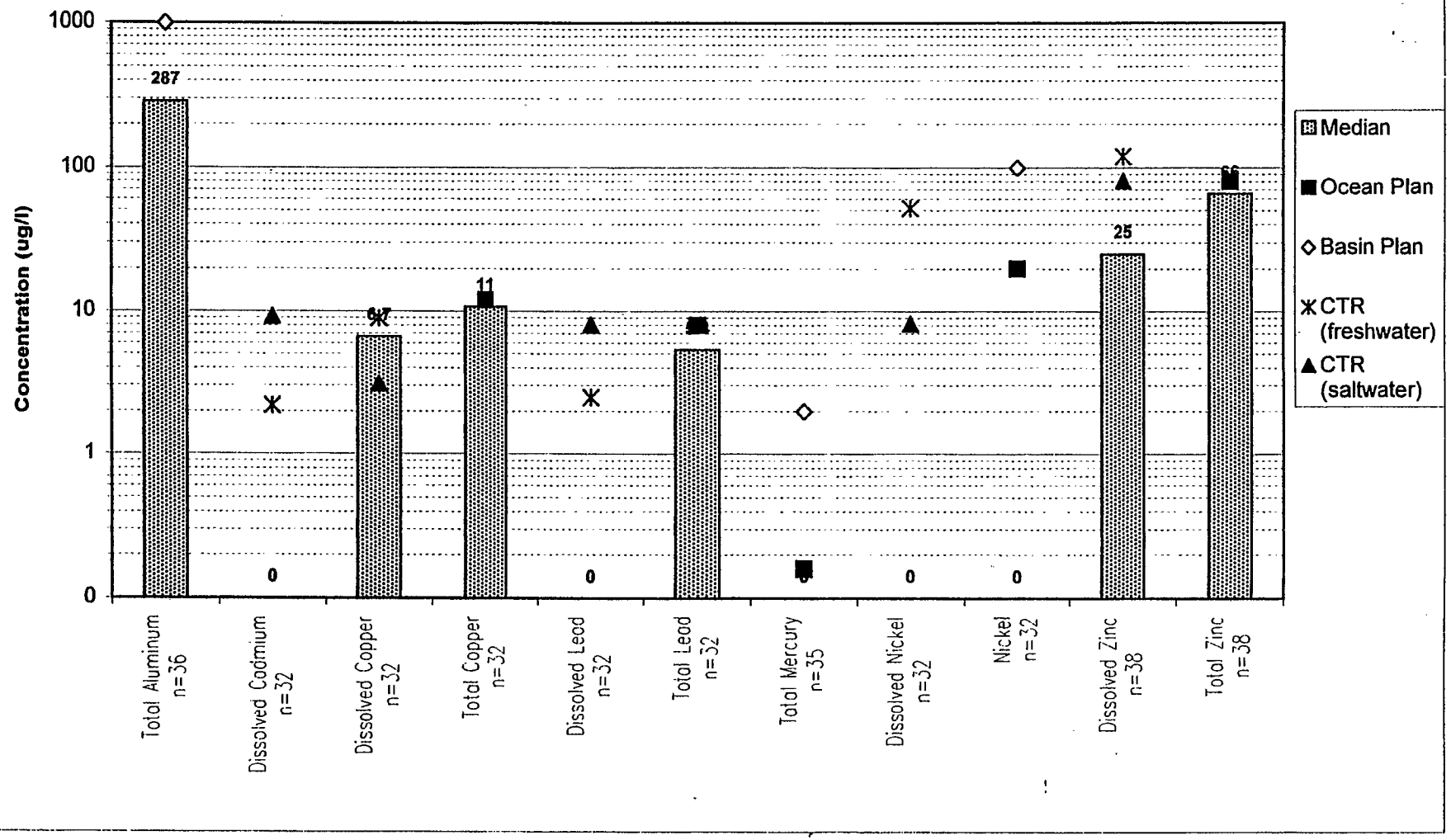


R0012173

LUmetalFigs.xls

Figure 4-22c. LONG TERM MEDIAN CONCENTRATIONS HIGH DENSITY SINGLE FAMILY RESIDENTIAL LAND USE METALS

NOTE THE Y AXIS IS LOGARITHMIC

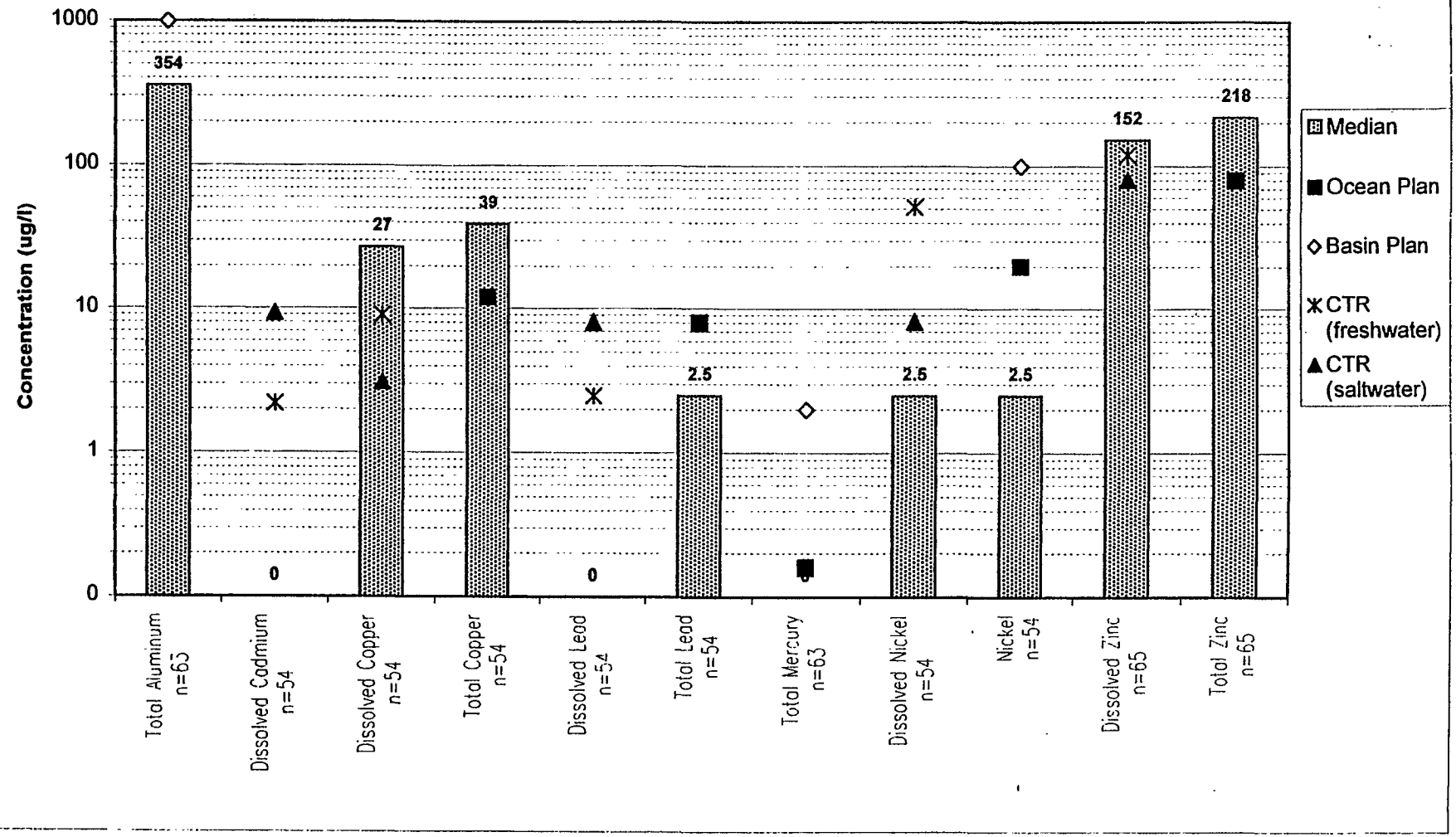


R0012174

LUmetalFigs.xls

Figure 4-22d. LONG TERM MEDIAN CONCENTRATIONS TRANSPORTATION LAND USE METALS

NOTE THE Y AXIS IS LOGARITHMIC

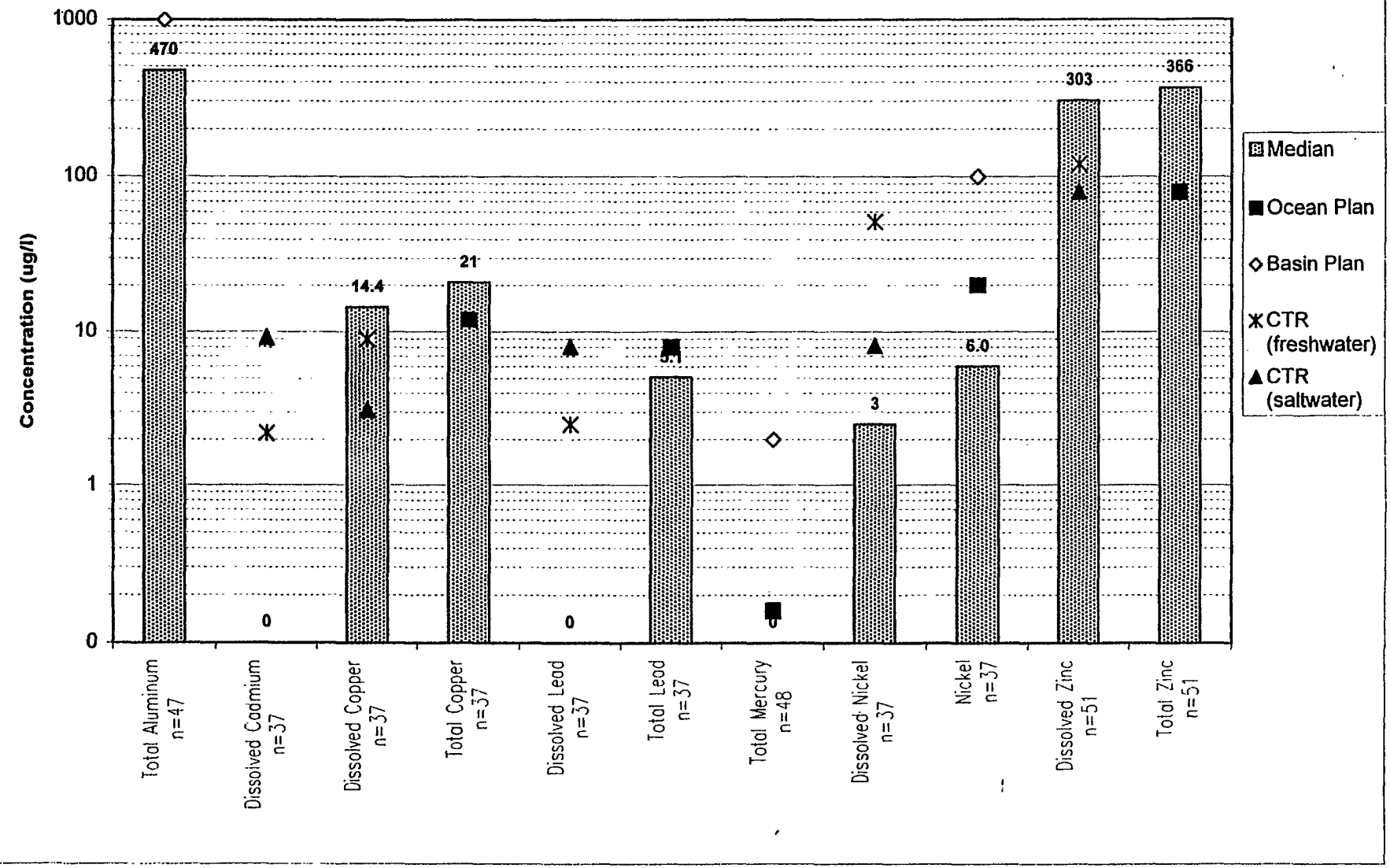


R0012175

LUmetalFigs.xls

Figure 4-22e. LONG TERM MEDIAN CONCENTRATIONS
LIGHT INDUSTRIAL LAND USE
METALS

NOTE THE Y AXIS IS LOGARITHMIC

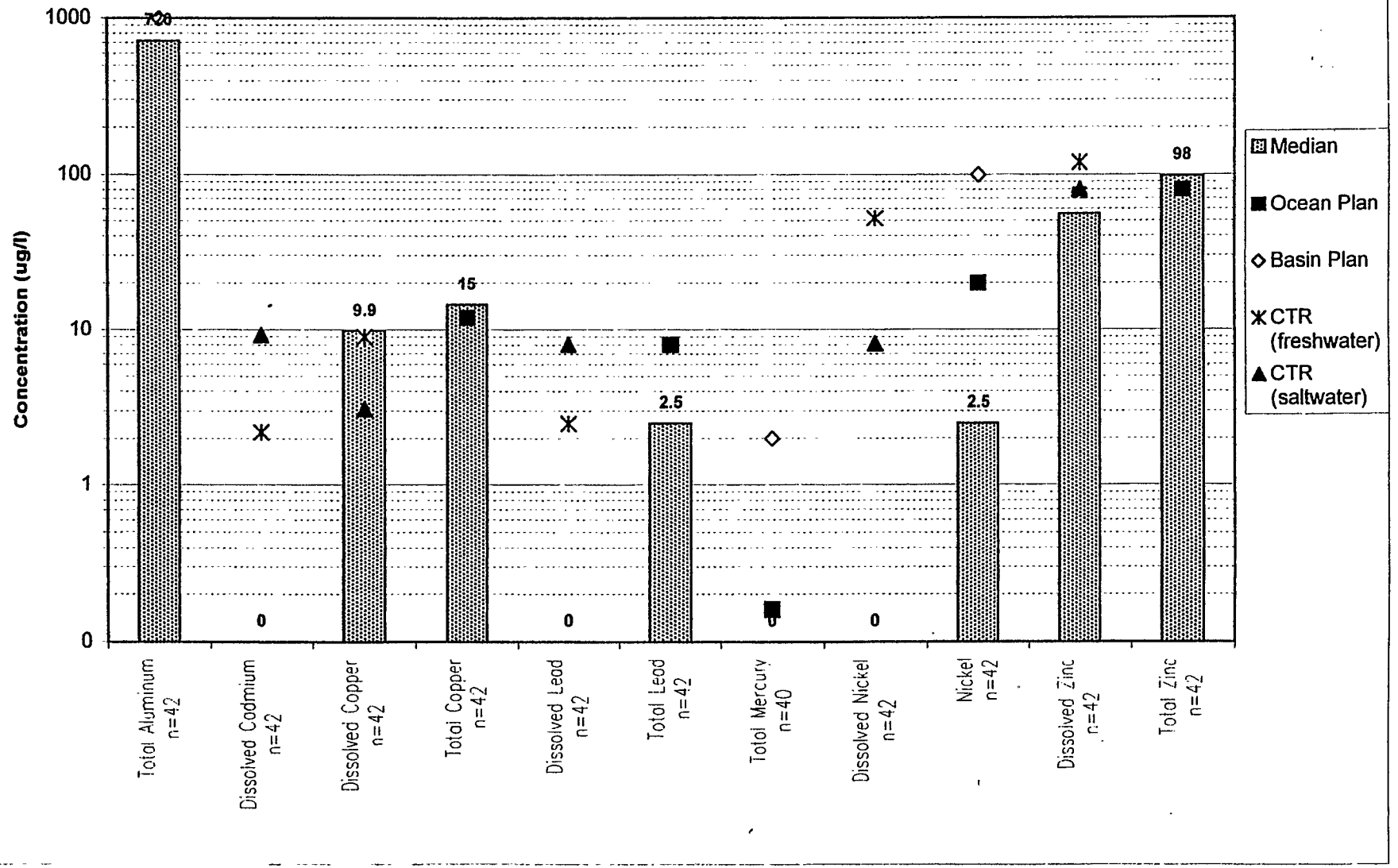


LUmetalFigs.xls

R0012176

Figure 4-22f. LONG TERM MEDIAN CONCENTRATIONS
EDUCATIONAL LAND USE
METALS

NOTE THE Y AXIS IS LOGARITHMIC



R0012177

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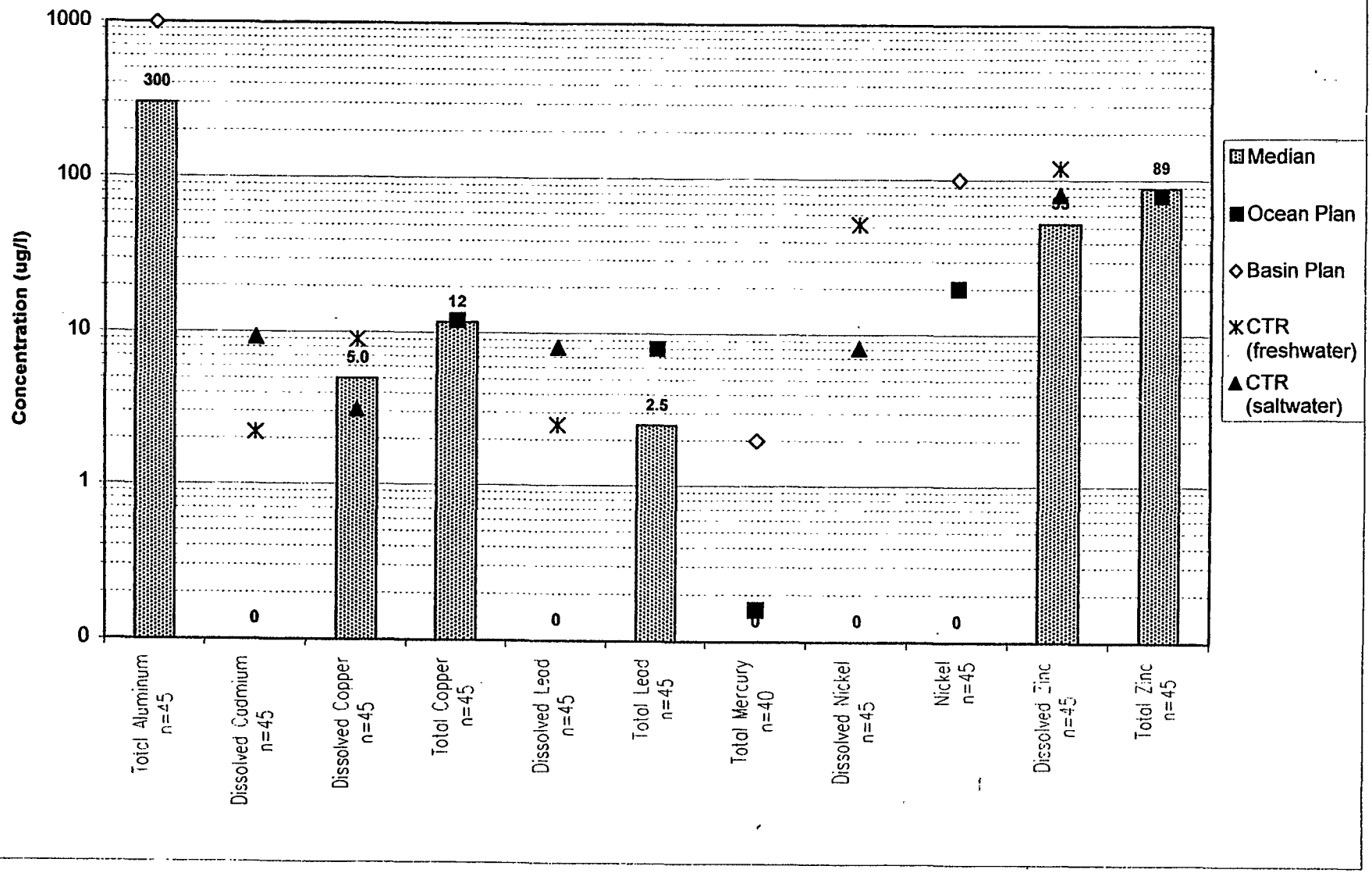
Figure 4-22g. LONG TERM MEDIAN CONCENTRATIONS MULTIFAMILY RESIDENTIAL USE METALS

NOTE THE Y AXIS IS LOGARITHMIC



LUmetalFigs.xls

R0012178

Figure 4-22h. LONG TERM MEDIAN CONCENTRATIONS MIXED RESIDENTIAL USE METALS

NOTE THE Y AXIS IS LOGARITHMIC

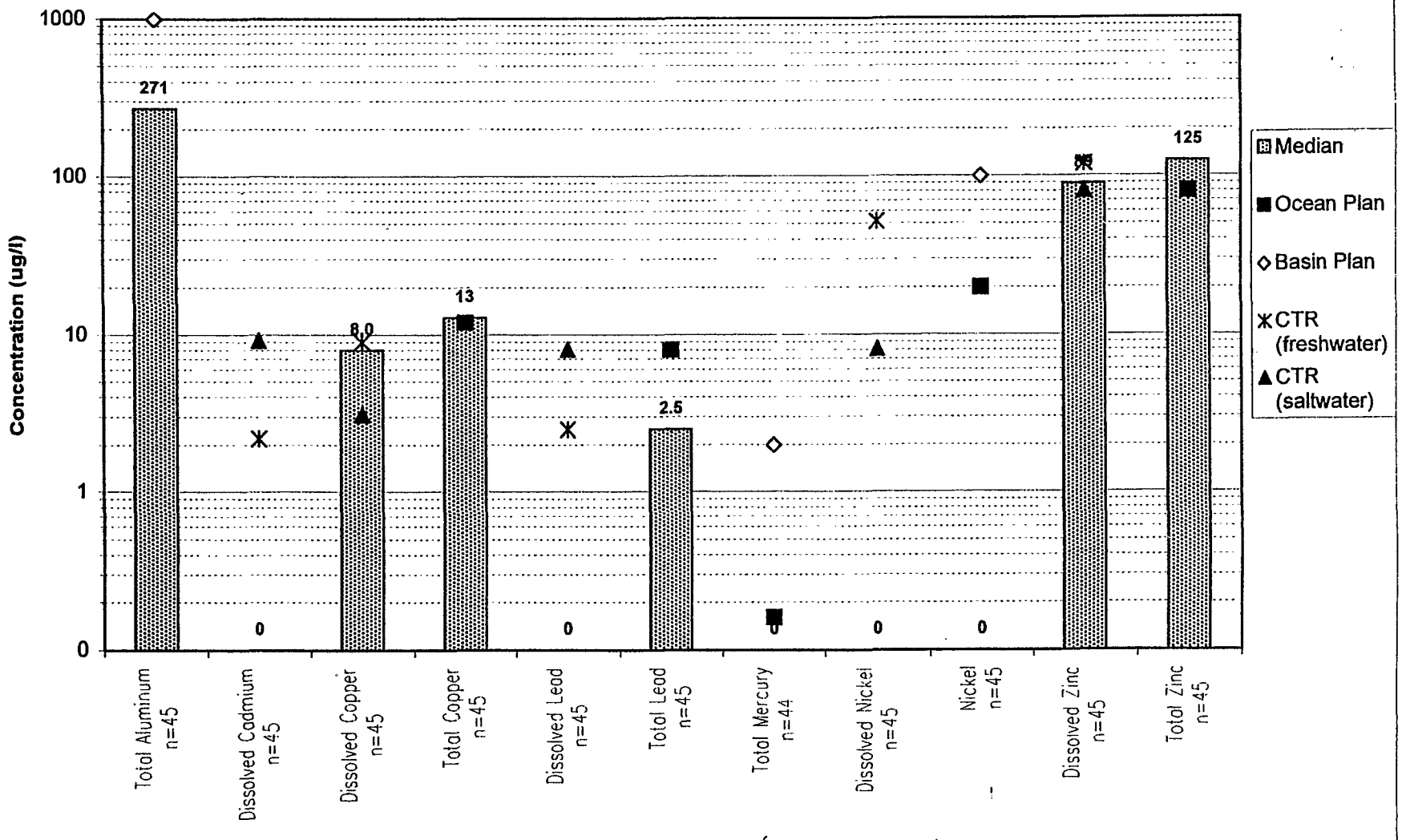


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Figure 4-23a. LONG TERM MEDIAN CONCENTRATIONS
VACANT LAND USE
NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC

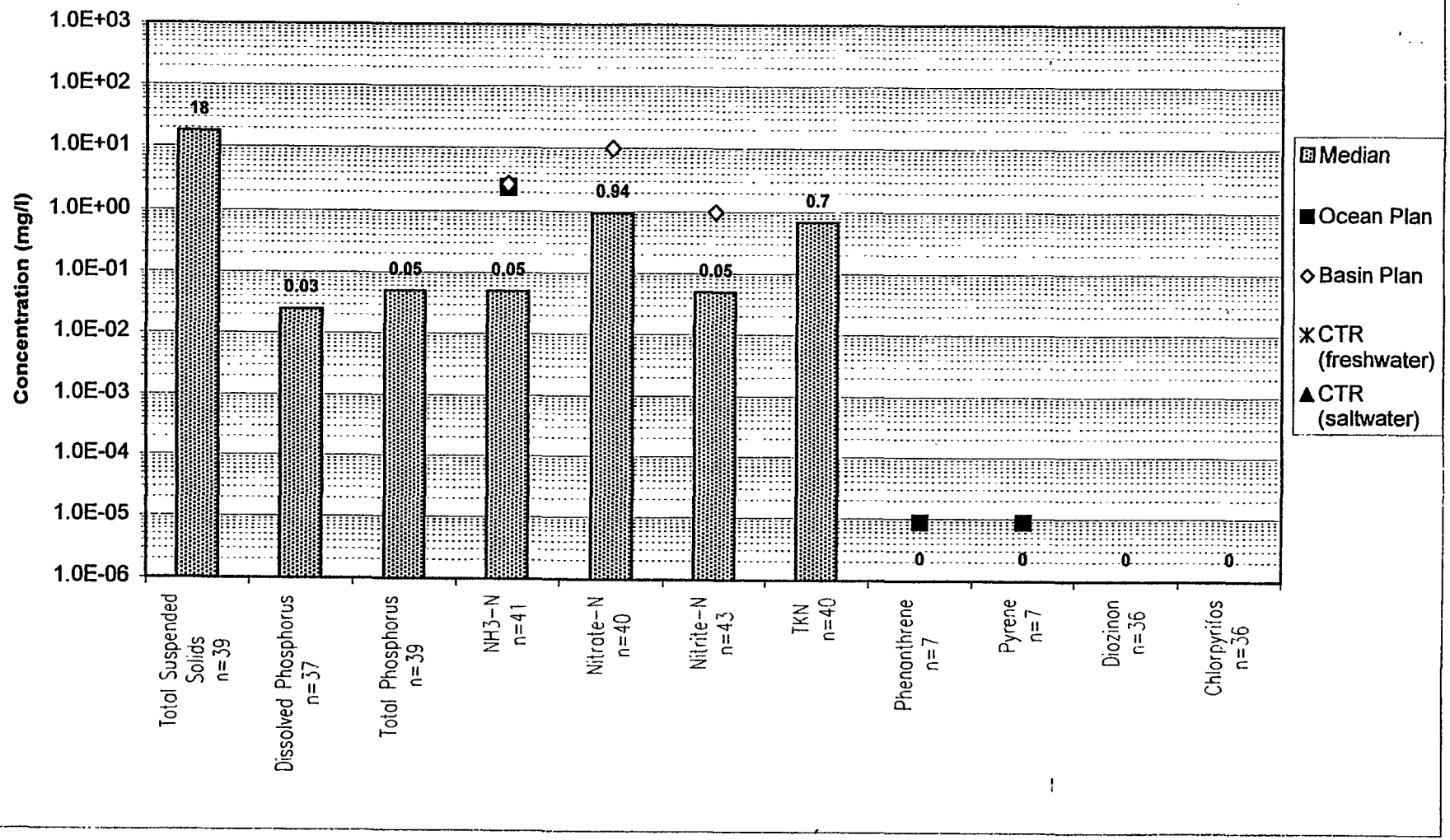

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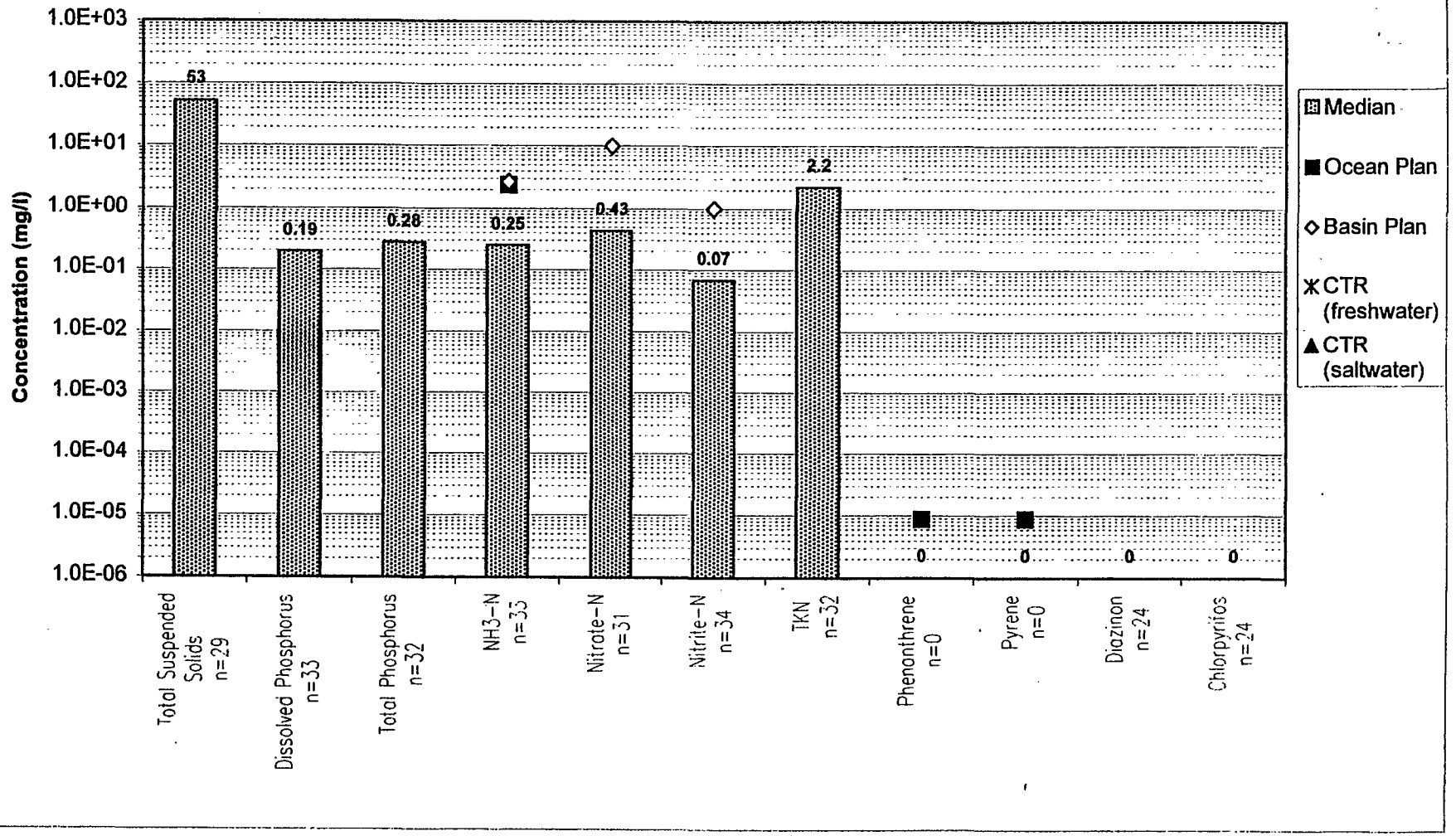
Figure 4-23b. LONG TERM MEDIAN CONCENTRATIONS
COMMERCIAL LAND USE
NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC

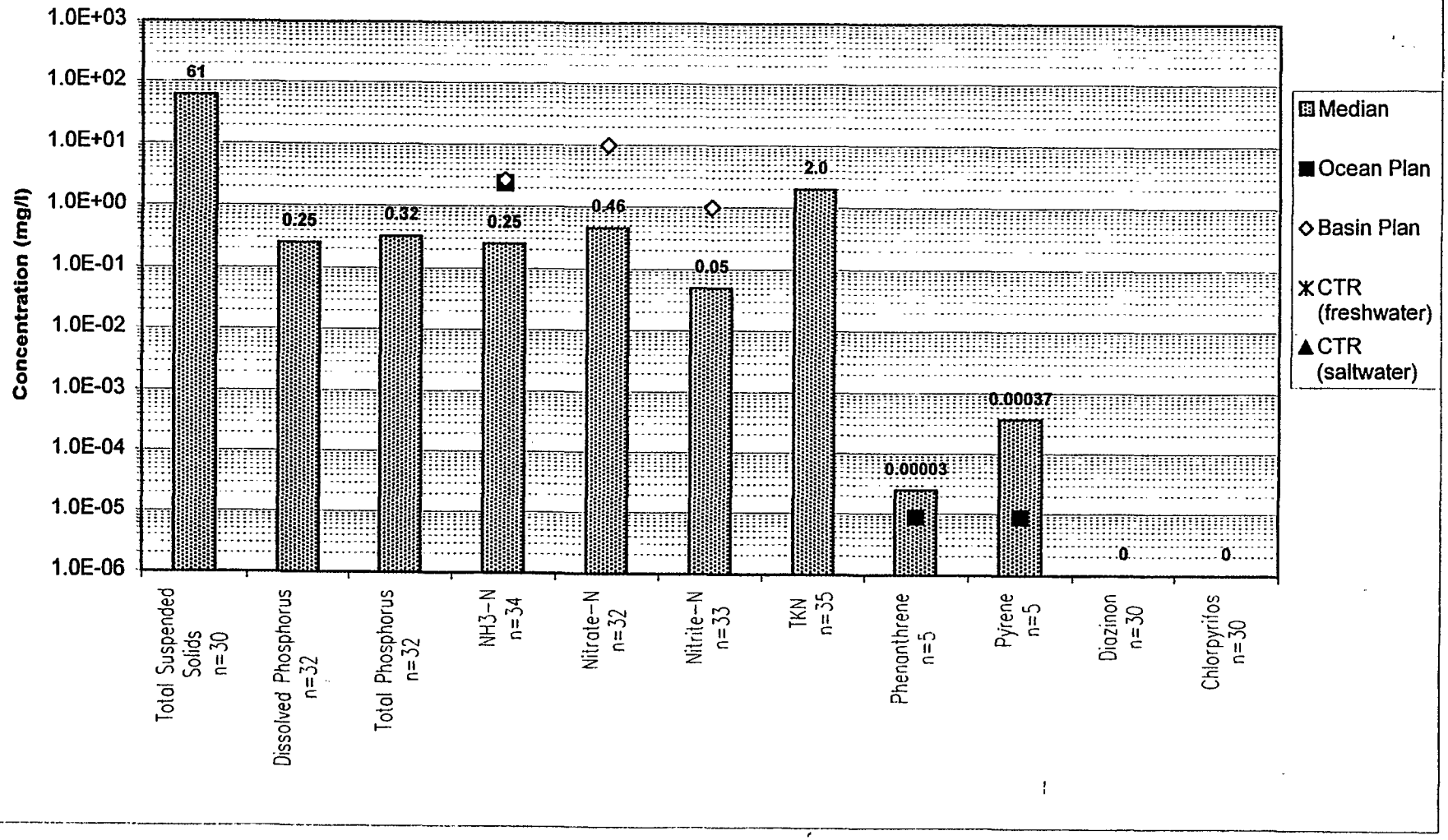


R0012181

LUotherFigs.xls

Figure 4-23c. LONG TERM MEDIAN CONCENTRATIONS HIGH DENSITY SINGLE FAMILY RESIDENTIAL LAND USE NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC



R0012182

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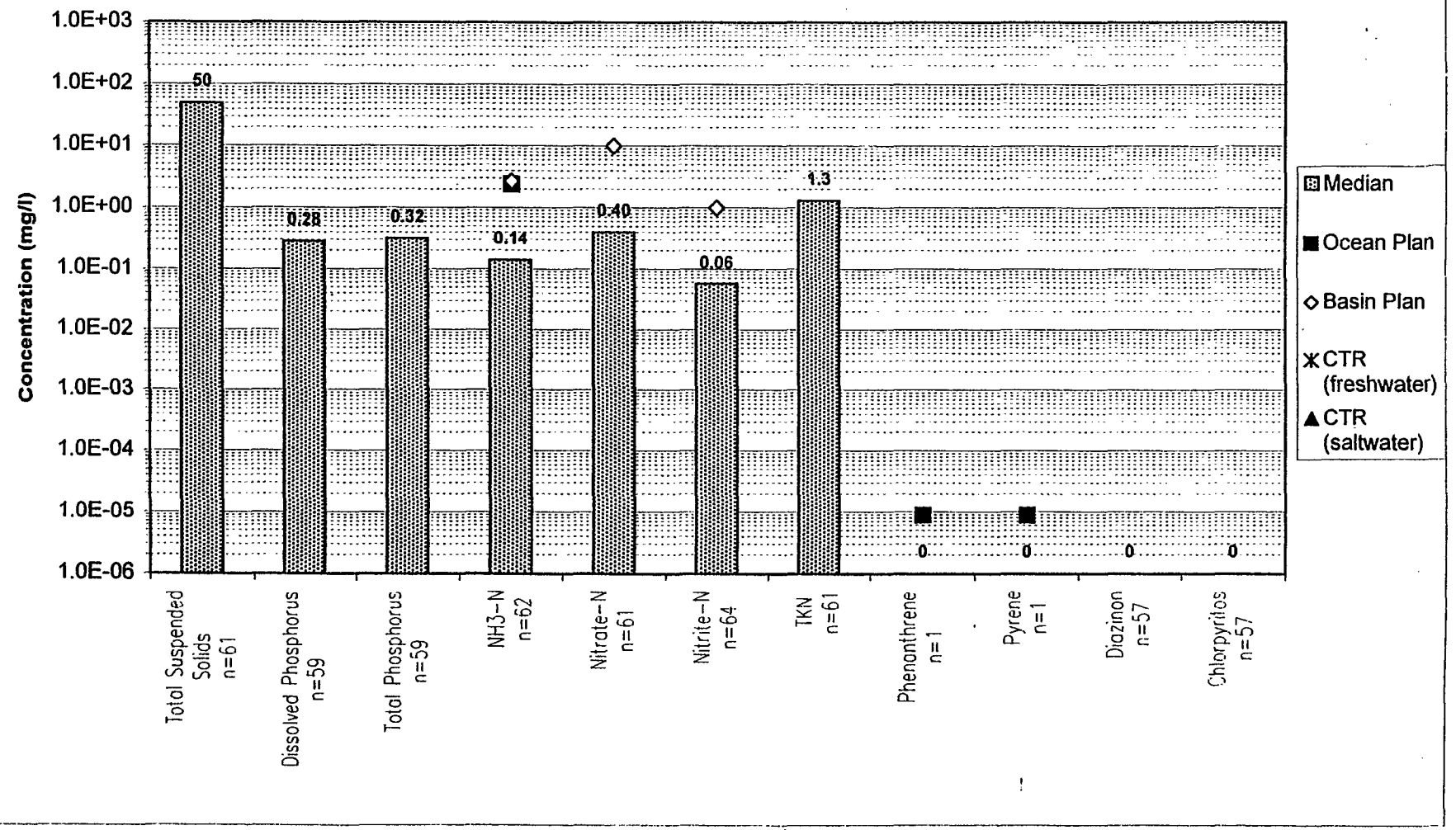
Figure 4-23d. LONG TERM MEDIAN CONCENTRATIONS TRANSPORTATION LAND USE NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC

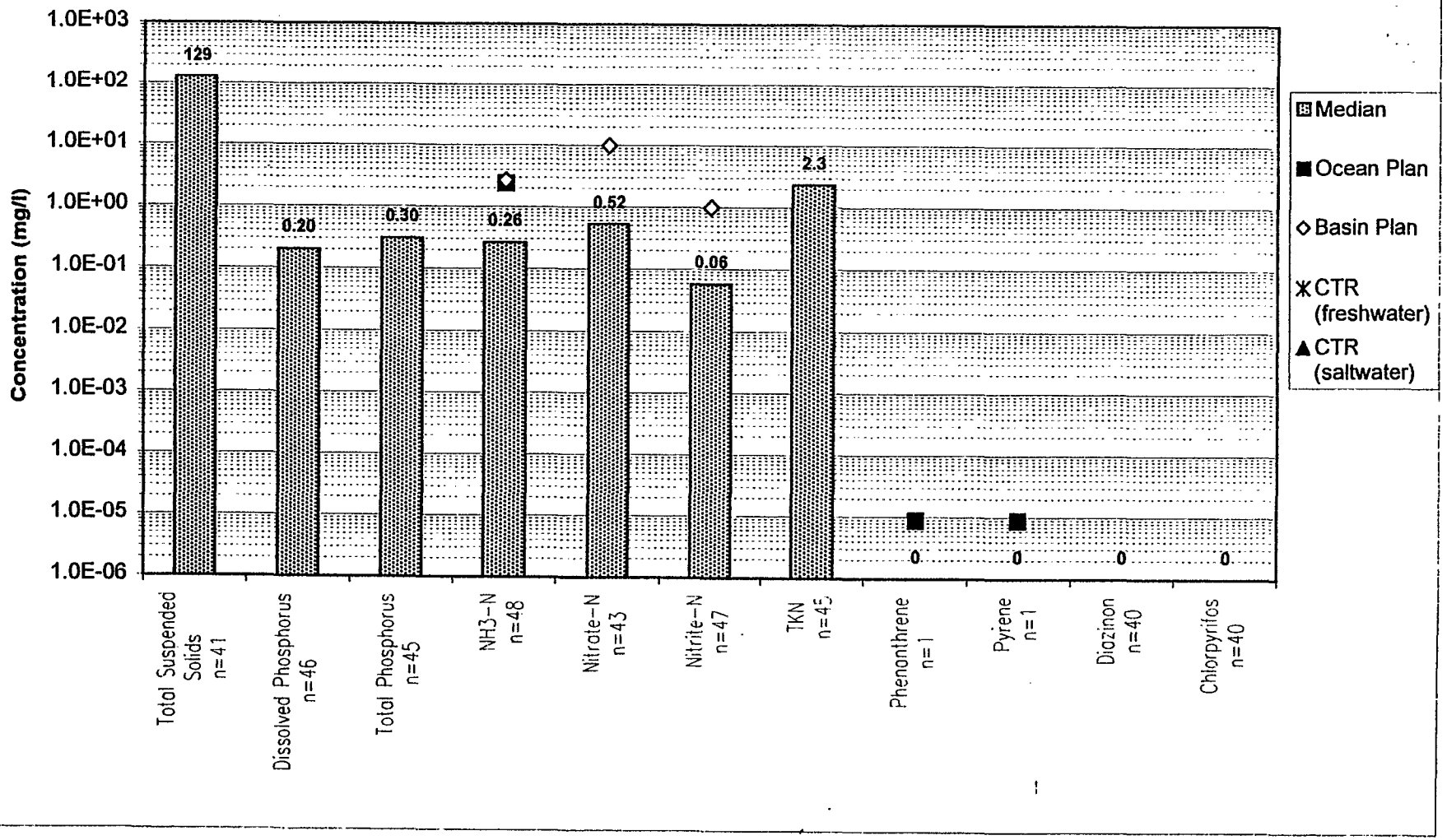


R0012183

LUotherFigs.xls

Figure 4-23e. LONG TERM MEDIAN CONCENTRATIONS
LIGHT INDUSTRIAL LAND USE
NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC



R0012184

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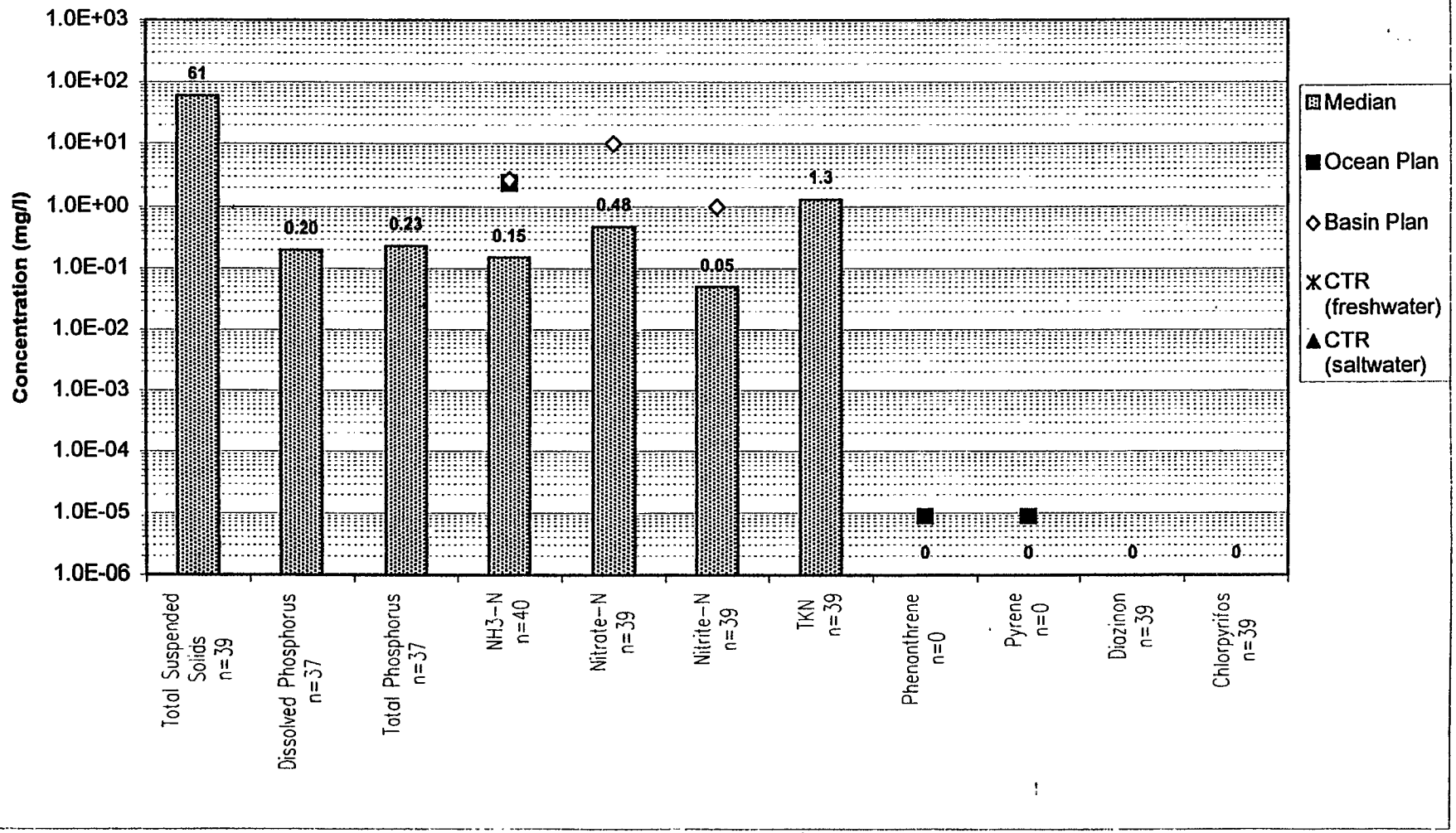
Figure 4-23f. LONG TERM MEDIAN CONCENTRATIONS
EDUCATIONAL LAND USE
NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC



R0012185

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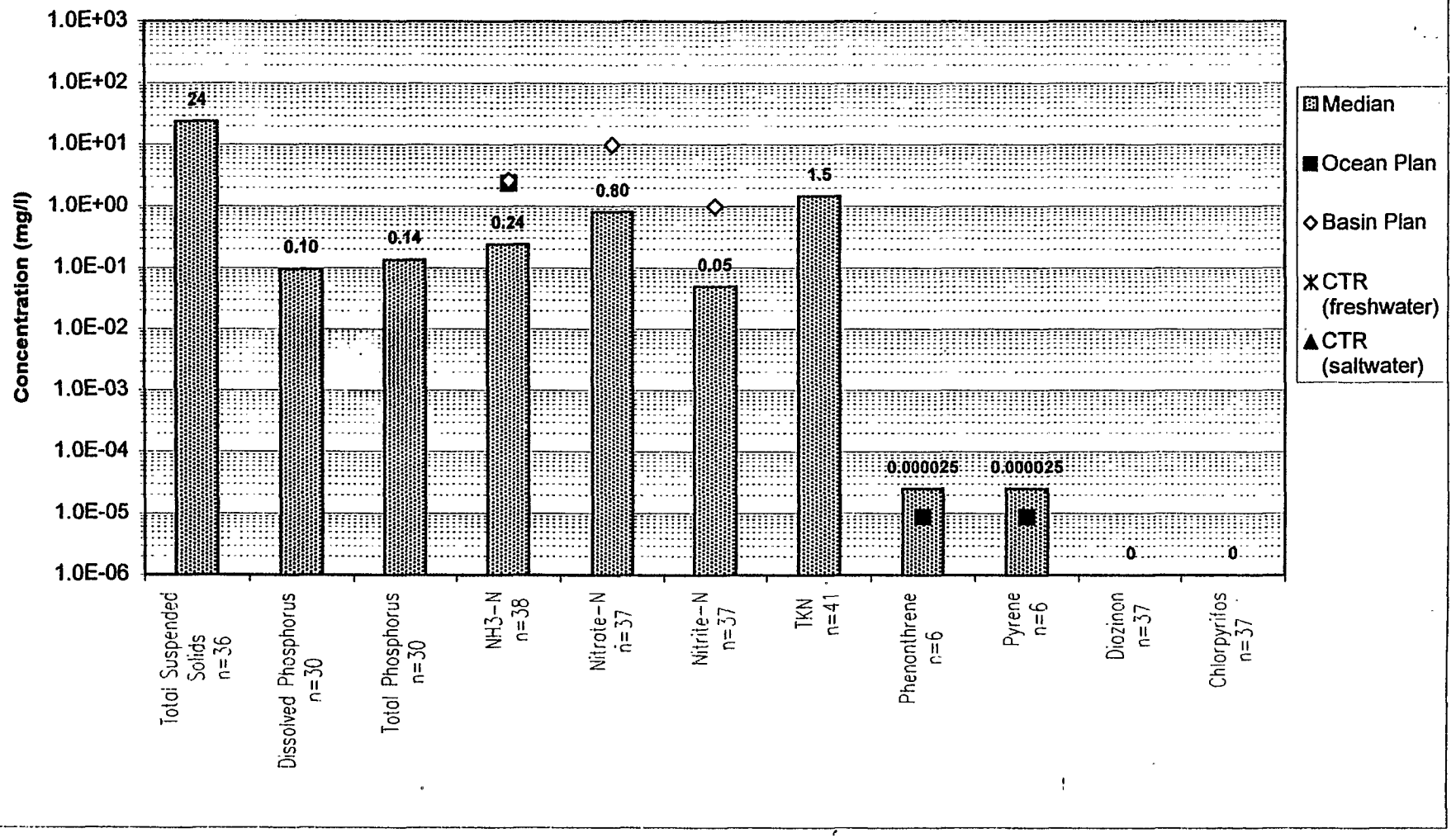
Figure 4-23g. LONG TERM MEDIAN CONCENTRATIONS MULTIFAMILY RESIDENTIAL LAND USE NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC

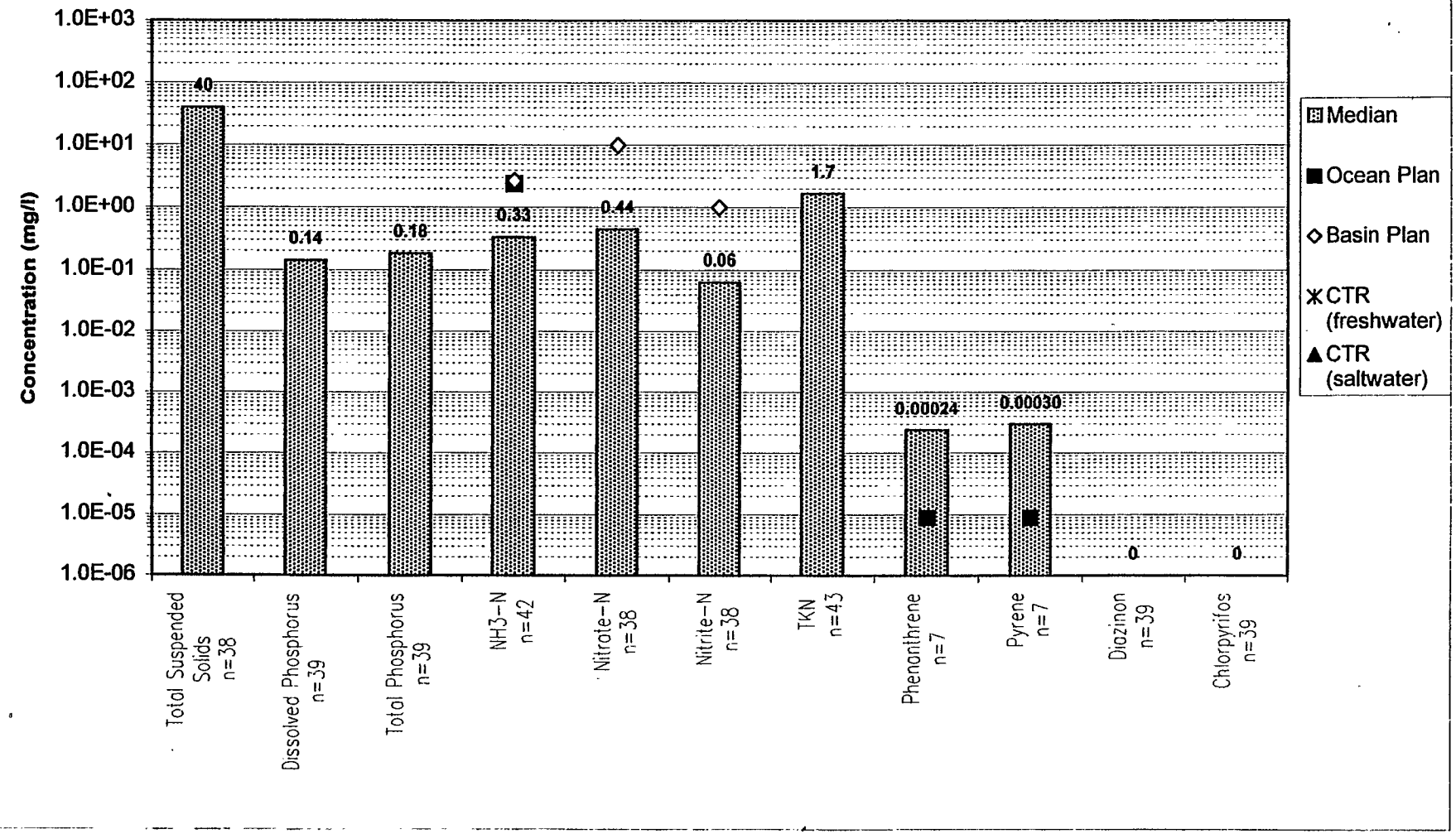


R0012186

LUotherFigs.xls

Figure 4-23h. LONG TERM MEDIAN CONCENTRATIONS
MIXED RESIDENTIAL LAND USE
NON-METALS

NOTE THE Y AXIS IS LOGARITHMIC

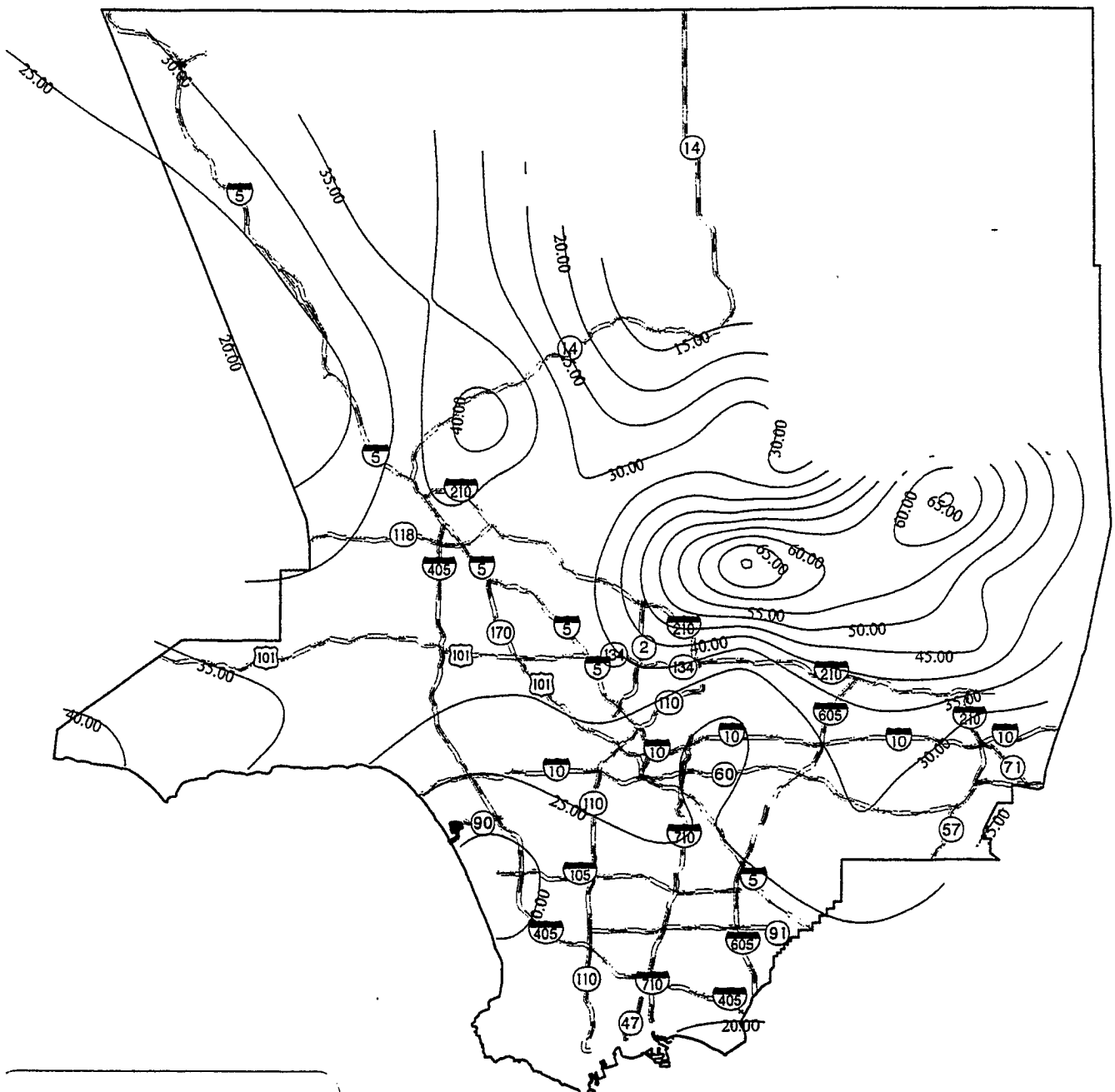


R0012187

LUotherFigs.xls

Appendix A
Rainfall Contour Maps

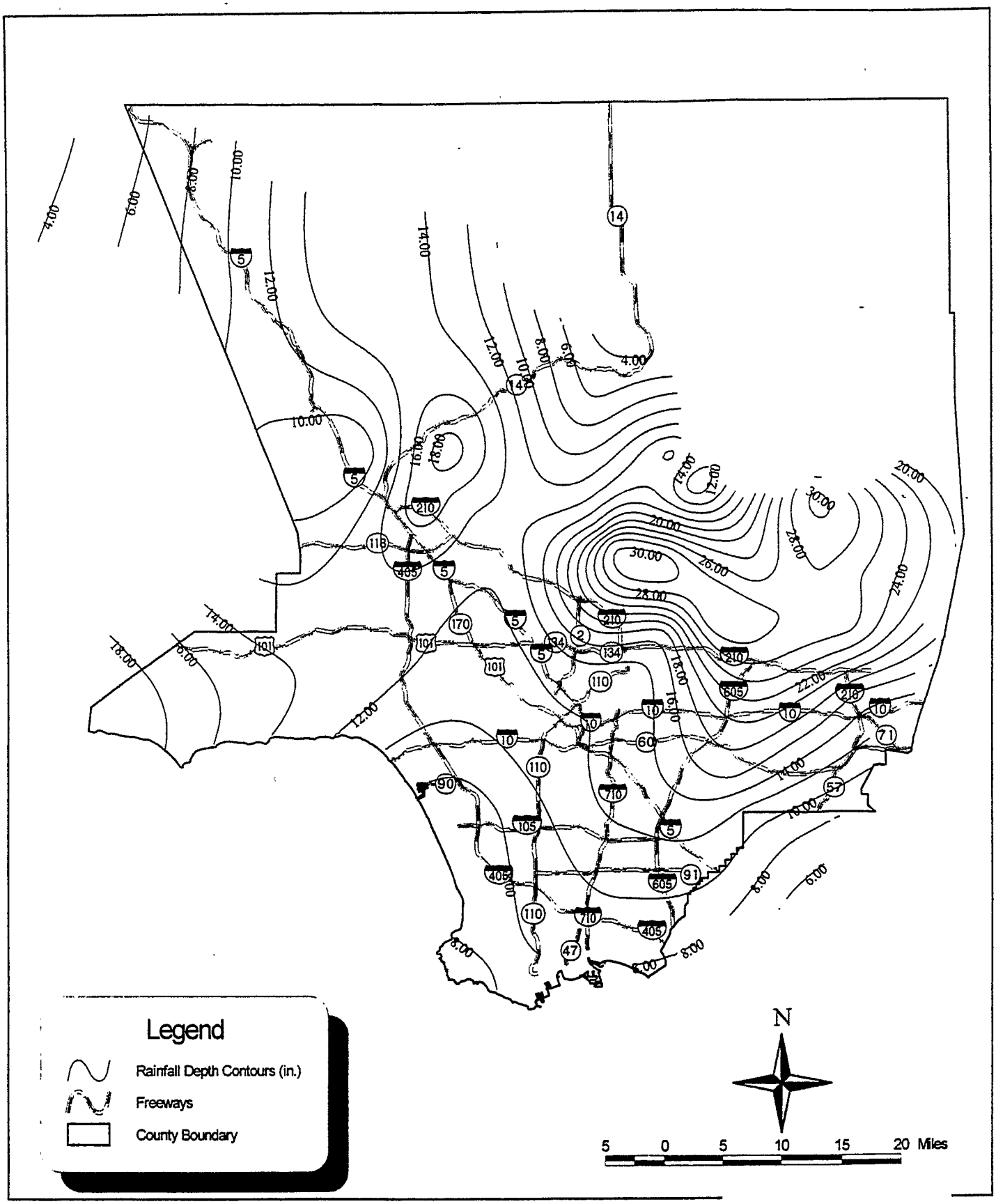
TOTAL RAINFALL CONTOURS
1994-1995 STORM SEASON



STORM EVENT DATE: 1994-1995 Storm Season RUN DATE: 07/12/2000

R0012189

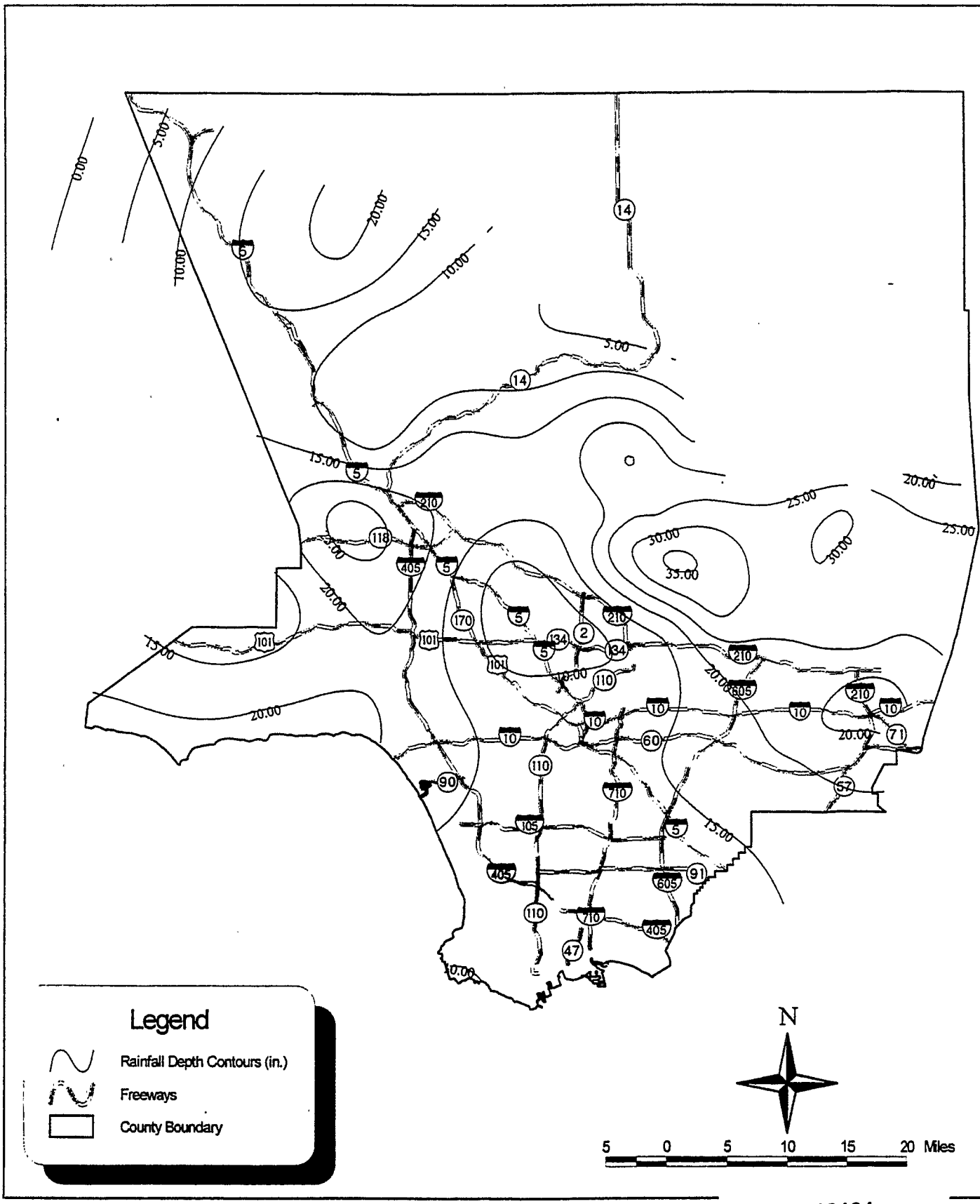
TOTAL RAINFALL CONTOURS
1995-1996 STORM SEASON



STORM EVENT DATE: 1995-1996 Storm Season RUN DATE: 07/12/2000

R0012190

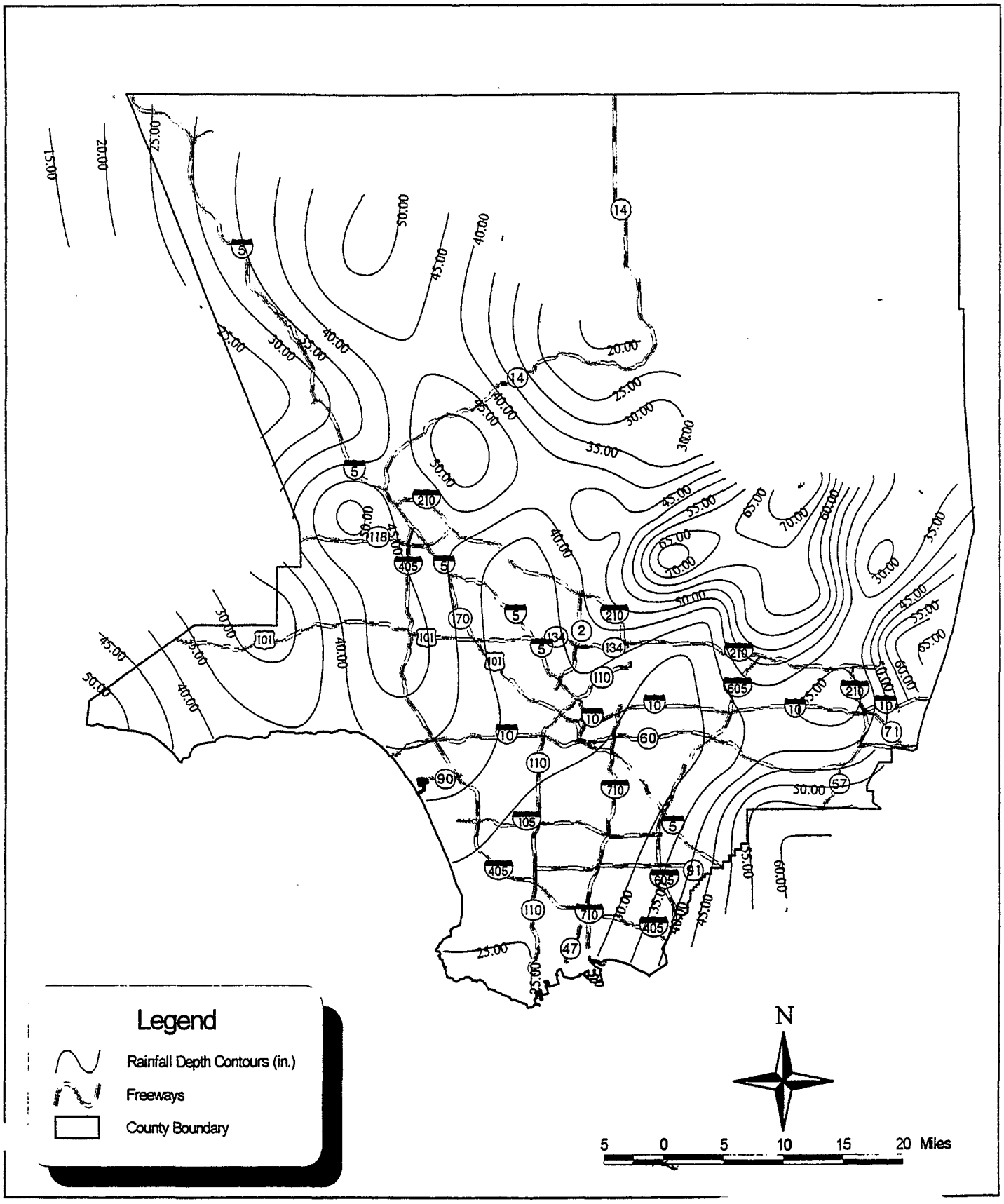
TOTAL RAINFALL CONTOURS
1996-1997 STORM SEASON



STORM EVENT DATE: 1996-1997 Storm Season RUN DATE: 07/12/2000

R0012191

TOTAL RAINFALL CONTOURS
1997-1998 STORM SEASON



STORM EVENT DATE: 1997-1998 Storm Season RUN DATE: 07/12/2000

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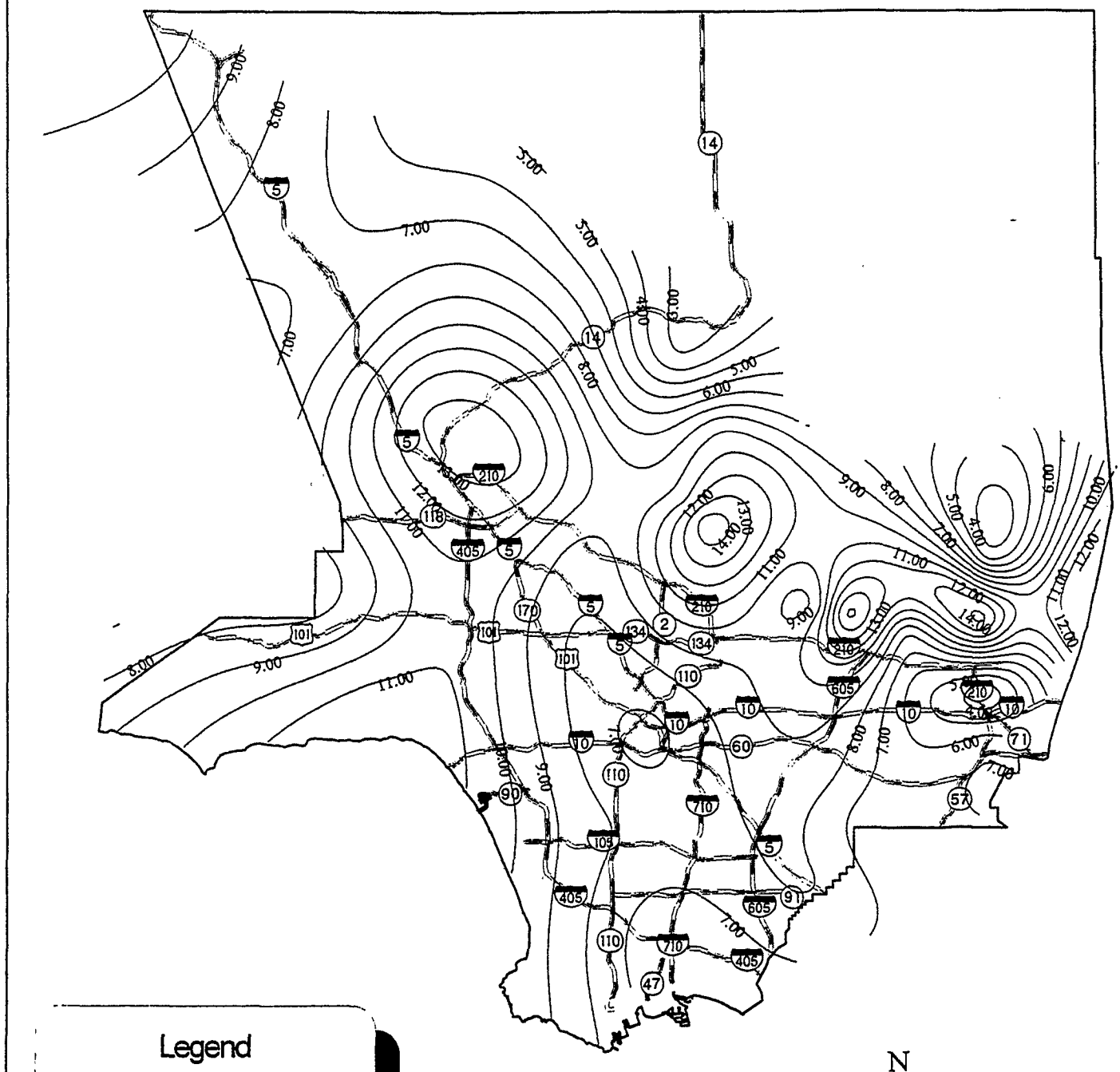
TOTAL RAINFALL CONTOURS
1998-1999 STORM SEASON



STORM EVENT DATE: 1998-1999 Storm Season RUN DATE: 07/12/2000

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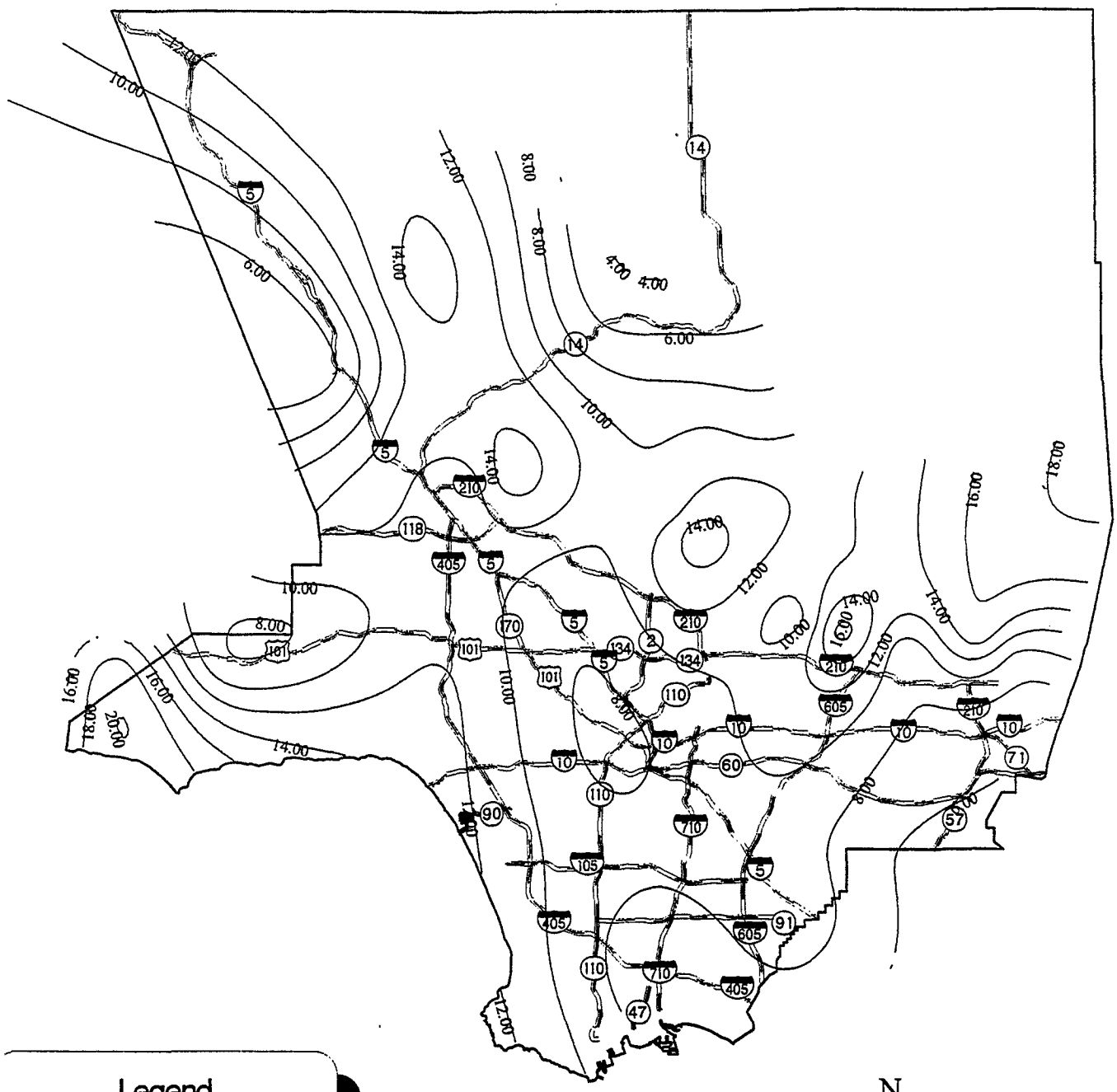
TOTAL RAINFALL CONTOURS
1999-2000 STORM SEASON



STORM EVENT DATE: 1999-2000 Storm Season RUN DATE: 07/25/2000

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Appendix B
Monitoring Costs

LACDPW WATER QUALITY MONITORING COSTS 1990 Permit Totals								
Element	No. of Sites	No. of Events	Capital	Sampling Labor	Materials	Station Maintenance	Laboratory	TOTAL
Mass Emissions	9	31	$540,000	$80,010	$37,373	$161,939	$115,476	$934,798
Land Use	15	18	$900,000	$133,350	$67,601	$354,226	$97,126	$1,552,303
Corporate Yd. (MD3)	1	5	N/A	$381	N/A	N/A	$55,682	$56,063
TOTAL	25	54	$1,440,000	$213,741	$104,974	$516,165	$268,284	$2,543,164

LACDPW WATER QUALITY MONITORING COSTS 1996 Permit Totals as of: 07/20/00								
Element	No. of Sites	No. of Events*	Capital (not including 1990 permit costs, above)	Sampling Labor	Materials	Station Maintenance	Laboratory	TOTAL
Receiving Waters to Date	2	13	$628,500	N/A	N/A	N/A	N/A	$628,500
Mass Emissions to Date	5	50	$0	$91,487	$11,130	$49,733	$237,598	$389,948
Land Use to Date	8	67	$30,000	$134,258	$13,104	$77,214	$546,695	$801,271
Critical Source to Date	48	26	$33,293	$177,284	$5,510	N/A	$245,313	$461,400
River Toxicity to Date	2	6	N/A	$2,365	N/A	N/A	$7,200	$9,565
El Nino Study to Date	1	4	$48,735	$0	$0	$0	$0	$48,735
Aerial Deposition to Date	1	14	$75,000	N/A	N/A	N/A	N/A	$75,000
TOTAL TO DATE	67	180	$815,528	$405,394	$29,744	$126,947	$1,036,806	$2,414,419

N/A = Not Applicable

* Not every station collected every storm.

R0012196

Appendix C
Executive Summary of the Santa Monica Bay Receiving Waters Study by Southern California Coastal Waters Research Project

Study of the Impact of Stormwater Discharge on the Beneficial Uses of Santa Monica Bay

Executive Summary
July 8, 1999

Prepared for:

Los Angeles County Department
of Public Works
Alhambra, California

Submitted by:

Steven Bay
Southern California Coastal Water Research Project

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R0012198

ACKNOWLEDGMENTS

The authors wish to acknowledge the Los Angeles County Department of Public Works and the Natural Resources Defense Council who helped design the workplan, guide the study elements, and evaluate the results. We also acknowledge the expertise in sample collection and laboratory analysis provided by the following organizations: City of Los Angeles (R/V *Le Mer* and R/V *Marine Surveyor*), Southern California Ocean Studies Consortium (R/V *Sea Watch*), University of California Los Angeles (R/V *Sea World*), CRG Laboratories, Inc. (analytical chemistry), and MEC Analytical Systems, Inc. (benthic taxonomy). This project was funded by the Los Angeles County Department of Public Works, the University of Southern California Sea Grant, and the Southern California Coastal Water Research Project. The conclusions presented in this document are the views of the authors and do not necessarily represent positions of the Los Angeles County Department of Public Works, the Natural Resources Defense Council, or other collaborating agencies.

R0012199

INTRODUCTION

Stormwater runoff is widely believed to be one of the largest sources of contaminants to coastal waters.

Urban stormwater runoff is now regarded as one of the largest sources of pollution to the coastal waters of the United States. In southern California, point source control and advanced sewage treatment have greatly reduced the emissions of contaminants from sewage treatment plant and industrial discharges into the ocean. As a consequence, mass emissions from stormwater runoff now constitute a much larger portion of the constituent inputs to receiving waters and may represent the dominant source of some contaminants such as lead and zinc.

While stormwater runoff can produce impacts in both freshwater and seawater environments, effects on the ocean are of greatest concern in urban southern California. Our coastal waters provide many beneficial uses, including recreation, aesthetic enjoyment, fishing, marine habitat, fish reproduction, industrial water supply, and navigation. Ocean-dependent activities contribute approximately $9 billion annually to the economies of coastal communities in southern California.

Current water quality monitoring programs do not assess the effects of stormwater runoff on the environment.

Substantial resources are spent monitoring the chemical constituents in stormwater runoff, yet little is known about the effects of these inputs once they enter the ocean. Of greatest concern to the public are whether impairments are occurring to the beneficial uses that relate to human health (safety of swimming and seafood consumption) or ecosystem health (presence of a natural balance of species). Stormwater discharge has the potential to impair these beneficial uses through 1) contamination of recreational waters or seafood with disease-causing microbes, 2) aesthetic degradation from trash and reduced water clarity, and 3) ecosystem degradation from contaminants or other stormwater constituents.

Understanding the effects of stormwater on beneficial uses is essential. Information about the extent and type of adverse impacts is useful to guide and refine management actions to improve water quality. The monitoring programs of various agencies collect information that is useful for assessing some beneficial use impairments, primarily those related to human health. For example, public health and sanitation agencies regularly conduct shoreline microbiological monitoring near storm drain discharges, which indicates impacts to swimming and shellfish consumption. However, very little information is available to assess the impacts of urban stormwater on ecosystem health. Studies of

R0012200

impacts to freshwater systems (particularly in the west) are rare; impacts to the coastal ocean have never been assessed.

This study is one of the first to assess stormwater impacts on the marine ecosystem.

This report summarizes a three-year study, funded by the Los Angeles County Department of Public Works, Southern California Coastal Water Research Project (SCCWRP), and University of Southern California Sea (USC) Grant Program, to assess the impacts of urban stormwater runoff to the receiving waters of Santa Monica Bay. The goal of this study was to examine impacts that were relevant to ecosystem health, rather than impacts related to human health or recreation issues. This effort was conducted by an interdisciplinary team of scientists from SCCWRP, the University of Southern California, and the University of California at Santa Barbara.

This study examined plume characteristics, water column and seafloor biology.

The Santa Monica Bay Receiving Waters Study incorporated four design elements. The first element used physical and optical oceanographic instruments to characterize the size, composition, and mixing of stormwater plumes, providing information on the impacts to beneficial uses that are associated with water clarity. The second element used toxicity tests to assess the biological effects of runoff on water column biota and to identify the responsible toxicants. The third element examined seafloor biota and chemistry in order to assess the long-term effects of storm-discharged particles with their associated contaminants.

Comparisons between Ballona and Malibu Creeks evaluated effects of different watershed types.

The fourth element of the study design was a comparison of stormwater impacts from different watershed types. Land use patterns and development within a watershed are thought to influence the composition and quantity of stormwater runoff. The influence of watershed type was investigated by comparing stormwater impacts in the receiving water offshore of the highly urbanized Ballona Creek watershed with impacts in the receiving water offshore of the less-urbanized Malibu Creek watershed (Figure 1).

Sampling and analyses were conducted over three wet seasons (1995/96 to 1997/98). This document provides a summary of the study and focuses on major concepts and important findings. For the detailed results and raw data, we encourage readers to consult the Annual Progress Reports available through USC Sea Grant.

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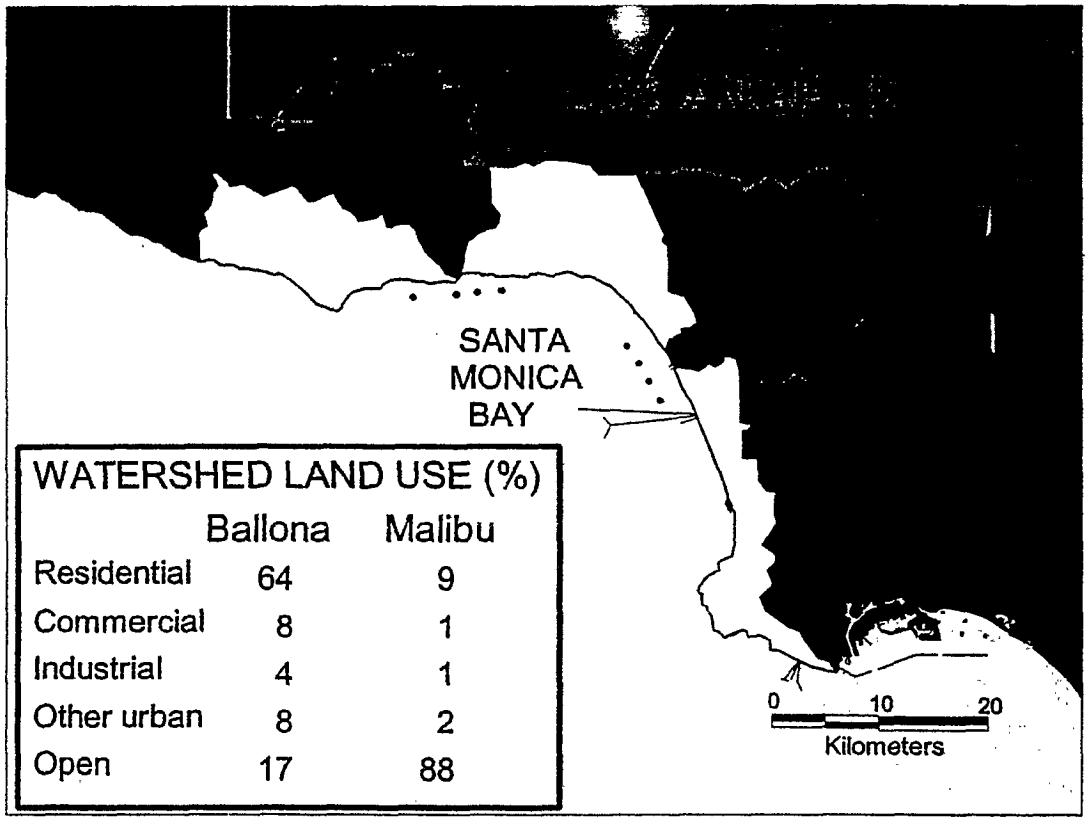

FIGURE 1. Locations of Ballona Creek and Malibu Creek sub-watersheds and the offshore sampling stations for sediment measurement. Other portions of the Santa Monica Bay watershed are shown in white.

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STORMWATER PLUME CHARACTERIZATION

The impact of stormwater on the coastal ocean is determined by the composition of the stormwater and the dynamics (mixing, transport, and persistence) of the stormwater plume once it enters the coastal ocean. These dynamics influence the location, duration, and magnitude of impacts from stormwater.

The research team mapped the three-dimensional distribution of the stormwater plumes resulting from several winter storm events during 1996-1998. Mapping was performed using a towyo system, which carried sensors to measure temperature, salinity, light transmission (turbidity), chlorophyll fluorescence (plant biomass), and ambient visible light. The towyo was towed through the water in a vertical zigzag pattern that enabled us to map the horizontal and vertical distributions of the measured parameters. In addition, surface water was pumped to similar sensors on the boat so that the distribution of these parameters at the water's surface could be mapped. Maps were constructed for two regions of Santa Monica Bay, the receiving waters offshore of Ballona Creek and those offshore of Malibu Creek.

The low salinity and high turbidity of stormwater provide markers that allow plumes to be mapped in the ocean.

The characteristics of stormwater discharged into Santa Monica Bay from the two watersheds were similar in several respects. The most obvious and important physical characteristic was that the stormwater, being primarily composed of freshwater, had very little salinity. This low salinity enabled us to trace the stormwater plume in the ocean and differentiate it from the ambient seawater, which was not directly influenced by stormwater discharge. The stormwater also contained high concentrations of suspended particulate material, derived from various sources such as land erosion, street dust, aerial deposition, and litter. Suspended particulate material increased the turbidity of water by scattering and absorbing light. The turbidity and salinity together allowed the differentiation of seawater influenced by stormwater discharge from seawater containing freshwater from direct rainfall input.

Understanding the dispersion and fate of stormwater plumes is a complex task. The distribution of dissolved components such as nutrients and small particles is dependent upon the amount of rainfall, the coastal currents, and the winds, which can drive currents and cause vertical mixing (Figure 2). Large stormwater particles often have a different fate; they settle out of the low salinity plume, become incorporated into bottom sediments, and may be redistributed later by wave resuspension and transport. As

R0012203

the plume disperses, the components of stormwater mix with other sources of suspended particles, nutrients, and freshwater in the receiving water. These sources include bottom resuspension, phytoplankton growth, and wastewater discharge.

The stormwater plume was most concentrated in the surface layer.

Stormwater plumes usually formed relatively thin layers at the surface of the ocean that are 2-10 m deep (Figure 3). The depth of penetration increased with time as winds mixed the upper layer vertically. The horizontal scales of the plumes studied in Santa Monica Bay were variable, with plumes extending from 1 to 6 miles cross-shelf (offshore) for storms of 1- to 2-year frequencies (0.8 to 4 in. of rainfall). During the February 19-21, 1996 storm (4 in. of rainfall), the plume spread approximately 4 miles offshore of Ballona Creek (Figure 4).

The speed and direction of coastal currents determine the cross-shelf scale of the plume. The Coriolis force (an apparent force that acts on oceans and lakes) also has an influence on the distribution of stormwater plumes. This force is due to the rotation of the earth and its motion through space, resulting in a tendency for currents to turn toward the right in the Northern Hemisphere. If the plume is carried to the north when it enters the ocean, it will be more likely to remain near the coast due to the influence of the Coriolis force.

The distribution of stormwater plumes along the coast depended upon the tidal variations in the currents, the presence of additional runoff sources, and the amount of runoff. Longshore distances of up to 6 miles were measured for plumes within Santa Monica Bay.

Suspended stormwater particles reduced surface water clarity.

Spatial gradients in the dissolved and particulate components of the plume occurred as it was diluted through mixing with the receiving water. Although larger stormwater particles tended to settle out from the plume rapidly, smaller, lighter particles remained in suspension near the surface (Figures 3 and 4), where they can reduce the amount of light available for photosynthesis by marine plants. Measures of primary production were not part of this study, so adverse effects on phytoplankton in Santa Monica Bay resulting from turbid stormwater plumes were not determined.

R0012204

Stormwater plumes persisted for several days after a storm.

The duration of stormwater plumes depends upon the rate of plume dispersion and particle sinking. Stormwater plumes were observed to persist in Santa Monica Bay for at least three days, even for the smallest storm sampled (0.8 in. rainfall). The maximum duration of stormwater plumes could not be assessed in this study because measurements did not extend more than three days after a storm.

High concentrations of the plant pigment chlorophyll were present in the surface layer during some storm events, indicating the presence of increased phytoplankton populations. Phytoplankton growth may have been stimulated by stormwater discharge due to the addition of nutrients to the surface layer, where light is readily available. Dense patches of phytoplankton were observed off of Malibu Creek on the boundary of stormwater plumes 1-2 days after rain events. Off of Ballona Creek, we observed increased phytoplankton in the plume even while a large proportion of suspended particulate material was still present in the surface water. The ecological effects of these changes in phytoplankton density were not determined in this study.

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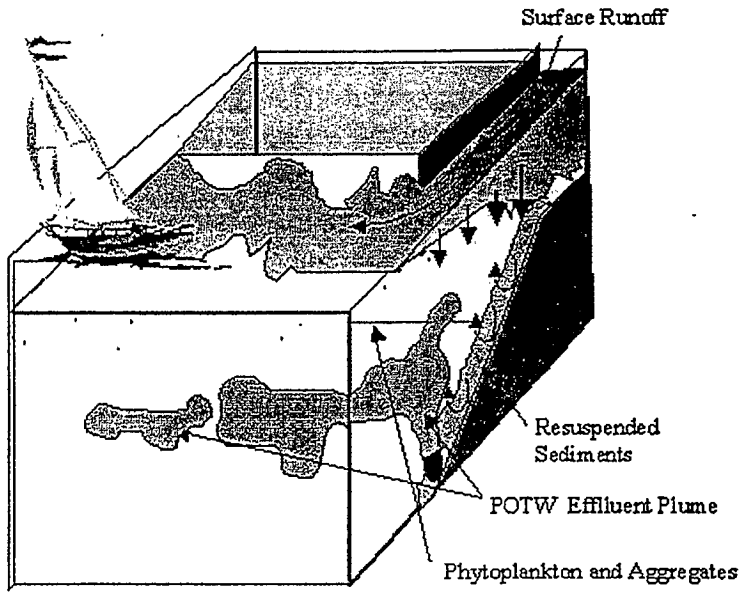

FIGURE2. A three-dimensional representation of the dispersion of the dissolved and particulate Components in surface runoff and municipal (POTW) wastewater effluent.

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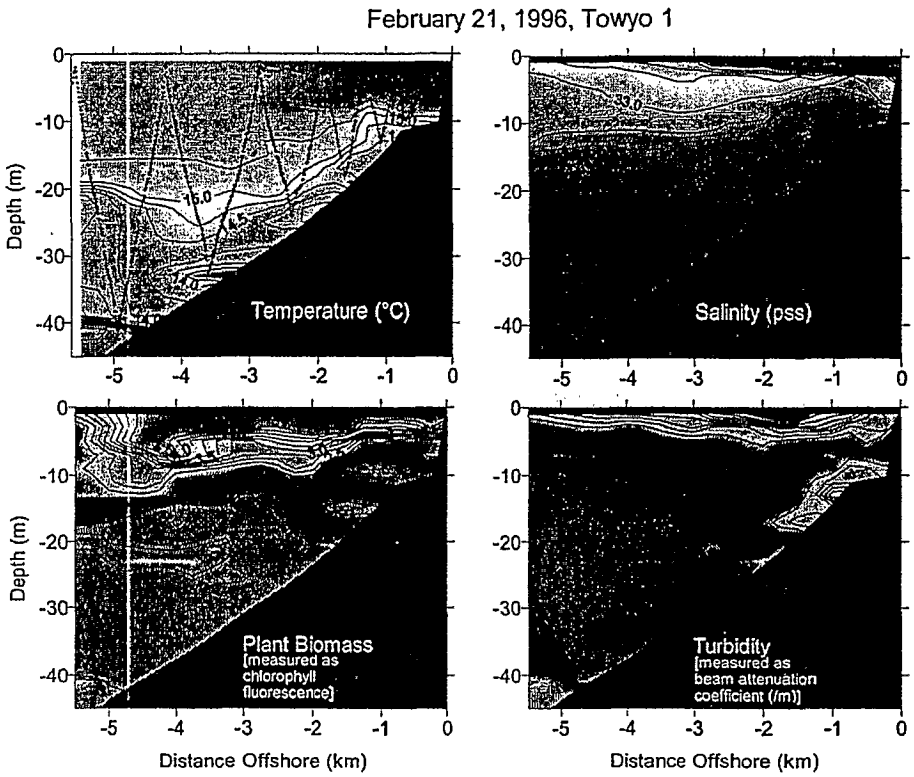

FIGURE 3. Vertical cross-shelf sections of the Ballona Creek discharge plume following a storm event in February, 1996. The maps were generated using a towyo system, which carried sensors for temperature, salinity, turbidity (beam attenuation), and plant biomass (chlorophyll fluorescence). The zigzag pattern on the temperature section indicates the path of the towyo system. The stormwater plume is indicated by water with a salinity less than 33.0 practical salinity units (psu).

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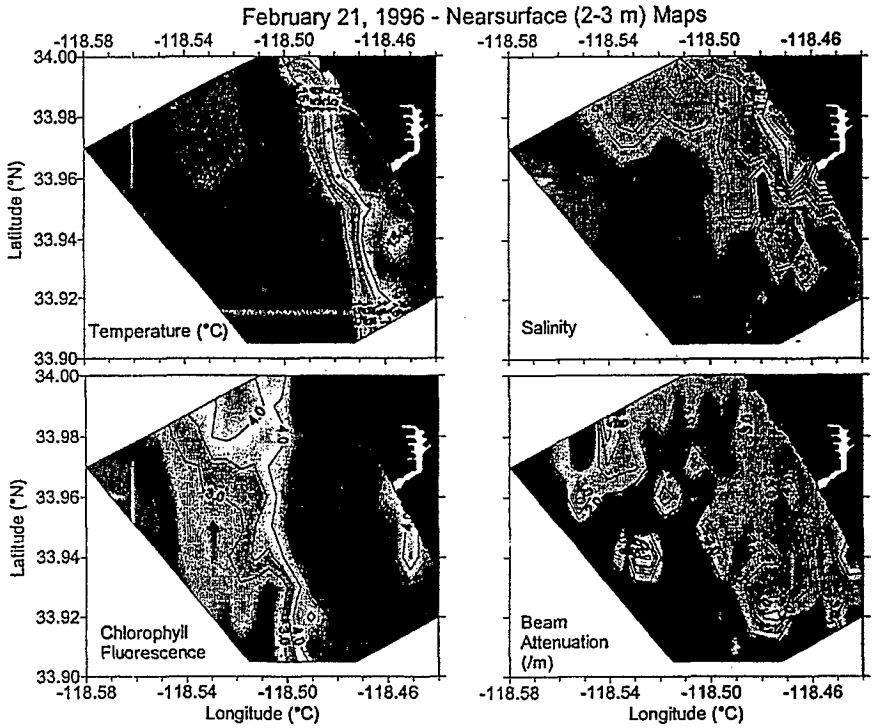

FIGURE 4. Near surface map of the February, 1996 stormwater plume from a 2-year storm off of Ballona Creek. The plume (surface water with a salinity less than 33.0 psu) extended approximately 4 miles offshore.

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WATER COLUMN BIOLOGY

The initial and most concentrated exposure to stormwater occurs in the upper few meters of the water column. A diversity of organisms occupies this habitat, ranging from mobile fish and mammals to drifting microscopic plants and animals (plankton). Plankton have a relatively high potential to be affected by stormwater toxicants because they have a limited ability to avoid the plume and are often more sensitive to contaminants than larger animals. Changes in the abundance and type of plankton present can have important consequences for the marine ecosystem. This group of organisms constitutes the base of the food chain for most marine life, so changes in plankton numbers may affect populations of other species. The larvae of many fish and other animals such as sea urchins, clams, and shrimp occur in the plankton, providing the potential for diminished reproductive success if their survival is reduced by water column toxicity.

Water column effects were measured using toxicity tests.

Toxicity tests were used to determine whether stormwater plumes contained harmful concentrations of dissolved constituents. Surface water samples were collected offshore of the two study sites in conjunction with measurements of the plume characteristics so that the data could be related to the concentration of the stormwater discharge plume. Samples of stormwater collected from Ballona Creek were also measured for comparison. The toxicity tests used sensitive stages of marine species that occur in southern California. Most samples were measured using the sea urchin fertilization test, in which the effect of the sample on the ability of sea urchin sperm to fertilize eggs is measured. Sea urchin sperm are highly sensitive to some types of dissolved metals. The fertilization test is appropriate for stormwater monitoring because it is rapid (40 min exposure) and uses an organism which spends a portion of its life cycle in the water column of Santa Monica Bay. All tests were adjusted to the appropriate salinity prior to exposure so only the effect of chemical constituents were evaluated.

Virtually every sample of Ballona Creek stormwater tested was toxic.

Undiluted samples of urban stormwater collected from drainage channels (before discharge into the ocean) usually contained toxic concentrations of constituents. Toxicity was detected in virtually every sample obtained from Ballona Creek and this toxicity was often present even after the sample was diluted 10-fold in the laboratory. The results indicated that even though a large portion of the constituents present in stormwater may be bound to particles, the dissolved concentrations of some materials are high enough to cause toxicity. Prior research by SCCWRP and

R0012209

others has detected toxicity in stormwater from other watersheds in Los Angeles, Orange, and San Diego Counties.

The first storms of the year produced the most toxic stormwater.

The results showed that time of year was an important variable influencing stormwater toxicity (Figure 5). Samples of Ballona Creek stormwater, obtained from the first storm of the season, were between two and ten times more toxic than samples from later storms. These data indicated that the first storms of the year provide the most concentrated inputs of toxicants to the environment.

Toxicity was frequently detected in surface water within the stormwater plume offshore of Ballona Creek, indicating that the initial dilution of stormwater discharge from this watershed was not sufficient to reduce the concentrations of stormwater toxicants below levels that are harmful to marine organisms. The magnitude of toxicity was greatest in the portion of the plume nearest the mouth of Ballona Creek (Figure 6), where the highest concentrations of stormwater were present. Within the plumes studied, toxicity was usually present whenever stormwater concentrations above 10% were present. The duration of toxicity in surface waters was not specifically addressed in this study, but can be expected to be determined by the rate of plume dispersion. In this study, toxicity was detected in surface water near the mouth of Ballona Creek 2 days after a storm event.

Toxic portions of the stormwater plume were variable in size, extending from ¼ to 2 miles offshore of Ballona Creek.

The spatial extent of surface water toxicity varied between storms, and was influenced by the amount of storm flow, the degree of toxicity of the stormwater, and the amount of mixing that occurred upon discharge. The greatest offshore extent of toxicity was measured following a storm on February 21, 1996, a two-year event, when toxicity was detected 2 miles offshore of Ballona Creek. For other storms, the toxic portion of the plume extended ¼-1 mile offshore. The distribution of toxicity along the shoreline was not determined in this study. The boundaries of stormwater plumes can be described using a number of parameters (*i.e.*, salinity, turbidity, and toxicity) each with different thresholds of detection. Because a relatively high concentration of stormwater is needed to produce toxicity, the area of potential biological impact within a plume will be smaller than the region defined by physical characteristics such as salinity (Figure 6).

An unexpected result of this study was the detection of toxicity in receiving waters that appeared to be due to sources other than urban runoff. An average of 53% of the surface water samples

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Surface water toxicity caused by unidentified sources was frequently encountered during dry weather.

collected offshore of Ballona and Malibu Creeks during periods of dry weather were found to be toxic. The location of the toxic samples was variable and there was no relationship between toxicity and the amount of freshwater in the samples, indicating that dry weather urban runoff was not the cause. Additional sources of receiving water toxicity were also indicated during the wet weather sampling, as some water samples were more toxic than could be accounted for by the amount of stormwater present.

The dry weather toxicity results suggest that factors other than stormwater discharge have a major influence on surface water quality in Santa Monica Bay. While the cause of dry weather toxicity was not determined, its frequent detection indicates that impaired surface water quality in Santa Monica Bay extends beyond the spatial and seasonal boundaries associated with stormwater discharge. Potential sources of dry weather toxicity include the deposition of contaminants from the atmosphere, biological events such as red tides, and inputs from boating activities.

Dissolved metals in stormwater were identified as important contributors to impaired water quality in Ballona Creek stormwater plumes. This conclusion was the result of experiments that combined chemical treatments designed to remove specific types of constituents in water samples with sea urchin toxicity tests, a process known as Toxicity Identification Evaluation (TIE). The toxicity of Ballona Creek stormwater and receiving water samples was usually eliminated when treatments were applied that neutralized toxic trace metals by complexation (Figure 7). Chemical analyses confirmed that dissolved concentrations of zinc, and occasionally copper, were at toxic levels in undiluted stormwater. The dissolved concentrations of other metals were below toxic levels for the sea urchin test. Measurements of receiving water also detected elevated concentrations of zinc (but not copper) in the stormwater plume offshore of Ballona Creek.

Zinc was the most important toxic constituent identified in stormwater. Copper and other unidentified constituents may also be responsible for some of the toxicity measured.

Chemical analyses were unable to attribute all of the toxicity measured to zinc and copper, indicating that additional constituents may contribute to the toxicity of stormwater discharged into Santa Monica Bay. The measured concentrations of zinc and copper in Ballona Creek stormwater were estimated to account for only 5-44% of the observed toxicity. Zinc concentrations in the toxic portion of the discharge plume were usually below levels shown to cause toxicity in the laboratory. The unaccounted-for toxicity may be due to synergistic interactions between toxic metals, variability in the chemical analyses, or the influence of other toxic chemicals,

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such as pesticides. Additional research is needed before these alternatives can be evaluated. TIE studies have not been completed for other stormwater discharges into the Bay, so we do not know if the pattern demonstrated for Ballona Creek is representative of other sites.

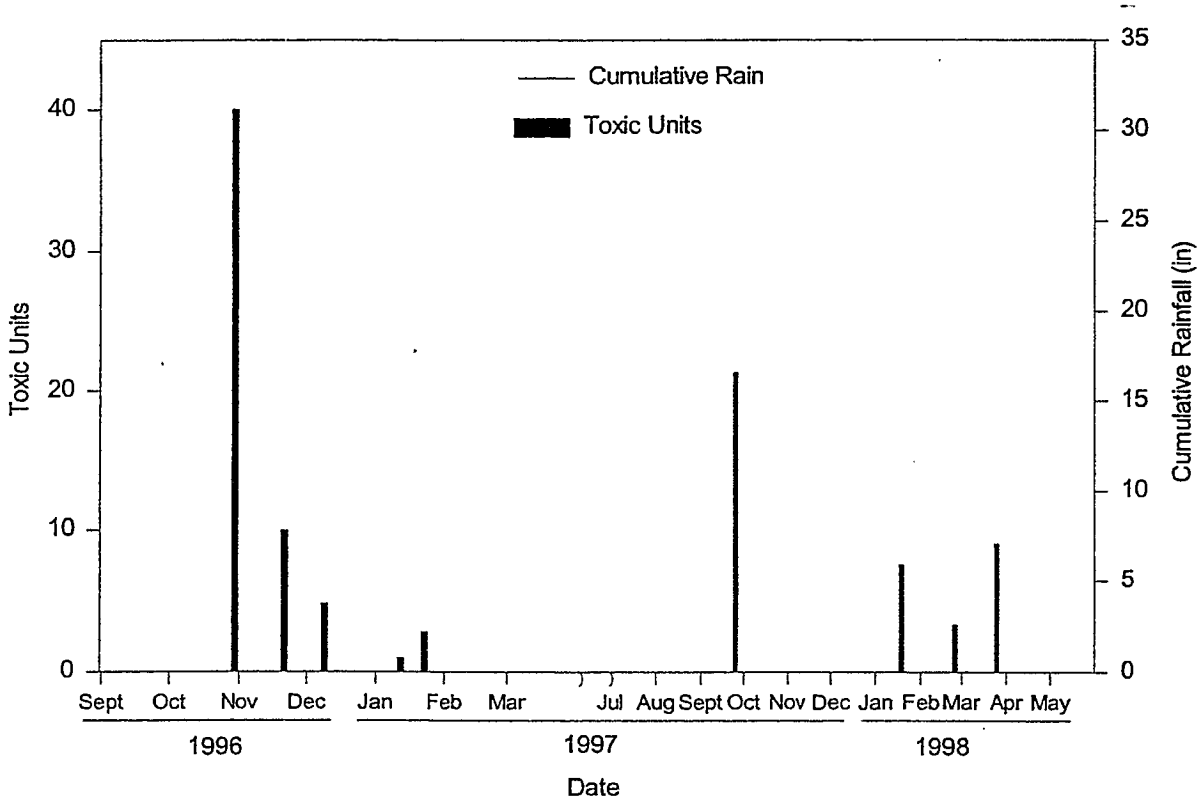

FIGURE 5. Seasonal changes in the toxicity of Ballona Creek stormwater over two storm seasons. Toxicity was measured using the sea urchin fertilization test (Toxic Units = 100/EC50). The greatest toxicity was observed in stormwater obtained from the first storm of each year.

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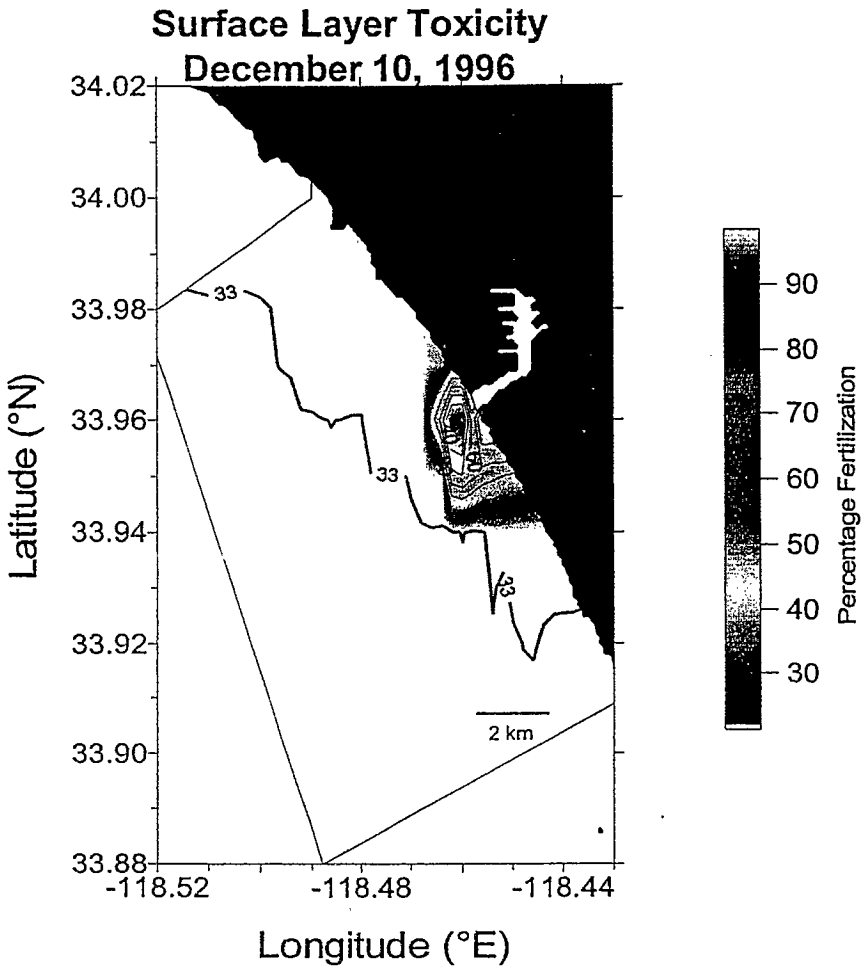

FIGURE 6. Map of surface layer toxicity (effect on sea urchin fertilization) from Ballona Creek stormwater discharge following a 2-year storm in December, 1996 (3.1 in. rainfall). Expected toxicity was calculated from measurements of salinity (indicates concentration of stormwater) and the concentration dose-response curve for the effects of stormwater on sea urchin fertilization. The greatest toxicity (lowest fertilization percentage) was present closest to the point of discharge. The area of toxicity was smaller than the physical extent of the plume, as indicated by the solid line showing a salinity of 33 psu. This figure illustrates the relative size of the toxic portion of the plume for a single storm, but does not represent the largest plume studied. Toxic portions of the plume were found to extend greater and smaller distances offshore for other storms.

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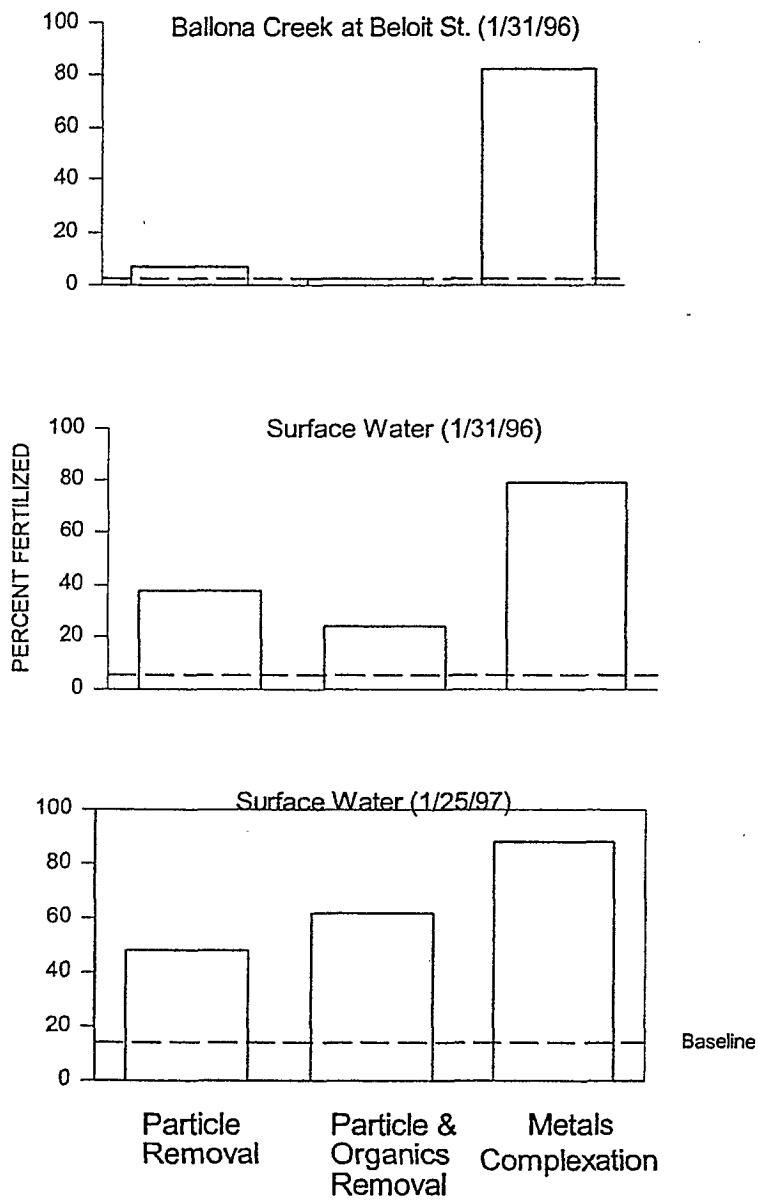

FIGURE 7. Effect of toxicity identification evaluation treatments on the toxicity of Ballona Creek stormwater and two samples of surface water collected within the Ballona Creek discharge plume. Complexation of metals by addition of EDTA usually eliminated toxicity, as shown by the large increase in sea urchin fertilization above the untreated (baseline) value. Other treatments, removal of particles by filtration and removal of organic compounds, were of limited effectiveness. Similar results were found for other samples of stormwater and surface water.

R0012214

SEAFLOOR BIOLOGY

The deposition of stormwater particles influences the physical and chemical characteristics of the seafloor.

Much of the natural diversity and many of the commercially important species in the ocean occur on the seafloor. Clams and shrimp live in this environment, as well as worms and starfish, all of which serve as food for fish. This is also the location where stormwater particles, and associated contaminants, eventually settle. Unlike the water column, where a stormwater plume eventually mixes and disperses, the sediments on the seafloor can accumulate runoff inputs over an entire storm, over several storms, or over several seasons. These inputs can alter the seafloor biology by either changing the habitat, such as altering sediment grain size, or by the build-up of pollutants. The potential for impacts to seafloor organisms is great because they are not mobile and are therefore subjected to the accumulated stormwater inputs for long periods of time. Typically, these seafloor organisms are relatively sensitive and changes to the number or types of organisms may result in changes to fish populations.

We estimated impacts of stormwater runoff discharges on the seafloor by collecting samples from the ocean bottom between one and two weeks following large storm events, after the stormwater plumes had dispersed and particles had time to settle, and then again during dry weather. Seafloor samples were collected directly offshore of Ballona and Malibu Creeks at 75 ft. depth in the heart of the stormwater plumes, along intervals upcoast and downcoast representing gradients of plume impact, and then outside the area of the plume. The top 2 cm (< 1 inch) of these seafloor samples, which represented the most recent seafloor accumulations, were collected for contaminant analysis and toxicity testing. Sediment samples were analyzed for contaminants including trace metals, chlorinated hydrocarbons (DDTs and PCBs), and petroleum hydrocarbons (PAHs). The toxicity tests included survival of crustaceans (an amphipod) and sea urchins, fertilization success and development of sea urchin embryos, and bioaccumulation of contaminants from seafloor mud in adult sea urchins. A second sediment sample was collected, sieved through a fine mesh screen, and the organisms were enumerated to determine the abundance and diversity of the native seafloor fauna.

An increase in sediment constituents was present on the seafloor offshore Ballona Creek.

Alterations to the seafloor habitat and sediment constituent concentrations had occurred offshore of the Ballona Creek watershed (Table 1). The sediments offshore of Malibu Creek generally had higher concentrations of naturally abundant constituents including fine-grained particles, organic carbon, and

R0012215

trace metals such as chromium. In contrast, the sediments offshore of Ballona Creek generally had higher concentrations of urban contaminants including common stormwater constituents such as lead and zinc, as well as other rarely detected constituents in routine stormwater monitoring programs, such as DDTs, PCBs, and PAHs. Moreover, sediments offshore of Ballona Creek showed evidence of stormwater impacts over a large area. Concentrations of copper, lead, zinc, DDTs, PCBs, and PAHs were highest directly offshore of the creek mouth and then decreased in both the upcoast and downcoast directions at distances up to 3 miles away (Figure 8). The increased sediment contamination was also observed more than 1 mile offshore, where water depths reached over 100 feet.

Biological communities offshore of Ballona Creek were similar to those offshore of Malibu Creek (Table 2). Both areas had comparable abundance and similar species composition. Seventeen of the 19 most commonly found taxa offshore of Ballona Creek were present offshore of Malibu Creek, and both watersheds had a low abundance of so-called "pollution indicator" organisms. Both areas had healthy benthic communities, as measured by the Benthic Response Index, which is a tool for assessing the relative importance of pollution indicator species at a site. Species richness and diversity were statistically higher near Malibu Creek than Ballona Creek.

Biological communities offshore of Ballona and Malibu Creeks were also similar to background reference conditions established in previous studies of southern California (Table 2). The mean abundance, mean number of taxa per sample, and mean diversity at the creek sites were comparable to reference sites located in waters of similar depth, but distant from river and creek mouths. The present study was limited to the area offshore of the Ballona Creek jetty; previous studies by other scientists have shown impacts to benthic communities and the presence of pollution indicator organisms inside of the jetty (adjacent to Marina del Rey).

The seafloor biology results were consistent with the results from sediment toxicity tests. Seafloor sediments offshore of Ballona Creek did not kill amphipods or impair the fertilization success or normal embryo development of sea urchins. However, seafloor sediments were found to be a potential source of contaminants that bioaccumulate in seafloor organisms such as adult sea urchins. Concentrations of lead, DDTs, and PCBs were three to ten times higher in sea urchins exposed to sediments

R0012216

collected offshore of Ballona Creek than in sea urchins living on sediments from our reference location. While the effect of this bioaccumulation on the sea urchin is not known, it does represent a mechanism by which sediment-associated pollutants can enter the food chain and biomagnify within fish.

The fate of most stormwater constituents is unknown.

One significant finding of this study was that the fate of most stormwater constituents discharged to Santa Monica Bay is unknown. Although we documented the accumulation of contaminants on the seafloor offshore of Ballona Creek, these amounts were not permanent and represent only a fraction of the total mass emissions discharged. Further, reductions in constituent concentrations were observed at some locations that may have resulted from the resuspension and transport of sediments by waves and currents. Until the location where this material eventually settles is known, we cannot be certain that we have examined the seafloor areas having the greatest influence from stormwater or dry weather discharges. An additional concern is that constituents from other sources may have similar transport and fate mechanisms, producing enhanced impacts from the cumulative effects of multiple sources.

R0012217

TABLE 1. Average concentrations of sediment constituents offshore (75 ft. depth) of creek mouths in Santa Monica Bay following storm events between 1995 and 1997. Boxed numbers indicate significantly higher concentrations. Sediment offshore of the less urbanized watershed (Malibu Creek) had higher levels of naturally occurring constituents such as aluminum and iron. Higher concentrations of anthropogenic constituents such as lead and PAHs were present offshore of the more urbanized watershed (Ballona Creek).

		Sediment Concentration	
		Ballona Ck (n=8)	Malibu Ck (n=7)
Fines	% dry	31.6	**53.1**
TOC	% dry	0.594	**0.963**
Aluminum	µg/dry g	11492	**17280**
Arsenic	µg /dry g	5.1	5.6
Cadmium	µg /dry g	0.5	0.7
Chromium	µg /dry g	40.7	**52.6**
Copper	µg /dry g	12	13
Iron	µg /dry g	14997	**21720**
Lead	µg /dry g	**26.4**	10.3
Mercury	µg /dry g	**0.18**	0.08
Nickel	µg /dry g	14.29	**27.76**
Silver	µg /dry g	**0.95**	0.31
Zinc	µg /dry g	54	56
Total DDTs	ng/dry g	**25.6**	15.5
Total PCBs	ng/dry g	**21.5**	3.0
Total PAHs	ng/dry g	**240.6**	56.2

R0012218

TABLE 2. Biological community parameters offshore of a highly urbanized watershed (Ballona Creek), a less urbanized watershed (Malibu Creek), and other reference areas in near-coastal waters of southern California at similar depths (30 to 75 feet). Values are the mean (±95% confidence limits).

	Ballona (n=6)	Malibu (n=5)	Reference (n=29)
Abundance (No. organisms/ 0.1 m^2)	238 (±51)	316 (±55)	276 (±61)
No. Species (No. taxa/ 0.1 m^2)	75 (±6)	91 (±8)	71 (±9)
Diversity (Shannon-Wiener H')	1.65 (±0.02)	1.73 (±0.04)	1.55 (±0.15)
Benthic Response Index (BRI units)	24.0 (±1.7)	30.5 (±0.7)	3.0 – 30.6

R0012219

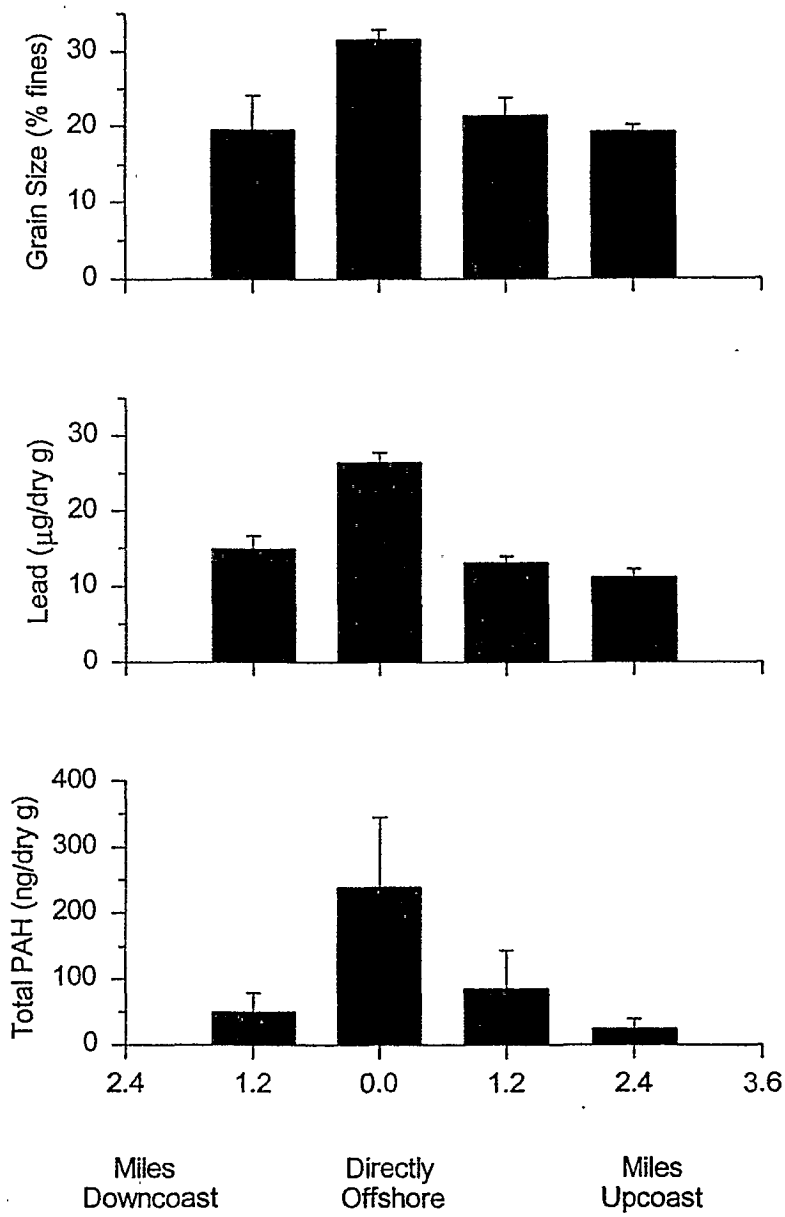

FIGURE 8. Grain size and contaminant concentrations in surface sediments across the gradient of stormwater influence offshore of Ballona Creek. Sampling stations were located 1.5 miles offshore (25 m depth) and at various distances upcoast or downcoast of the creek. Each value represents the mean (+95% confidence interval) of eight samples, each collected after a storm event. The influence of stormwater particle deposition is shown by the elevated values directly offshore of Ballona Creek.

R0012220

EFFECTS OF WATERSHED TYPE ON BENEFICIAL USES

Different impacts to Santa Monica Bay were produced by an urbanized and an unurbanized watershed.

The comparison of receiving water impacts from different watersheds is a powerful tool to distinguish between natural and man-made effects. Although the Ballona Creek and Malibu Creek watersheds are similar in size and discharge into the same body of water (Santa Monica Bay), they differ in their degree of urbanization (Figure 1). The measurement of similar parameters in each receiving water area provides the information needed to distinguish between natural processes and impairment due to man-made factors. This approach also identifies which monitoring methods are most useful for detecting man-made impacts.

The characteristics and impacts of stormwater from the Ballona Creek and Malibu Creek watersheds were found to differ in a number of respects (Table 3). The impacts observed were the result of the interaction of three key factors: land use, flow characteristics, and receiving water conditions. Receiving water impacts were less near Malibu Creek and were related to the discharge of less toxic stormwater and lower peak flows.

R0012221

TABLE 3. Characteristics of a highly urbanized watershed (Ballona Creek) and a less urbanized watershed (Malibu Creek) adjacent to Santa Monica Bay, California.

	Ballona Creek	Malibu Creek
Watershed Characteristics	The largest watershed draining to Santa Monica Bay, 83% of its 130 square miles is developed. The principal land use is residential.	Similar in size to Ballona Creek (110 square miles), 88% of this watershed is undeveloped.
Flow Characteristics	The largely impermeable surface area (41% overall) and concrete channel drainage system results in rapid changes in flow following rainfall. Peak flows are relatively high and of shorter duration compared to other areas.	More permeable surface area (96% overall) absorbs early season rainfall and increases lag time between rainfall and peak flow. Discharges have relatively lower peak flows but duration can be days longer than concrete channelized systems. Discharge into Malibu Lagoon may reduce flows and particle loads to ocean.
Plume Characteristics	The stormwater plume in both areas consisted of a thin buoyant layer of low salinity water floating at the surface. The dissolved and particulate components of stormwater were most concentrated in the upper 2 m of the water column. Plumes extended up to 6 miles offshore and were widely distributed along the shore.	
	Higher flows and less mixing produced well-defined plumes that contained higher concentrations of stormwater near Ballona Creek.	Lower flows, more mixing, and discharges from adjacent canyons resulted in more complex and ill-defined plume boundaries near Malibu Creek.
Debris	Floating debris was often concentrated near the margins of the plume and contained many items of man-made origin, such as plastic.	Floating debris was dominated by organic materials of natural origin, such as twigs and charred wood.

TABLE 3. Continued.

R0012222

	Ballona Creek	Malibu Creek
Water Clarity	Less mixing of stormwater usually produced larger areas of reduced water clarity.	Stormwater inputs were often more turbid, but lower flows and greater dilution near the mouth resulted in better clarity.
Stormwater Toxicity	Samples from the creek were always toxic to sea urchins. Concentrations higher than 10% stormwater usually produced adverse effects in laboratory tests.	Samples were less toxic than Ballona Creek stormwater and occasionally nontoxic. High concentrations (>25%) usually needed to produce toxicity.
Receiving Water Toxicity	Surface water in most concentrated portion of plume was often toxic to sea urchins. Toxicity was detected in receiving waters up to 2 miles from discharge.	Toxicity in water column was rarely present and was not related to plume concentration.
Cause of Toxicity	Zinc is responsible for a portion of the stormwater toxicity. The influence of pesticides and other organics is uncertain.	Metals are implicated but have not been confirmed as important toxicants.
Seafloor Habitat	Sediments were higher in urban stormwater associated contaminants, such as lead and zinc.	Higher concentrations of constituents were derived from natural sources, such as fine sediments and organic carbon.
Sediment Toxicity	Changes in sediment toxicity were minor and not related to stormwater discharges.	
Seafloor Biological Communities	Biological communities were similar among Malibu Creek, Ballona Creek, and background reference sites.	

R0012223

RECOMMENDATIONS FOR FUTURE STUDIES

The Santa Monica Bay receiving waters study produced the first integrated assessment of impacts from stormwater discharges into the Bay. The presence of well-developed plumes containing toxic materials demonstrates the need for continued studies of the impacts from urban stormwater runoff in Santa Monica Bay and elsewhere. Additional information regarding the sources, characteristics, and extent of the receiving water impacts should be determined in order to refine management actions.

A high priority should be placed upon locating sources of toxicity and contamination within the Ballona Creek watershed. Identification of the land uses or regions of the watershed that contribute most to the impacts will enable management actions to be targeted where they will have the greatest beneficial impact. Source identification studies should include sampling of systems tributary to Ballona Creek for measurement of toxicity and chemical constituents.

Additional receiving water studies are recommended for Santa Monica Bay to provide a more complete understanding of the nature and magnitude of stormwater impacts. Future studies should include constituents of concern that were not emphasized in this study, such as bacteria, nutrients, pesticides, and trash. These constituents should be incorporated into studies of plume persistence, cause of toxicity, and constituent fate.

Information on the duration, size, and cause of adverse impacts is needed to identify appropriate stormwater management actions.

Plume persistence information is needed to estimate the duration of exposure of: 1) swimmers to bacteria and 2) marine life to stormwater toxicants and nutrients. Improved information on plume persistence can be obtained by the use of moored sensors in the discharge area in combination with data from remote sensing instruments (e.g., satellites). A goal of these studies should be to develop plume dilution and/or tracking models of plume duration and magnitude. This information is valuable because different management responses may be appropriate for stormwater discharges that produce short- versus long-lived impacts.

A suite of species should be used to identify toxicants in stormwater.

Toxicity testing using multiple marine species is also needed to provide a more complete assessment of the causes of toxicity in stormwater discharged into Santa Monica Bay. Identification of zinc and copper as contaminants of concern was based primarily on studies with a single species (sea urchin). Because different species vary in their sensitivity to contaminants, tests with multiple species

R0012224

are needed to determine if other contaminants are present at toxic concentrations. Tests with crustaceans (e.g., shrimp) are especially recommended as they are likely to be sensitive to pesticides such as diazinon and chlorpyrifos, which have been found to be important factors in the toxicity of stormwater from other watersheds. These tests should include toxicity identification procedures so that potential constituents of concern (e.g., metals and pesticides) can be confirmed and others can be discounted. Toxicant identification is needed to prioritize chemical-specific management actions.

The fate of stormwater particles must be determined in order to assess seafloor impacts.

Chemical and oceanographic studies are needed to determine the fate of stormwater particles discharged into Santa Monica Bay. Although some of the particles in Santa Monica Bay stormwater plumes may be deposited near the mouth of an urban watershed, they do not necessarily persist there for long periods of time. Since the spatial extent of particle dispersal in Santa Monica Bay was not determined, there may be areas of significant accumulation that were not investigated. Studies of currents, sediment resuspension, and sediment transport, coupled with chemical source identification methods, should be conducted to determine whether stormwater discharge is a significant source of adverse sediment contamination within Santa Monica Bay. This information is needed to identify areas of the seafloor with the greatest potential for biological impacts from stormwater discharge.

Additional receiving water systems should be studied to identify impairments from other watersheds.

The impacts of stormwater runoff on other receiving water systems should also be studied. This is because differences in watershed size and land use patterns will likely result in different levels of risk to the receiving water beneficial uses. For example, changes in land use may contribute different toxicants, and changes in watershed size will influence the magnitude of the toxicant input. The nature of the receiving water environment is also important. Semi-enclosed water bodies, such as most bays and harbors, do not have the mixing and dilution capacity of the open coastal environment studied in Santa Monica Bay. The potential for impairment will be greater in these areas because organisms will have an increased exposure to the stormwater plume and more stormwater particles will settle nearby and influence sediment quality. Until the effects of variations in watershed or receiving water characteristics can be accurately predicted, additional integrated studies will be necessary to assess impacts to receiving waters in other areas.

R0012225

Appendix D
Low Flow Pilot Study

D.1 INTRODUCTION

The purpose of the Low Flow Pilot Study was to assess feasibility of modifying the sampling equipment at land use stations to monitor storms as small as 0.1 inches of rainfall. Currently the land use monitoring equipment is designed to monitor storms greater than 0.25 inches of rainfall. To conduct the assessment the equipment at a single land use monitoring station was modified to capture events as small as 0.1 inches. The feasibility assessment was based on the following criteria:

- the operational effectiveness of the sampler at low storm volumes;
- the feasibility and effectiveness of sample retrieval and transport; and
- the ability to reprogram and maintain this setting at other samplers.

Based on these criteria, a decision will be made whether to set some or all of the remaining land use samplers to monitor storms totaling 0.1 inches of rainfall or greater.

D.2 EQUIPMENT AND METHODS

Stormwater Monitoring Site 24, known as Project 1202 Monitoring Station, was selected for the Low Flow Pilot Study. The Project 1202 site is located at a concrete box culvert. The site catchment drains based on an evaluation conducted in Monitoring Plan for 1996/1997 Low Flow Pilot (Woodward-Clyde and Larry Walker Associates, 1996) a 1.07 square mile watershed that is approximately 74 percent impervious. The land use in the watershed is approximately 42 percent commercial, 49 percent industrial and 9 percent vacant. Project 1202 was selected for this pilot study because, compared to the other land use stations, it produced the best runoff response to small events, it had high imperviousness, and it had the lowest and most consistent dry weather flows.

The sampling was conducted with the existing automatic water sampler. The sampler was programmed to start automatically based on the water depth reaching 0.125 feet (1.5 inches) as measured by the existing pressure transducer, and detection of 0.02 inches of rainfall by a tipping bucket rain gage. The sampler drew 1.0 liter aliquots on a flow-proportioned basis. An initial daily volume of 10,000 cubic feet of flow between

aliquot collections was selected. Ten aliquots were sampled per bottle, and the sampler housed four 10 liter bottles. The sample collection pacing volume was changed to 5,000 cubic feet after receiving poor results from the first small storm of the season (Storm 2A). Sampling discontinued when either all sample aliquots were taken or when the sampler was manually turned off.

Rainfall estimates for storm volume were not available until two to three hours before an event. With the required set-up for the other elements of the Monitoring Program (i.e., bottle and ice placement, equipment problem solving, and field team mobilization), the sampler pacing volume could not be set based on anticipated storm size. The sampler pacing volume was, therefore, maintained at 5,000 cubic feet (that is after Storm 2A, see above) to ensure proper sampling of storms down to 0.1 inches.

The automatic sampler does not have telemetric communications. All programming and data transfer is conducted in the field. For this and other reasons discussed above, the sample collection pacing volume could not be modified in response to changes in forecasted rainfall amounts.

The sampler bottles were checked frequently, starting several hours after sampling began, to evaluate whether the bottles were full and needed to be changed. To sample any events with more than 0.25 inches of rain, the composite bottles were changed at least once during the sample collection. In the 1996-97 storm season, 8 of 11 storms were greater than 0.25 inches of rain.

The samples collected for the Low Flow Pilot Study were stored, handled and analyzed in accordance with the currently approved Storm Water/Urban Runoff Monitoring Plan. The analytical methods for the constituents analyzed in this study are listed in Table B-1. The complete methods are presented in Monitoring Plan for 1996/1997 Low Flow Pilot Study (Woodward-Clyde and Larry Walker Associates, 1996).

Table D-1. Analytical Methods for Constituents Analyzed in Low Flow Pilot Study

Class	Constituent	Sample Type	Method	DL	PQL	Units	Preservation	Holding Time
General								
	Ammonia	Comp	A350.3	0.1	0.1	mg/l	H_2SO_4	28 days
	Calcium	Comp	A215.2	1.0	1.0	mg/l	HNO_3	6 months
	Magnesium	Comp	C3500MgD	1.0	1.0	mg/l	HNO_3	6 months
	Potassium	Comp	A258:1	1.0	1.0	mg/l	HNO_3	6 months
	Sodium	Comp	A273.1	1.0	1.0	mg/l	HNO_3	6 months
	Bicarbonate	Comp	A310.1	2.0	2.0	mg/l	-	14 days
	Carbonate	Comp	A310.1	2.0	2.0	mg/l	-	14 days
	Chloride	Comp	B429	2.0	2.0	mg/l	-	28 days
	Fluoride	Comp	B429	0.1	0.1	mg/l	-	28 days
	Nitrate	Comp	B429	0.1	0.1	mg/l	-	48 hours
	Sulfate	Comp	B429	0.1	0.1	mg/l	-	48 hours
	Alkalinity	Comp	A310.1	4.0	4.0	mg/l	-	14 days
	Hardness	Comp	A130.2	2.0	2.0	mg/l	HNO_3 or H_2SO_4	6 months
	Dissolved Phosphorus	Comp	A365.2	0.05	0.05	mg/l	-	48 hours
	Total Phosphorus	Comp	A365.2	0.05	0.05	mg/l	H_2SO_4	28 days
	COD	Comp	A410.4	5	10	mg/l	H_2SO_4	28 days
	pH	Comp	A150.1	na	na		-	immed.
	NH3-N	Comp	A350.3	0.1	0.1	mg/l	H_2SO_4	28 days
	Nitrate-N	Comp	C4110B	0.1	0.5	mg/l	-	48 hours
	Nitrite-N	Comp	C4110B	0.01	0.03	mg/l	-	48 hours
	TKN	Comp	A351.4	0.1	0.1	mg/l	H_2SO_4	28 days
	Specific Conductance	Comp	A120.1	1	1	umhos/cm	-	immed.
	Total Dissolved Solids	Comp	A160.1	2.0	2.0	mg/l	-	7 days
	Turbidity	Comp	A180.1	0.1	0.1	NTU	-	48 hours
	Suspended Solids	Comp	A160.2	2.0	2.0	mg/l	-	7 days
	Vol.Sus.Solids	Comp	160.4	1.0	1.0	mg/l	-	7 days
	MBAS	Comp	A425.1	0.05	0.05	mg/l	-	48 hours
	Total Organic Carbon	Comp	A415.1	1.0	1.0	mg/l	HCl, H_2SO_4, or H_3PO_4	28 days
	BOD	Comp	A405.1	2.0	2.0	mg/l	-	48 hours
Metals								
	Dissolved Aluminum	Comp	A202.2	100	100	ug/l	HNO_3	6 months
	Total Aluminum	Comp	A202.2	100	100	ug/l	HNO_3	6 months
	Dissolved Antimony	Comp	A204.2	1	5	ug/l	HNO_3	6 months
	Total Antimony	Comp	A204.2	1	5	ug/l	HNO_3	6 months
	Dissolved Arsenic	Comp	A206.2	1	5	ug/l	HNO_3	6 months
	Total Arsenic	Comp	A206.2	1	5	ug/l	HNO_3	6 months
	Dissolved Barium	Comp	A208.2	1	10	ug/l	HNO_3	6 months
	Total Barium	Comp	A208.2	1	10	ug/l	HNO_3	6 months
	Dissolved Beryllium	Comp	A210.2	1	1	ug/l	HNO_3	6 months
	Total Beryllium	Comp	A210.2	1	1	ug/l	HNO_3	6 months
	Dissolved Boron	Comp	A212.3	100	100	ug/l	HNO_3	6 months
	Total Boron	Comp	A212.3	100	100	ug/l	HNO_3	6 months
	Dissolved Cadmium	Comp	A213.2	1	1	ug/l	HNO_3	6 months
	Total Cadmium	Comp	A213.2	1	1	ug/l	HNO_3	6 months

DL = Detection limit
PQL = Practical quantitation limit
na = not applicable
"-" = No preservation required other than cooling the sample to 4° C.

Table D-1. Analytical Methods for Constituents Analyzed in Low Flow Pilot Study

Class	Constituent	Sample Type	Method	DL	PQL	Units	Preservation	Holding Time
Metals (cont.)								
	Dissolved Chromium	Comp	A218.2	1	5	ug/l	HNO_3	6 months
	Total Chromium	Comp	A218.2	1	5	ug/l	HNO_3	6 months
	Dissolved Chromium +6	Comp		10	10	ug/l	-	24 hours
	Total Chromium +6	Comp		10	10	ug/l	-	24 hours
	Dissolved Copper	Comp	A220.1	1	5	ug/l	HNO_3	6 months
	Total Copper	Comp	A220.1	1	5	ug/l	HNO_3	6 months
	Dissolved Iron	Comp	A236.1	100	100	ug/l	HNO_3	6 months
	Total Iron	Comp	A236.1	100	100	ug/l	HNO_3	6 months
	Dissolved Lead	Comp	A239.2	1	5	ug/l	HNO_3	6 months
	Total Lead	Comp	A239.2	1	5	ug/l	HNO_3	6 months
	Dissolved Manganese	Comp	A243.1	50	50	ug/l	HNO_3	6 months
	Total Manganese	Comp	A243.1	50	50	ug/l	HNO_3	6 months
	Dissolved Mercury	Comp	A245.1	0.1	1	ug/l	HNO_3	28 days
	Total Mercury	Comp	A245.1	0.1	1	ug/l	HNO_3	28 days
	Dissolved Nickel	Comp	A249.2	1	5	ug/l	HNO_3	6 months
	Total Nickel	Comp	A249.2	1	5	ug/l	HNO_3	6 months
	Dissloved Selenium	Comp	A270.2	0.2	5	ug/l	HNO_3	6 months
	Total Selenium	Comp	A270.2	0.2	5	ug/l	HNO_3	6 months
	Dissolved Silver	Comp	A272.2	0.2	1	ug/l	HNO_3	6 months
	Total Silver	Comp	A272.2	0.2	1	ug/l	HNO_3	6 months
	Dissolved Thallium	Comp	A279.2	1	5	ug/l	HNO_3	6 months
	Total Thallium	Comp	A279.2	1	5	ug/l	HNO_3	6 months
	Dissolved Zinc	Comp	A289.1	10	50	ug/l	HNO_3	6 months
	Total Zinc	Comp	A289.1	10	50	ug/l	HNO_3	6 months
Semi-Volatile Organics								
	Bis(2-ethylhexyl)phthalate	Comp	525	3.0	3.0	ug/l	-	7 days
	All other SVOCs	Comp	525	0.5 - 5.0	0.5 - 5.0	ug/l	-	7 days
Pesticides								
	Organochlorine Pesticides & PCBs	Comp	D608	0.05 - 1.0	0.05 - 1.1	ug/l	-	7 days
	Diazinon	Comp	507	0.05	0.25	ug/l	-	7 days
	Chlorpyrifos	Comp	507	0.20	1.00	ug/l	-	7 days
	Other N- and P-Containing Pesticides	Comp	507	1.0 - 2.0	1.0 - 2.0	ug/l	-	7 days
	Carbofuran	Comp	531.1	5.0	5.0	ug/l	-	7 days
	Chlorinated Herbicides & Bentazon							
	2,4-D	Comp	515.1	10.0	10.0	ug/l	-	7 days
	2,4,5-TP	Comp	515.1	1.0	1.0	ug/l	-	7 days
	Bentazon	Comp	515.1	2.0	2.0	ug/l	-	7 days
	Glyphosate	Comp	547	25	50	ug/l	$Na_2S_2O_3$	14 days

DL = Detection limit
PQL = Practical quantitation limit
na = not applicable
"-" = No preservation required other than cooling the sample to 4° C.

D.3 RESULTS

During the 1996-97 storm season, eleven events were monitored at the Project 1202 site. Of these eleven events, ten were sampled. The monitored storm events ranged in size from 0.13 inches to 4.25 inches of rainfall. In the 1996-97 storm season, 8 of 11 storms were greater than 0.25 inches of rain. Hydrographs for each event are presented in Attachment D-1. A summary of the events is presented below in Table D-2. Water quality results are presented in Table D-3.

Table D-2. Summary of the events monitored for the Low Flow Pilot Study.

Event No.	Date	Precipitation (in)	Runoff Volume (1000's of c.f.)	Antecedent Dry Period (days)	No. of Bottle Replacements[1]
1	10/29/96	0.75[2]	1,658	231	4
2	11/20/96	2.00	2,282	22	3
2A	12/5/96	0.16	113	13	1
3	12/9/96	4.25	5,205	3	3
4	12/22/96	0.15	60	10	1
5	12/27/96	0.84	1,053	5	3
5A	1/1/97	0.76	716	5	1
6	1/12/97	2.49	3,256	6	8
7	1/21/97	1.08 [3]	1,014[3]	5	4 [2]
8	1/25/97	0.98	4,560[4]	5	n/s
8A	2/10/97	0.13	265	16	2

Notes:

(1) number of actual bottle replacements, not number required.
(2) Precipitation value for Los Angeles River at Wardlow site (4 miles away)
(3) totals at time that the sampler malfunctioned.
(4) runoff volume not reliable due to pressure transducer problems.
n/s = not sampled.
A = small storm events not sampled at every station.

R0012231

Table D-3. Summary of Results for 1996-1997 Low Flow Pilot Study

DPW SAMPLE NO.						58960	59022	59045	59103	59153	59163	59280	59210	59251	59325	
STATION NO.						S24	S24	S24	S24	S24	S24	S24	S24	S24	S24	
STATION NAME						Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	
DATE SAMPLED						10/30/96	11/21/96	12/09/96	12/21/96	12/05/96	12/27/96	01/01/97	01/12/97	01/22/97	02/10/97	
DATE DELIVERED					Sample	10/30/96	11/21/96	12/10/96	12/23/96	12/06/96	12/27/96	01/06/97	01/13/97	01/22/97	02/11/97	
STORM NO.	EPA Method	DL	PQL	Units	Type	1	2	3	4	2A	5	5A	6	7	8A	Mean
General																
Ammonia	A350.3	0.1	0.1	mg/l	Comp	0.313	0.468	0.368	3.24	2.26	0.275	0.543	0.235	0.39	1.33	0.94
Calcium	A215.2	1.0	1.0	mg/l	Comp	12.02	4.4	6.41	16.51	12.83	6.41	4.81	3.85	5.82	14.8	9.1
Magnesium	C3500MgD	1.0	1.0	mg/l	Comp	1.94	2.18	0.58	3.31	1.94	0.488	0.97	1.75	1.75	3.79	1.87
Potassium	A258.1	1.0	1.0	mg/l	Comp	3.3	2.53	1.8	6.68	3.95	1.86	0.38	0.82	1.53	2.05	2.51
Sodium	A273.1	1.0	1.0	mg/l	Comp	10.2	5.9	3.6	31.8	21	5.58	3.2	3.33	20.9	18.5	12.40
Bicarbonate	A310.1	2.0	2.0	mg/l	Comp	12.84	17.1	16.1	38.52	32.1	18.2	12.8	12.8	23.5	38.5	22.2
Carbonate	A310.1	2.0	2.0	mg/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Chloride	B429	2.0	2.0	mg/l	Comp	11.7	6.57	5.45	43.3	17.5	5.62	3.67	5.59	25.8	16.6	14.16
Fluoride	B429	0.1	0.1	mg/l	Comp	0.13	0.108	0	0.22	0.237	0	0	0	0.108	0.148	0.10
Nitrate	B429	0.1	0.1	mg/l	Comp	5.73	2.13	1.54	5.29	8.22	2.53	1.44	1.89	2.21	13.5	4.45
Sulfate	B429	0.1	0.1	mg/l	Comp	11.5	6.87	5.53	29.7	19.1	4.37	5.72	4.44	10.9	17.5	11.6
Alkalinity	A310.1	4.0	4.0	mg/l	Comp	12.84	17.1	16.1	38.52	32.1	18.2	12.8	12.8	23.5	38.5	22.2
Hardness	A130.2	2.0	2.0	mg/l	Comp	38	20	18.4	54.8	40	18	16	17	29	52	30
Dissolved Phosphorus	A365.2	0.05	0.05	mg/l	Comp	0.319	0.242	0.07	0.59		0.14		0.071	0.23	0.44	0.26
Total Phosphorus	A365.2	0.05	0.05	mg/l	Comp	0.793	0.585	0.38	1.1		0.41		0.324	0.45	1.22	0.66
COD	A410.4	5	10	mg/l	Comp	89.6	133	108.5	81.6	201.3	57.9	17	70.73	50.98	147	95.78
pH	A150.1	0-14	0-14		Comp	6.63	6.61	6.54	6.89	7.23	6.53	6.6	6.81	7.03	6.93	6.78
NH3-N	A350.3	0.1	0.1	mg/l	Comp	0.259	0.387	0.3	2.68	1.87	0.227	0.449	0.194	0.322	1.1	0.779
Nitrate-N	C4110B	0.1	0.5	mg/l	Comp	1.29	0.481	0.348	1.2	1.86	0.572	0.325	0.427	0.499	3.051	1.005
Nitrite-N	C4110B	0.01	0.03	mg/l	Comp	0.05	0.048	0.042	0.171	0.206	0.058	0.043	0.046	0.108	0.21	0.098
TKN	A351.4	0.1	0.1	mg/l	Comp	2.2	2.72	1.81	5.08	5.75	1.82	1.36	1.846	1.78	5.18	2.95
Specific Conductance	A120.1	1	1	umhos/cm	Comp	136	94.6	60	325	210	78		70	183	229	154
Total Dissolved Solids	A160.1	2.0	2.0	mg/l	Comp	92	76	38	202	138	50		46	110	150	100
Turbidity	A180.1	0.1	0.1	NTU	Comp	10.9	25	24	48	24	37	23	29	25	140	38
Total Suspended Solids	A160.2	2.0	2.0	mg/l	Comp	127	107	88	155	57	129		119	71	1160	223
Volatile Suspended Solids	160.4	1.0	1.0	mg/l	Comp	45	42	32	65	23	47		48	22	122	50
MBAS	A425.1	0.05	0.05	mg/l	Comp	0.31	0.096	0.068	0.161	0.211	0.083		0.1	0.13	0.135	0.144
Total Organic Carbon	A415.1	1.0	1.0	mg/l	Comp	17.05	12.2	5.6	7.4	33.1	5.14	2.4	2.52	8.09	24.21	11.77
BOD	A405.1	2.0	2.0	mg/l	Comp	28	31	20	16.8	35.87	23.5		44	32.7	30.8	29.2
Metals																
Dissolved Aluminum	A202.2	100	100	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Aluminum	A202.2	100	100	ug/l	Comp	2540	1270					0	0	0	1029	807
Dissolved Antimony	A204.2	1	5	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Antimony	A204.2	1	5	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	A206.2	1	5	ug/l	Comp	0	0	0	1	0	0	0	0	0	0	0
Total Arsenic	A206.2	1	5	ug/l	Comp	0	0	0	2	0	0	0	0	0	2	0
Dissolved Barium	A208.2	1	10	ug/l	Comp	0	0	10	10	0	0	11	0	18	40	9
Total Barium	A208.2	1	10	ug/l	Comp	0	0	23	10	0	0	20	0	41	87	18
Dissolved Beryllium	A210.2	1	1	ug/l	Comp		0					0	0	0	0	0
Total Beryllium	A210.2	1	1	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Dissolved Boron	A212.3	100	100	ug/l	Comp	0	0	0	182	110	0	0	0	100	0	39
Total Boron	A212.3	100	100	ug/l	Comp	0	165	0	278	158	0	0	0	103	0	70
Dissolved Cadmium	A213.2	1	1	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Cadmium	A213.2	1	1	ug/l	Comp	0	0	0	1	0	0	0	0	0	0	0
Dissolved Chromium	A218.2	1	5	ug/l	Comp	0	0	0	0	0	0	5	2	2	1	1
Total Chromium	A218.2	1	5	ug/l	Comp	12	0	5	2	0	4	6	3	3	4	4
Dissolved Chromium +6		10	10	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Chromium +6		10	10	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0

DL - Detection limit
PQL - Practical quantitation limit

R0012232

Table D-3. Summary of Results for 1996-1997 Low Flow Pilot Study

DPW SAMPLE NO.						58960	59022	59045	59103	59153	59163	59280	59210	59251	59325	
STATION NO.						S24	S24	S24	S24	S24	S24	S24	S24	S24	S24	
STATION NAME						Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	
DATE SAMPLED						10/30/96	11/21/96	12/09/96	12/21/96	12/05/96	12/27/96	01/01/97	01/12/97	01/22/97	02/10/97	
DATE DELIVERED						10/30/96	11/21/96	12/10/96	12/23/96	12/06/96	12/27/96	01/06/97	01/13/97	01/22/97	02/11/97	
STORM NO.	EPA Method	DL	PQL	Units	Sample Type	1	2	3	4	2A	5	5A	6	7	8A	Mean
Metals (cont.)																
Dissolved Copper	A220.1	1	5	ug/l	Comp	12	10	0	16	24	2	5	6	4	16	10
Total Copper	A220.1	1	5	ug/l	Comp	60	24	13	990	51	19	7	9	15	34	122
Dissolved Iron	A236.1	100	100	ug/l	Comp	0	140	0	120	0	150	0	0	0	0	41
Total Iron	A236.1	100	100	ug/l	Comp	3930	1.4	410	700	1100	600	130	270	658	1720	952
Dissolved Lead	A239.2	1	5	ug/l	Comp	0	0	0	0	3	0	0	0	0	0	0
Total Lead	A239.2	1	5	ug/l	Comp	48	13	14	9	19	6	4	6	9	8	14
Dissolved Manganese	A243.1	50	50	ug/l	Comp	30	0	0	0	0	0	0	0	0	0	3
Total Manganese	A243.1	50	50	ug/l	Comp	160	40	0	0	0	0	0	0	0	0	20
Dissolved Mercury	A245.1	0.1	1	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Mercury	A245.1	0.1	1	ug/l	Comp	0	1	0	0	0	0	2	0	0	0	0
Dissolved Nickel	A249.2	1	5	ug/l	Comp	0	0	0	5	6	0	1	0	1	2	2
Total Nickel	A249.2	1	5	ug/l	Comp	21	0	7	9	16	3	5	4	4	7	8
Dissolved Selenium	A270.2	0.2	5	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Selenium	A270.2	0.2	5	ug/l	Comp	0	0	0	0	0	0	0	1	0	0	0
Dissolved Silver	A272.2	0.2	1	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Silver	A272.2	0.2	1	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	A279.2	1	5	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Total Thallium	A279.2	1	5	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	A289.1	10	50	ug/l	Comp	590	300	250	630	450	220	17	10	0	0	247
Total Zinc	A289.1	10	50	ug/l	Comp	1010	350	250	760	580	860	180	200	204	300	469
Semi-Volatile Organics																
Bis(2-ethylhexyl)phthalate	525	3.0	3.0	ug/l	Comp	3.7	3.2	31.5	8.6	28.1	3.8		12.2	17.5	5.9	12.7
All other SVOCs	525	0.5 - 5.0	0.5 - 5.0	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Pesticides																
Organochlorine Pesticides & PCBs	D608	0.05 - 1.0	0.05 - 1.1	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Diazinon	507	0.05	0.25	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Chlorpyrifos	507	0.20	1.00	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Other N- and P-Containing Pesticides	507	1.0 - 2.0	1.0 - 2.0	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Carbofuran	531.1	5.0	5.0	ug/l	Comp	0	0	0	0	0	0			0	0	0
Chlorinated Herbicides & Bentazon																
2,4-D	515.1	10.0	10.0	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
2,4,5-TP	515.1	1.0	1.0	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Bentazon	515.1	2.0	2.0	ug/l	Comp	0	0	0	0	0	0		0	0	0	0
Glyphosate	547	25	50	ug/l	Comp	0	0	0	0	0	0	0	0	0	0	0

DL - Detection limit
PQL - Practical quantitation limit

R0012233

The following problems occurred with the sampling equipment. For Storm 1, the adjacent triggering precipitation gauge was not yet operational. The flow record was inconsistent during Storm 7, which was the result of a calibration problem. For this event, data were analyzed for the first portion of the stormflow (shaded dark in the hydrograph in Attachment D-2). The calibration problem continued through Storm 8 and was fixed in early February before Storm 8A.

During the larger events the small pacing volume prevented the samplers from taking the correct number of samples. The sampler typically spends 2.5 minutes in the sampling mode once triggered by the flow meter. The flow meter will not begin to accumulate runoff volume for the next sample until the 2.5 minute sampling cycle is complete. There is, therefore, a down time following each pumping cycle. When the pacing volume is small and the runoff is high, the number of samples obtained is less than the target. This occurred in many of the larger events.

The sampler pacing for Storms 4, 5A, and 6 has been plotted to show this effect (Attachment D-2). In these figures the diamonds represent the theoretical sampler pacing assuming no down time. The triangles represent the theoretical sampler pacing with a 2.5 minute down time after each sample. Finally, the actual pacing is plotted with tick marks on the x-axis. All numbers above the symbols represent the number of samples taken during one hour.

During Storm 4 (0.15 inches of rain) the sampler collected three less samples than the calculated theoretical pacing. For Storm 5A (0.76 inches of rain) the sampler took one less sample than desired. However, for Storm 6 (2.49 inches of rain) the sampler took over 40 samples less than it theoretically should have. This figure does not include the periods of time not sampled when the bottles were completely filled and not yet replaced.

The water quality constituents analyzed showed some trends with storm size. A few higher concentrations than normal were seen in Storm 8A (0.13 inches rain). The composite sample for this event had the highest measured values of total suspended solids (TSS), turbidity, nitrate, total phosphorus, and hardness, while all other constituents were within the ranges of the other samples (Table D-3).

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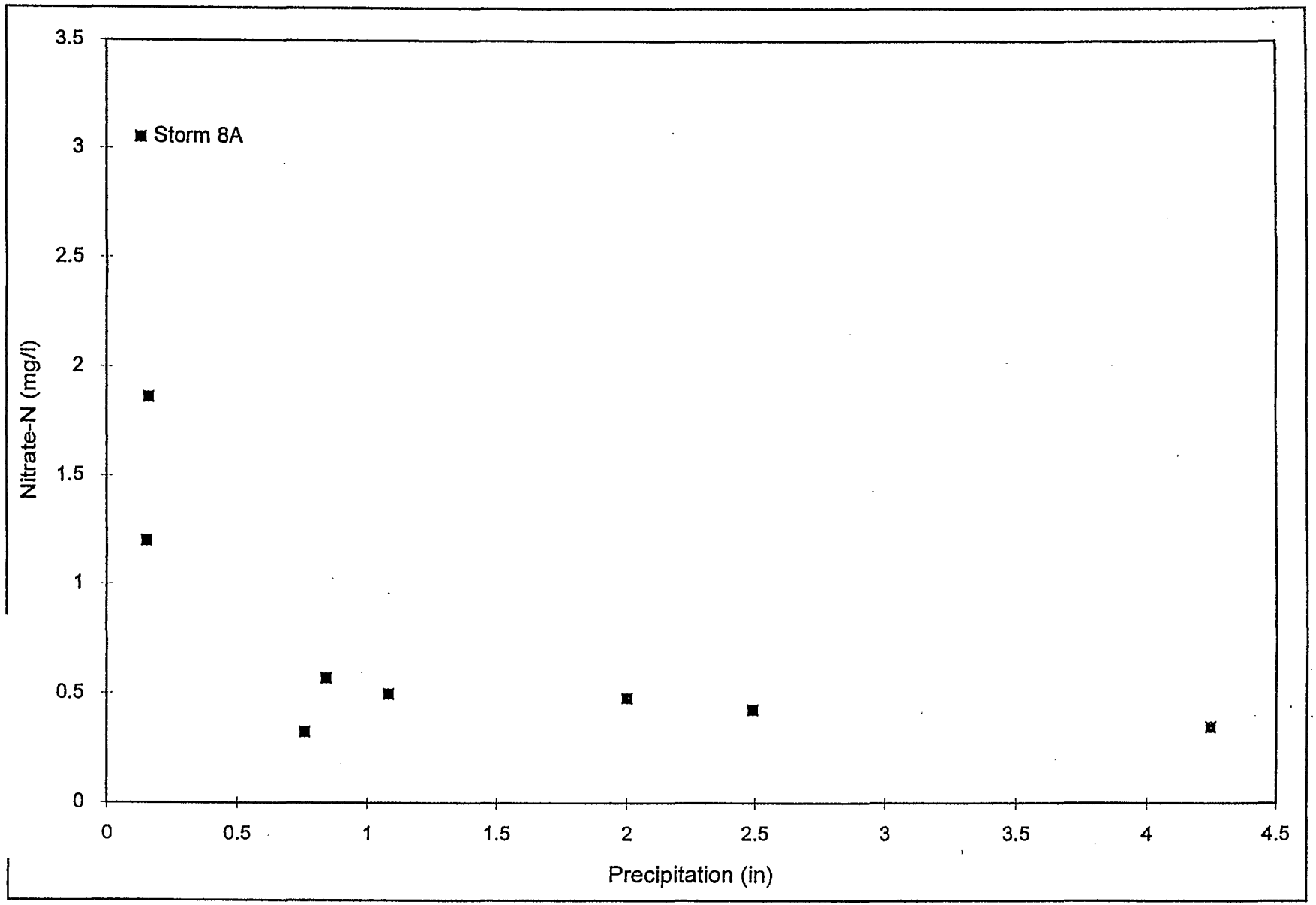
In terms of concentration of the constituents monitored, the smaller storms produced higher levels of some of the constituents than the medium to large storms. This effect is shown in Figures D-1 through D-4. It can be seen that the concentrations of nitrate and total phosphorus are higher in the smaller storms than the larger storms (Figures D-1 and D-2). The concentration of total suspended solids was highest for one of the small rainfall events (Storm 8A), but otherwise there is no trend with storm size (Figure D-3). The concentration of total metals (total zinc shown as an example) do not exhibit a trend with storm size (Figure D-4).

R0012235



R0012236

Figure D-1. Event concentrations of nitrate-N for nine storms at the Low Flow Pilot Study site (Project 1202).

b_figs.xls

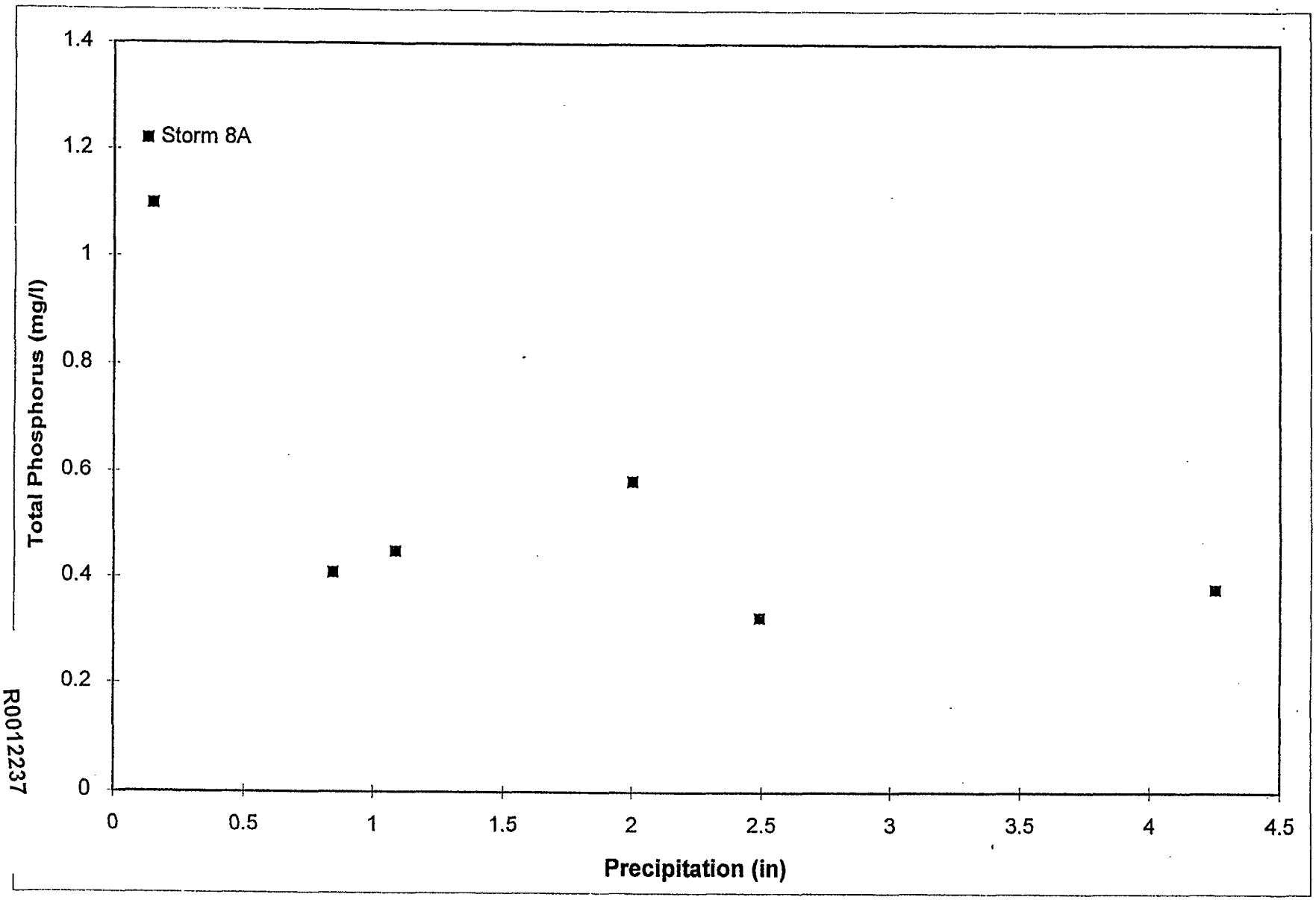
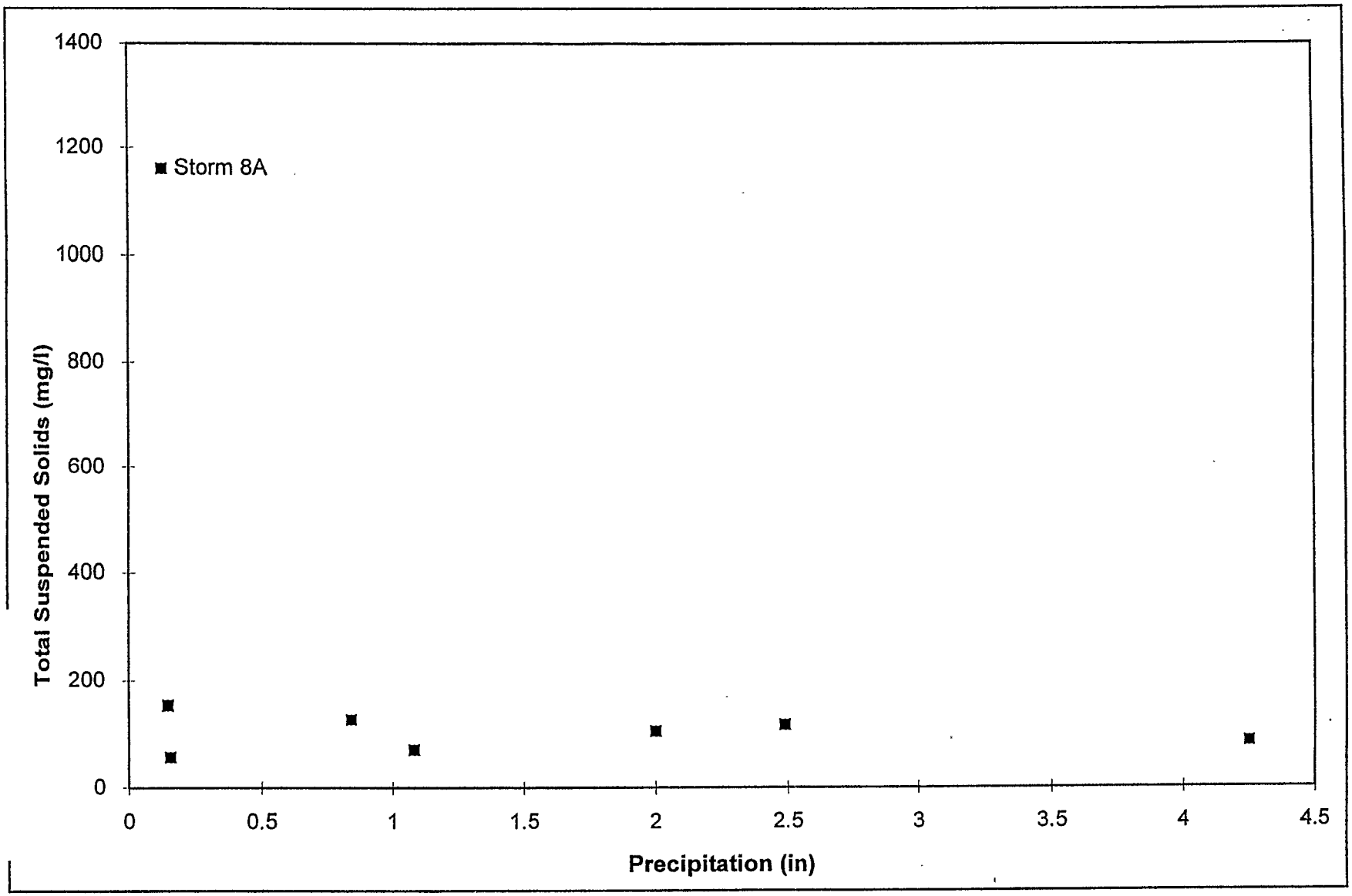


Figure D-2. Event concentrations of total phosphorus for nine storms at the Low Flow Pilot Study site (Project 1202).

B_figs



R0012238

Figure D-3. Event concentrations of total suspended solids for nine storms at the Low Flow Pilot Study site (Project 1202).

b_figs.xls

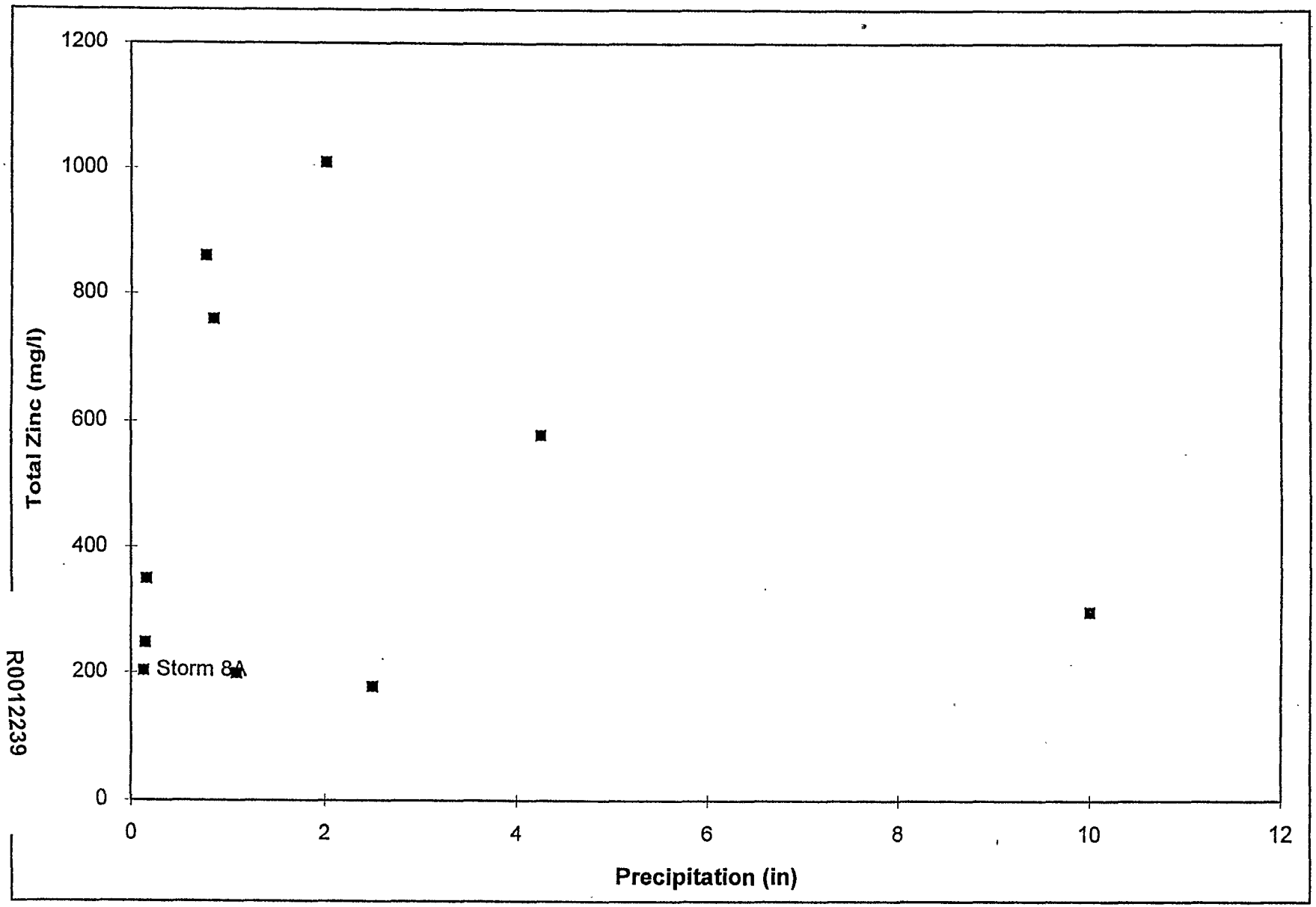


Figure D-4. Event concentrations of total zinc for nine storms at the Low Flow Pilot Study site (Project 1202).

b_figs.xls

R0012239

Field crews generally spent more time (by a factor of 2-3) on the sampling for this pilot study than any other sampling element of the Monitoring Program. Due to the small requirements for sampler pacing volume, sample bottles needed to be changed frequently throughout an event. During one event the crews needed to set up new bottles eight times (Table D-2). Transportation to and from sites during wet weather proved to be extremely time consuming. During the larger events, field crews had to handle and label many more bottles. The laboratory had to composite many more 2.5 gallon sample bottles, which also was very labor intensive.

Often the sample bottles were entirely filled and sampling discontinued for some time when field crews arrived at the sites. Thus, storm event coverage for the medium and large storm events was sacrificed to accommodate the 0.1 inches criterion.

D.4 CONCLUSIONS AND RECOMMENDATION

The conclusions presented below address the three criteria used to evaluate the effectiveness of 0.1 inches and greater event monitoring.

The operational effectiveness of the sampler

Sampler operational effectiveness dropped significantly for the Low Flow Pilot Study site. Although equipment failures were generally not a factor in this study, the equipment was not effective when the pacing volume was set so low. Due to the down time of the flow meter during the sampling cycle, samples were often missed during the highest flow rates. With the required pacing, bottles filled quickly and needed to be replaced frequently during events. With telemetry at the station and a trained staff person, the pacing volume could be charged depending on anticipated storm size. The sampling equipment should operate effectively for small storms, as evidenced by Storms 2A (0.16 inches), 4 (0.15 inches), and 8A (0.13 inches).

The feasibility and effectiveness of sample retrieval and transport

Overall, requiring that the smallest monitored storm be reduced from 0.25 inches to 0.1 inches resulted in extremely difficult sample retrieval and transport for field crews. Bottles needed to changed frequently during events, resulting in extensive travel on wet

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roads during the storms. For medium to large events the laboratory had to composite numerous 2.5 gallon bottles. If the pacing problem could be solved with telemetry and extra staff, the sample retrieval and transport would not be as burdensome for sampling events down to 0.1 inches.

The ability to reprogram and maintain this setting at other samplers

It would be relatively easy to reprogram other land use stations to sample 0.1 inches and larger storms. However, as shown in *Monitoring Plan for 1996/1997 Low Flow Pilot Study* (Woodward-Clyde and Larry Walker Associates, 1996), most of these stations would not effectively monitor the storms in the 0.1 to 0.25 inches range. This is because the flow at many stations do not respond well to small storms and also have excessive dry weather flows. There is only one other station that could potentially handle the 0.1 inches criteria as reported in the monitoring plan report. This station is Dominguez Channel (S23). Note that telemetry, tipping bucket rain gauges, and new samplers would need to be added to this station to perform the low flow monitoring. The current samplers cannot accommodate telemetry so they would need to be replaced.

Recommendation

Based on the three criteria discussed above, we recommend that all land use sites be monitored for storms 0.25 inches and greater for the duration of the 1996 Municipal Permit. It is our opinion that the 0.1 inches sampling will not be effective unless stations can be provided with telemetry. To convert stations to telemetry, sampling units will need to be replaced, which will be expensive, due to an incompatibility with telemetry. In this case, only two of the seven existing stations (Project 1202 and Dominguez Channel) could be monitored for storm over 0.1 inches, since the five other sites either have inadequate hydrologic responses to small events, low imperviousness, or high and variable dry weather flows.

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REFERENCES

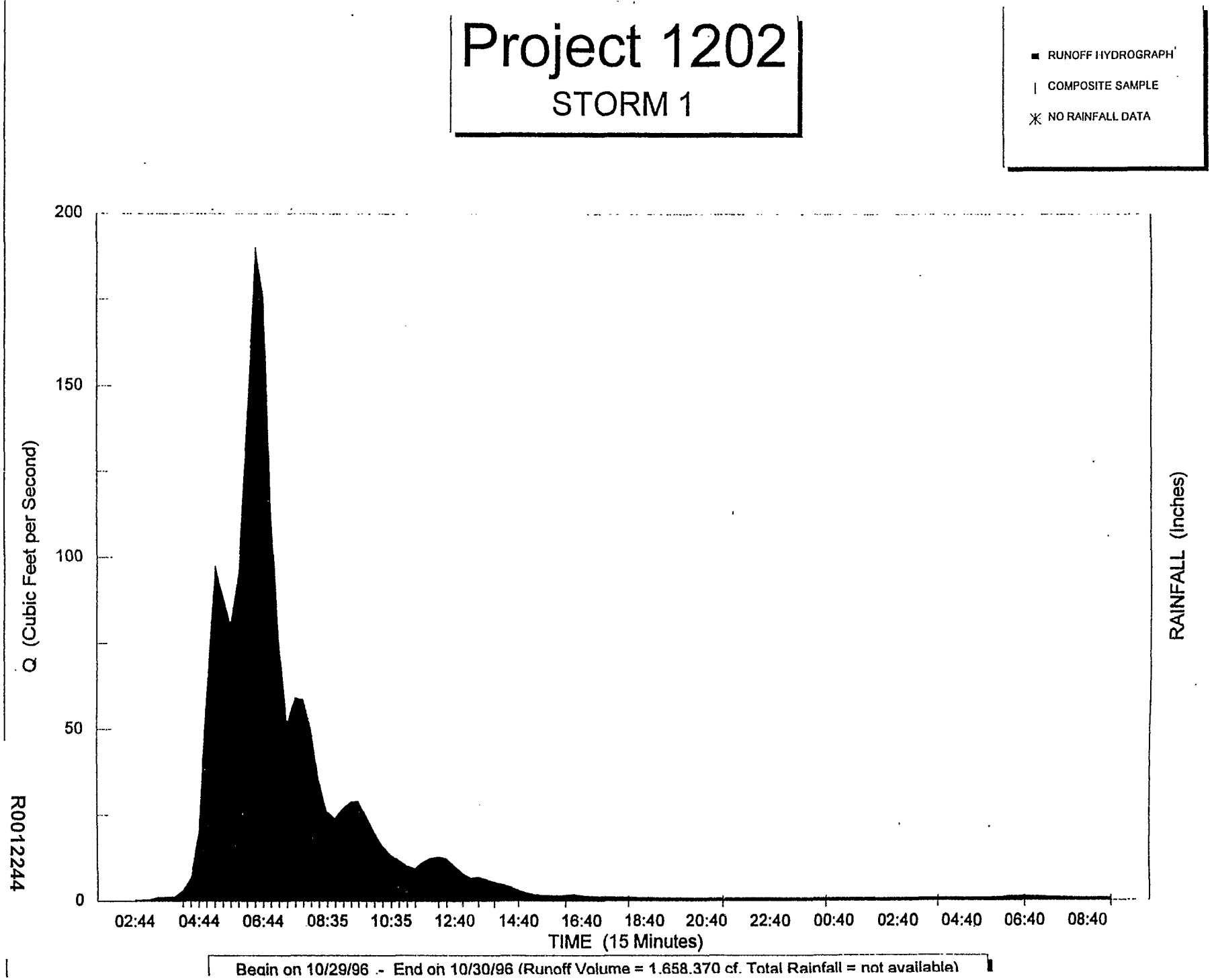
Woodward Clyde Consultants. 1996. Evaluation of analytes and QA/QC specifications for monitoring program. Report prepared for Los Angeles County Department of Public Works, Alhambra, CA, December 1996.

Woodward Clyde Consultants and Larry Walker Associates. 1996. Monitoring plan for 1996/1997 low flow pilot study. Prepared for Los Angeles County Department of Public Works, Alhambra, CA, November 1996.

R0012242

ATTACHMENT D-1

Project 1202
STORM 1



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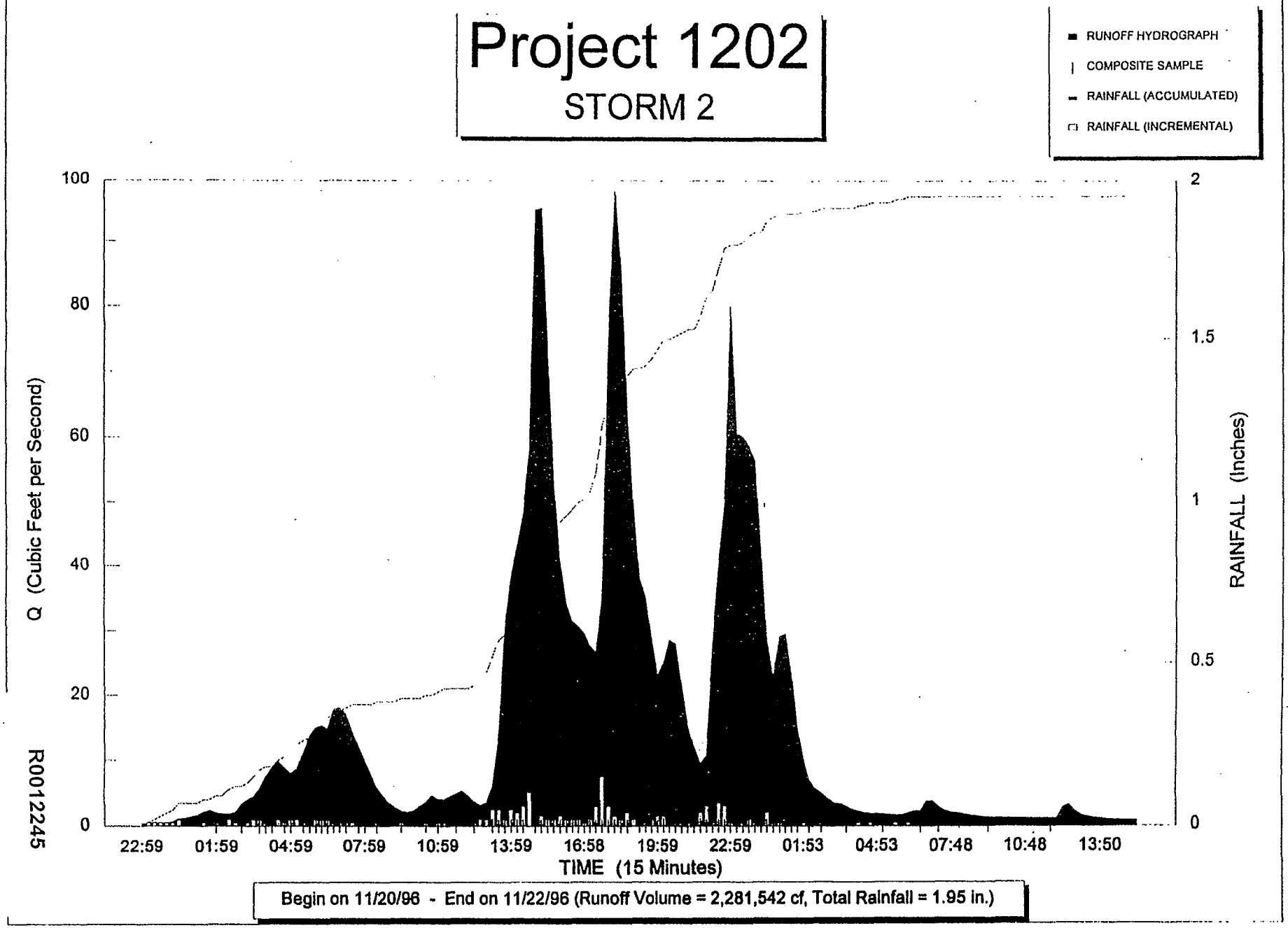
Project 1202
STORM 2



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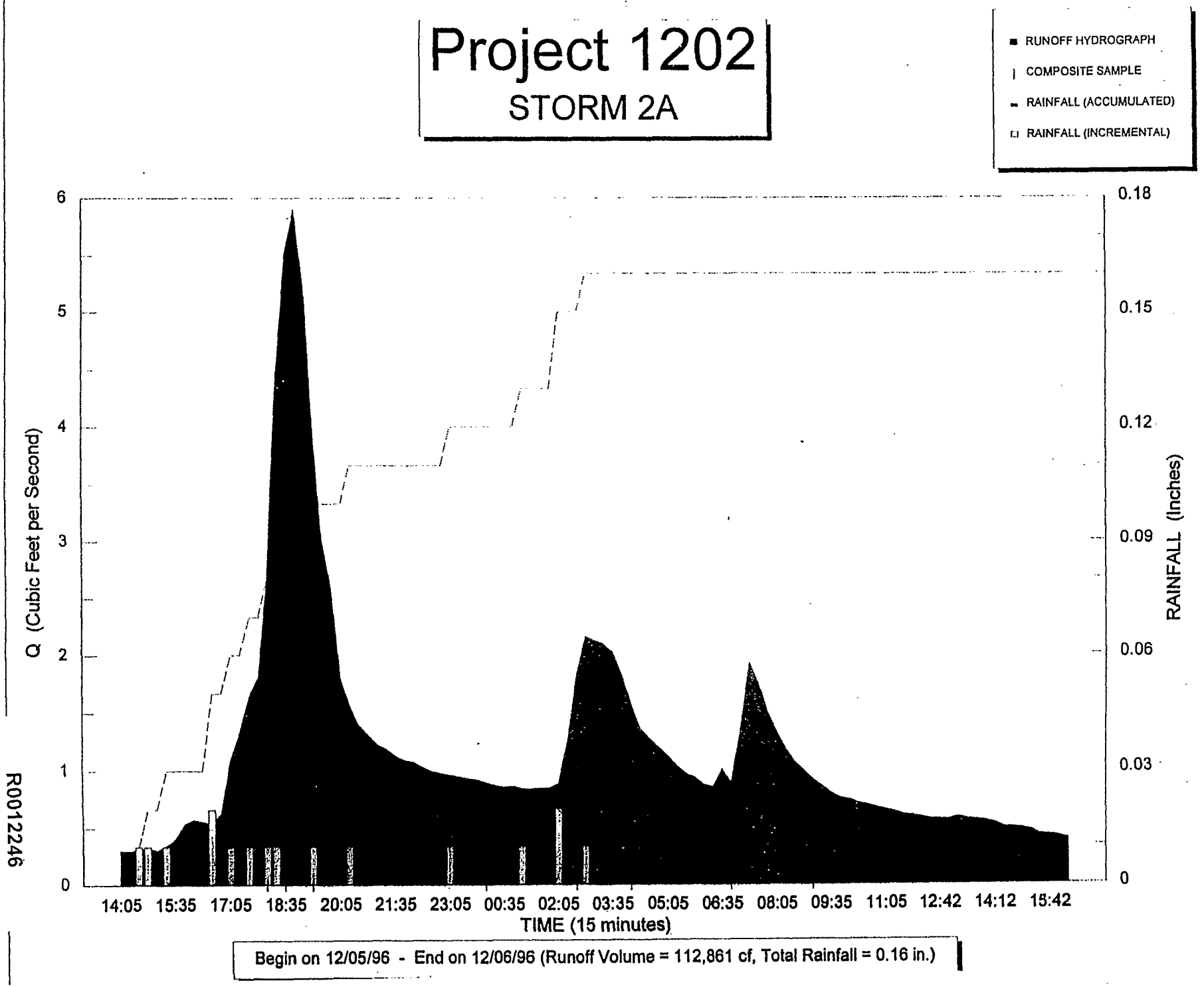
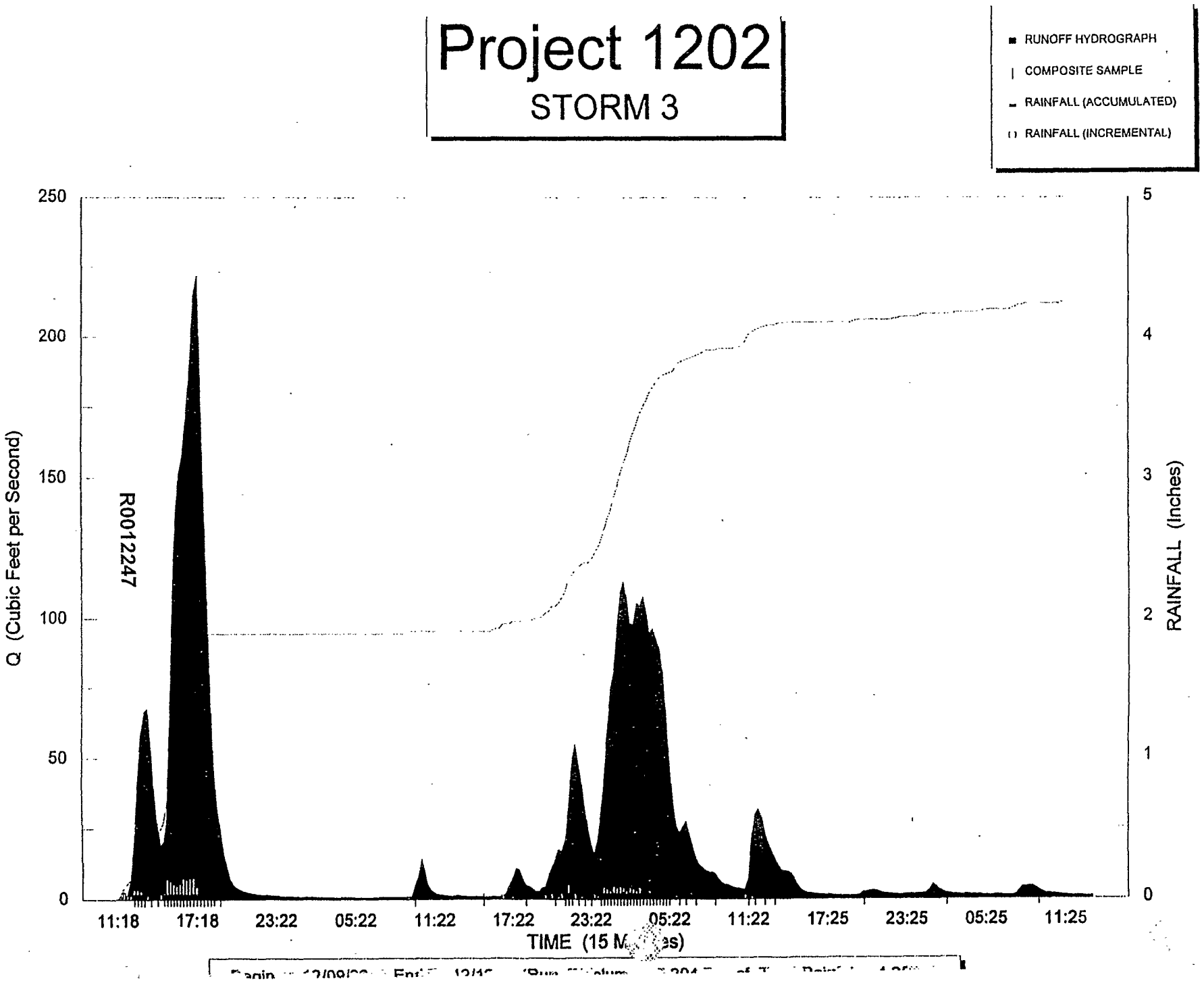
Project 1202
STORM 2A



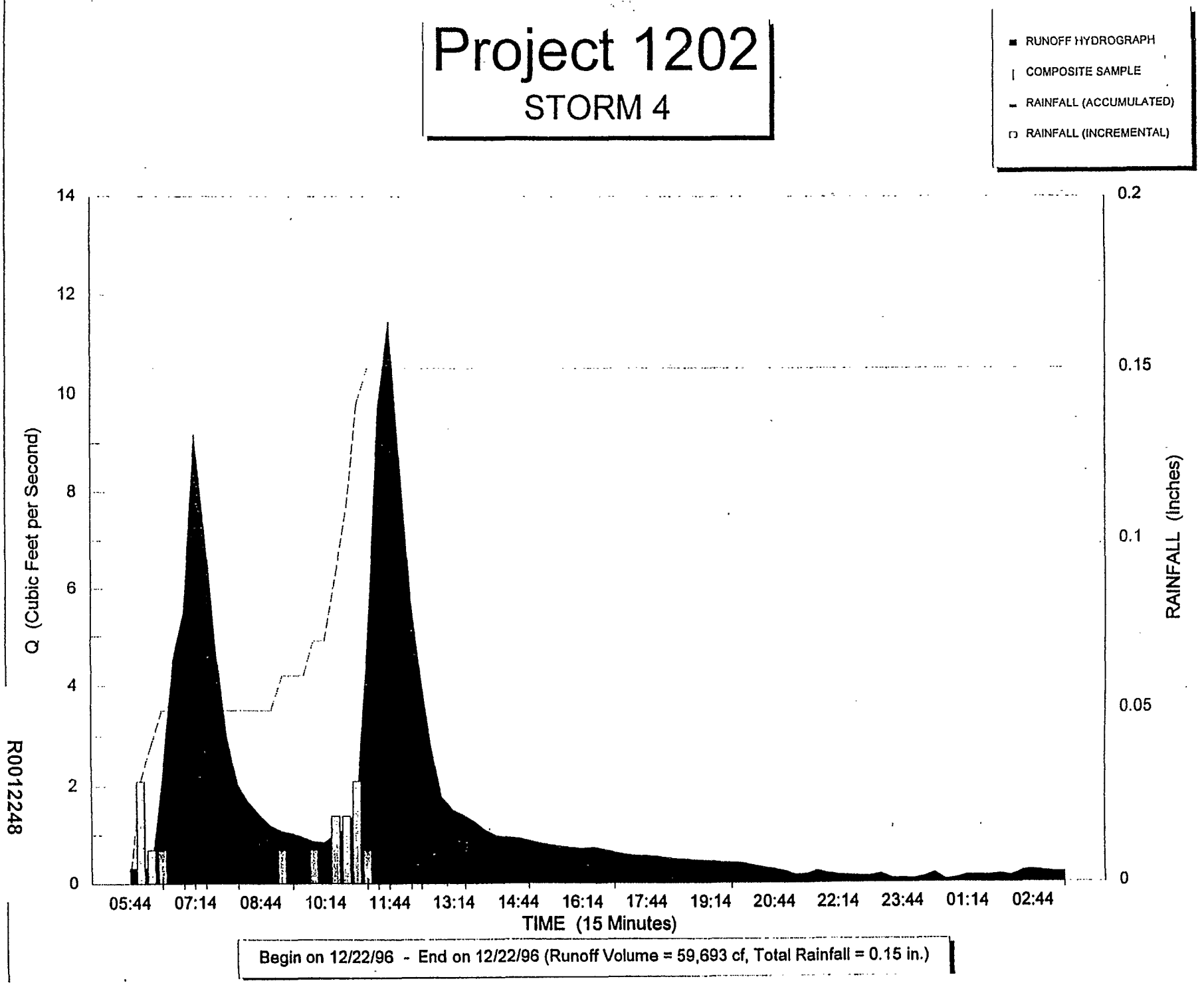
Begin on 12/05/96 - End on 12/06/96 (Runoff Volume = 112,861 cf, Total Rainfall = 0.16 in.)

R0012246

Project 1202
STORM 3



Project 1202
STORM 4



Begin on 12/22/96 - End on 12/22/96 (Runoff Volume = 59,693 cf, Total Rainfall = 0.15 in.)

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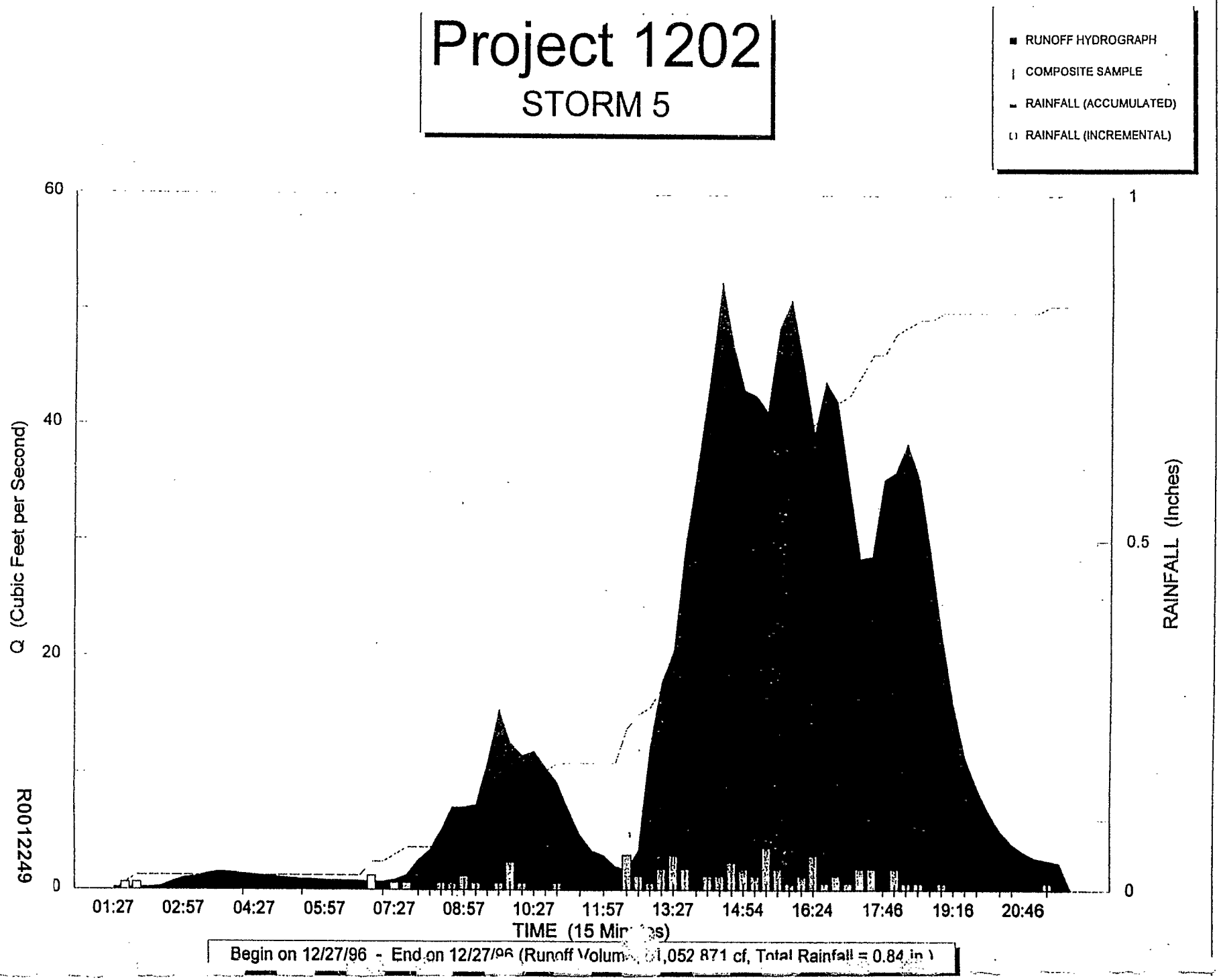
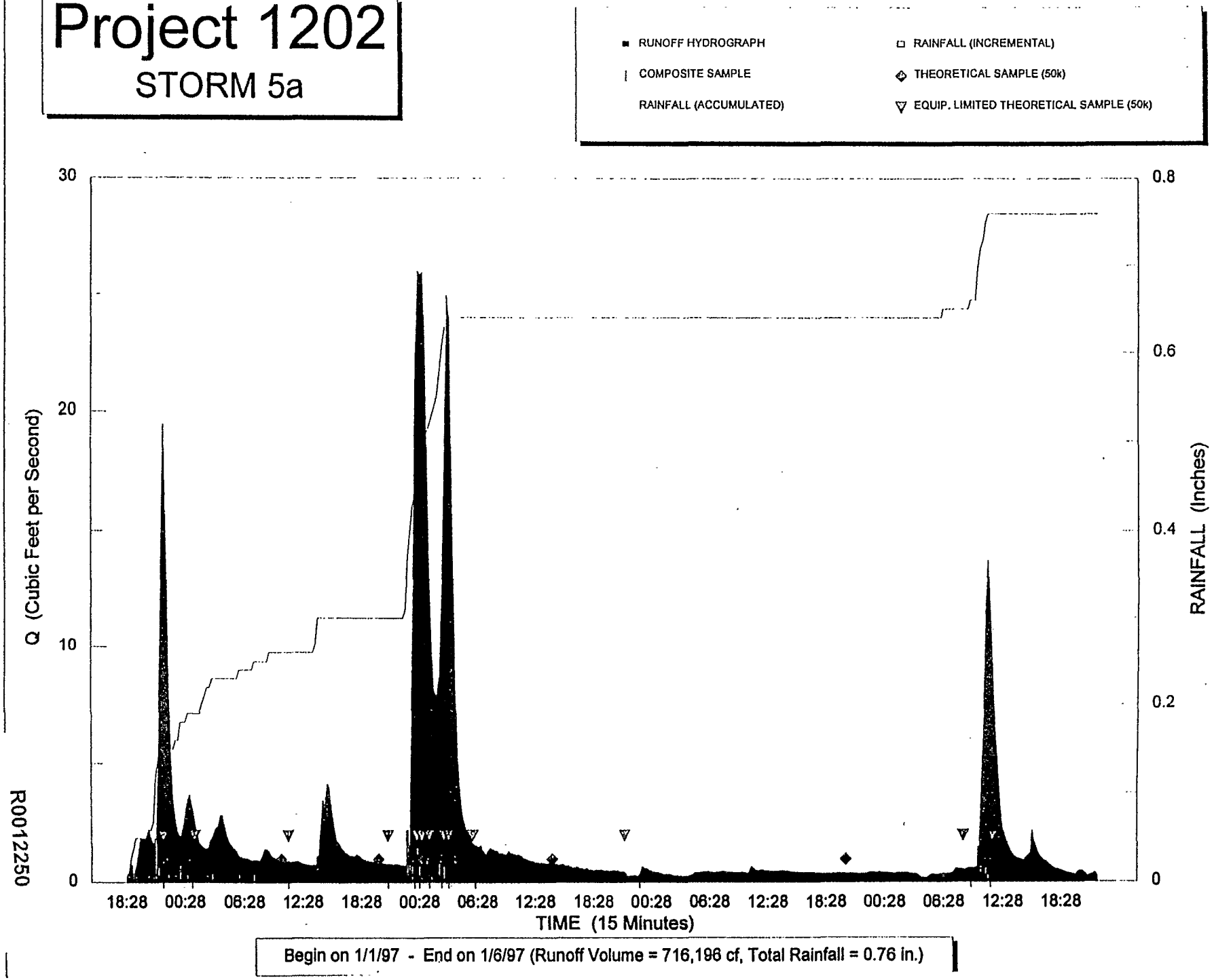
Project 1202
STORM 5



R0012249

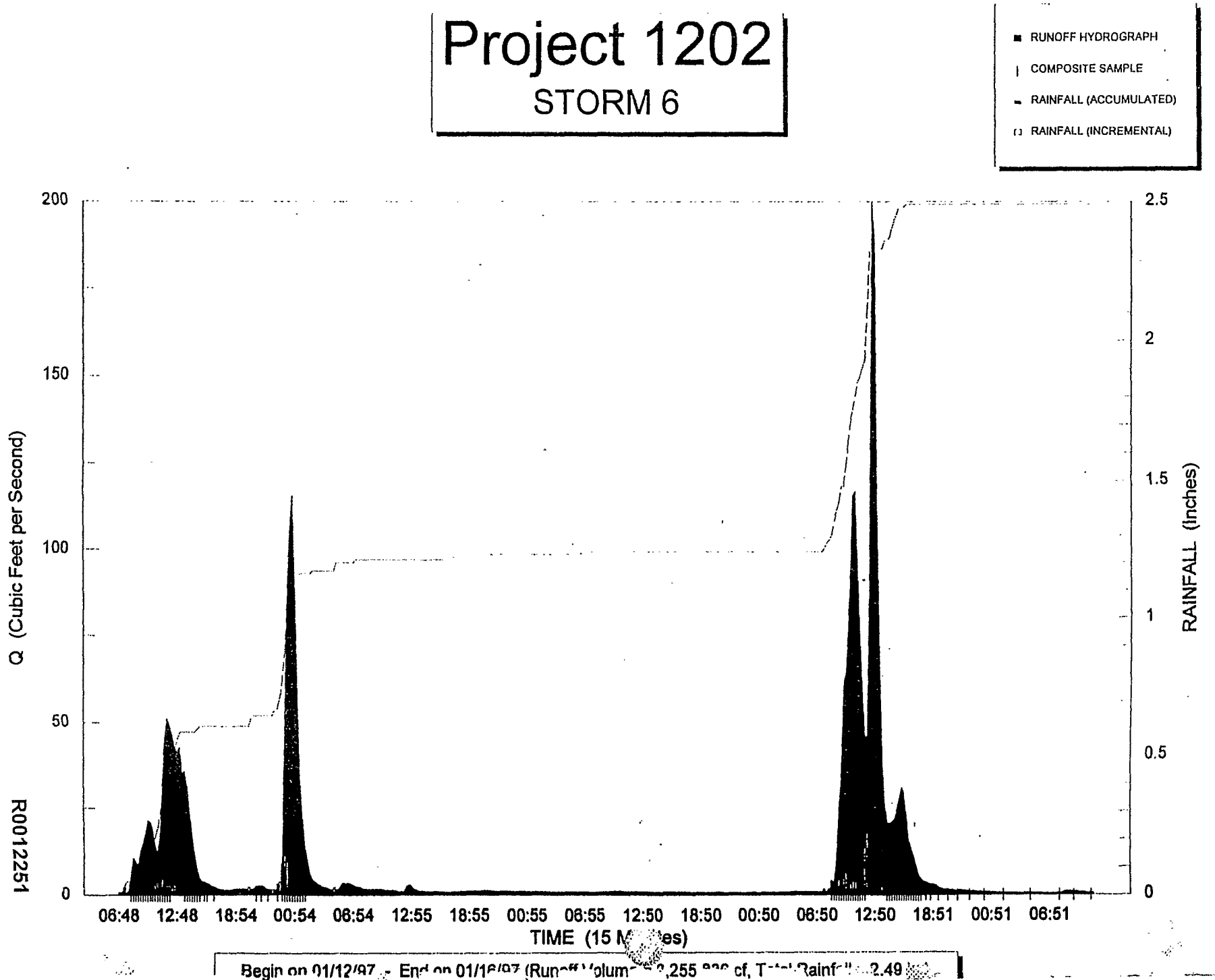
Project 1202
STORM 5a



Begin on 1/1/97 - End on 1/6/97 (Runoff Volume = 716,196 cf, Total Rainfall = 0.76 in.)

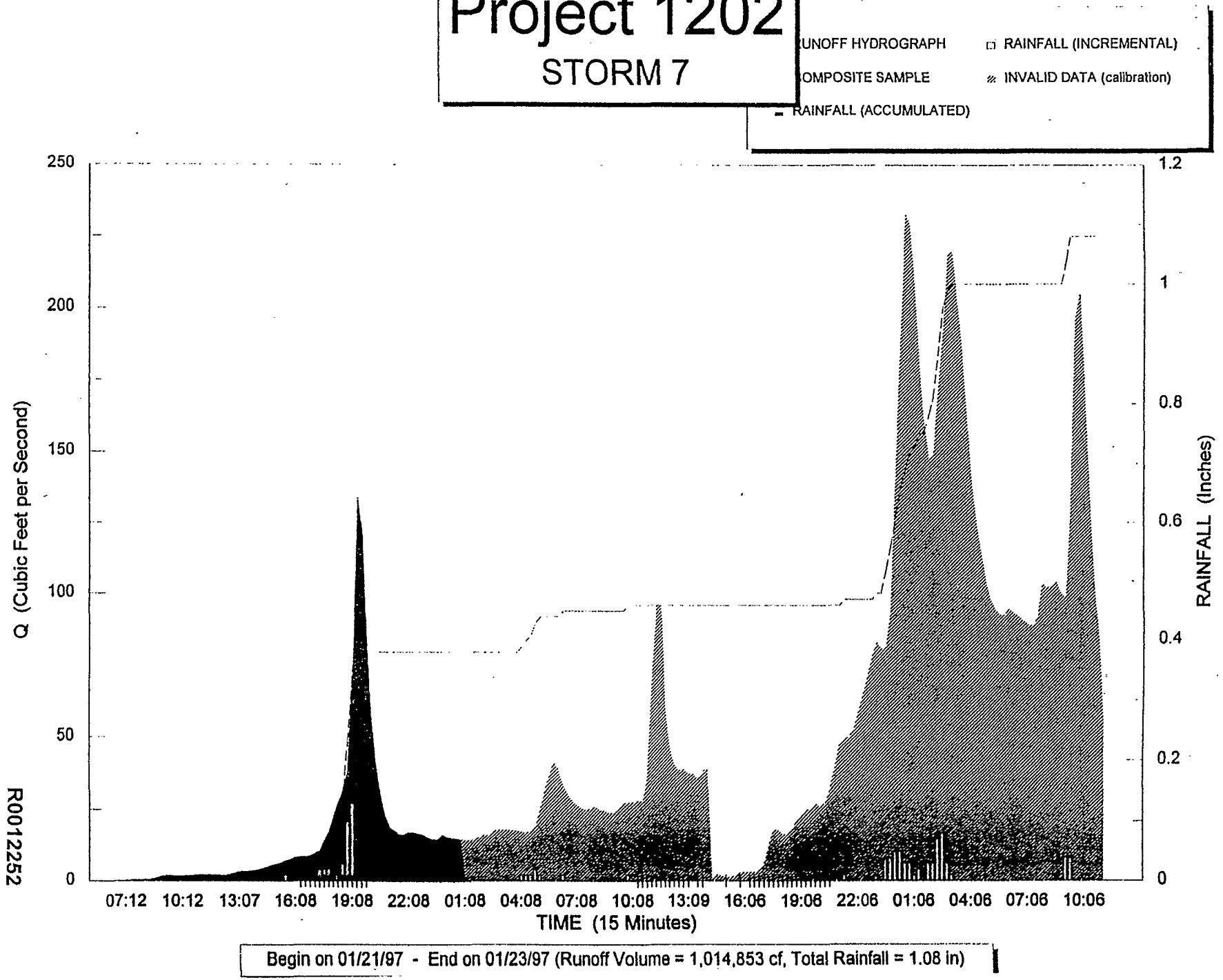
R0012250

Project 1202
STORM 6



Project 1202

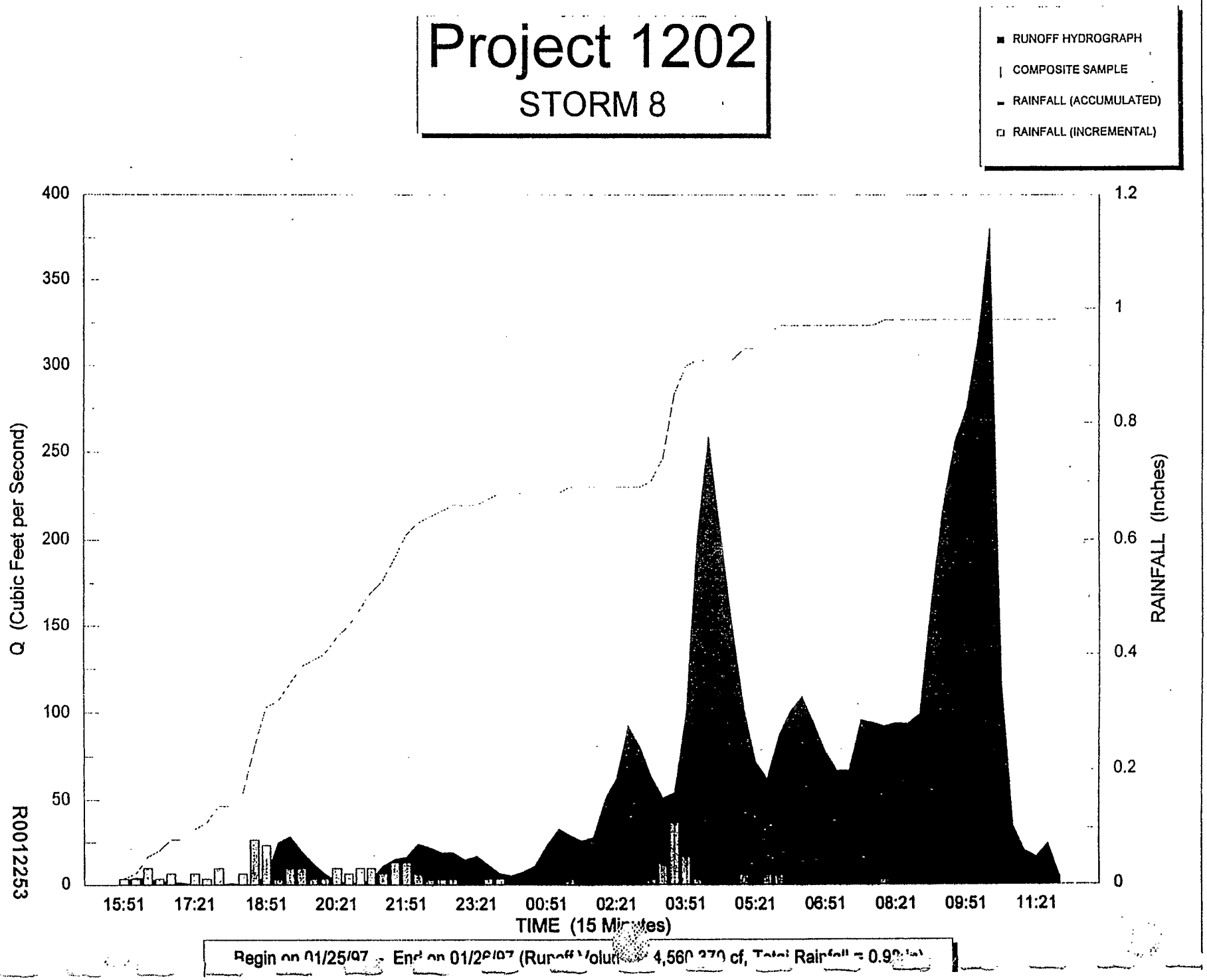
STORM 7



Begin on 01/21/97 - End on 01/23/97 (Runoff Volume = 1,014,853 cf, Total Rainfall = 1.08 in)

R0012252

Project 1202
STORM 8



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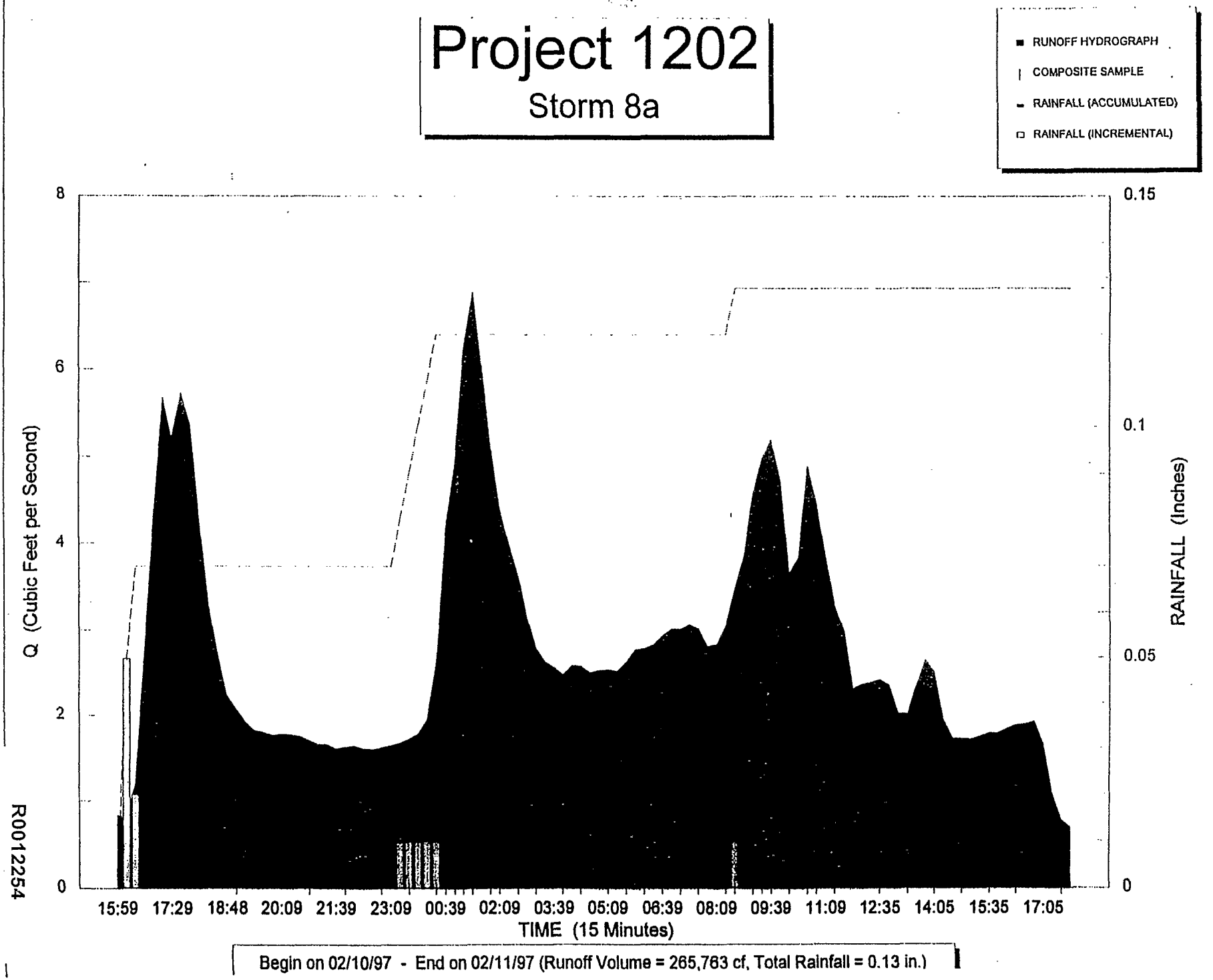
Project 1202

Storm 8a



Begin on 02/10/97 - End on 02/11/97 (Runoff Volume = 265,763 cf, Total Rainfall = 0.13 in.)

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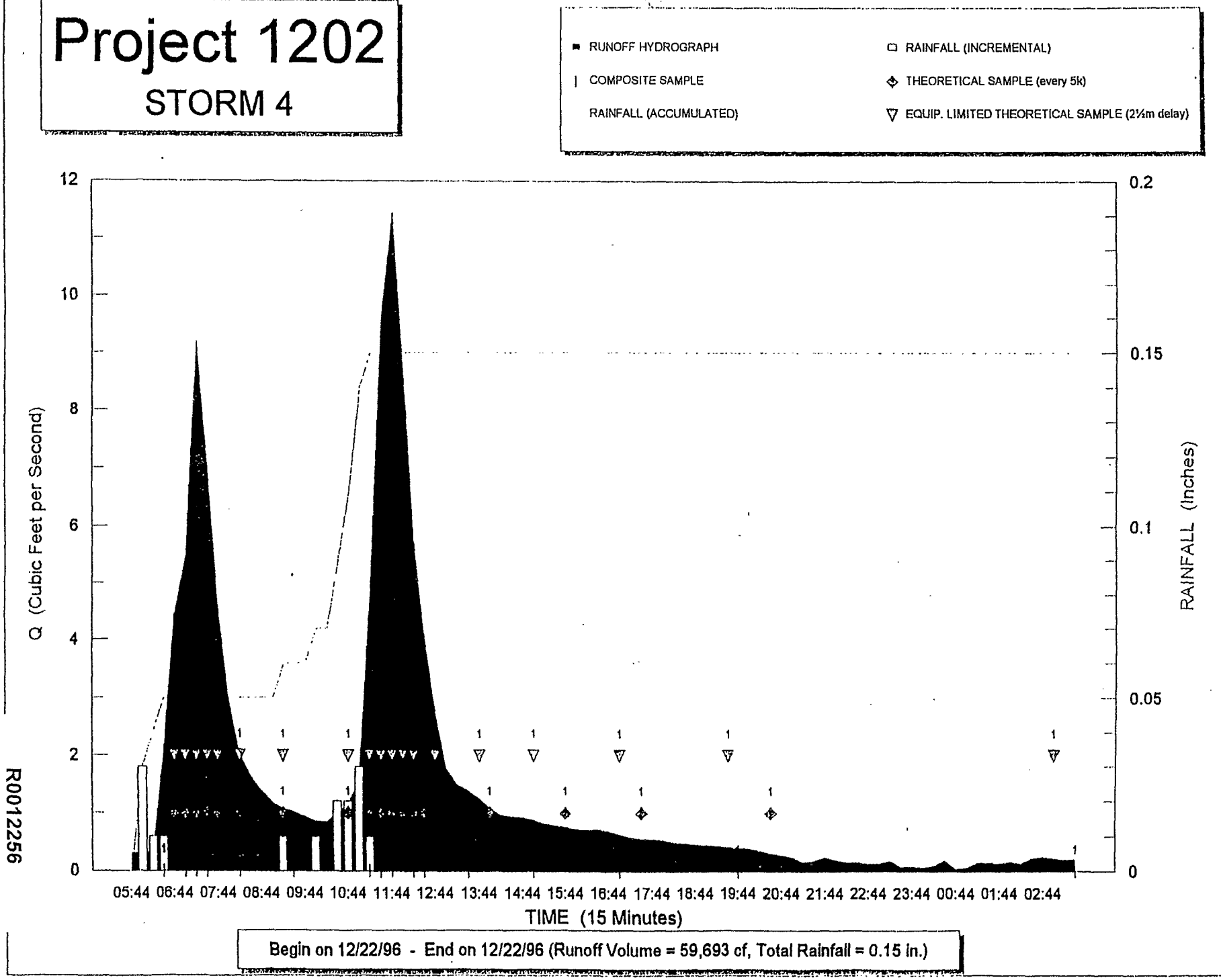
ATTACHMENT D-2

Project 1202

STORM 4



Begin on 12/22/96 - End on 12/22/96 (Runoff Volume = 59,693 cf, Total Rainfall = 0.15 in.)

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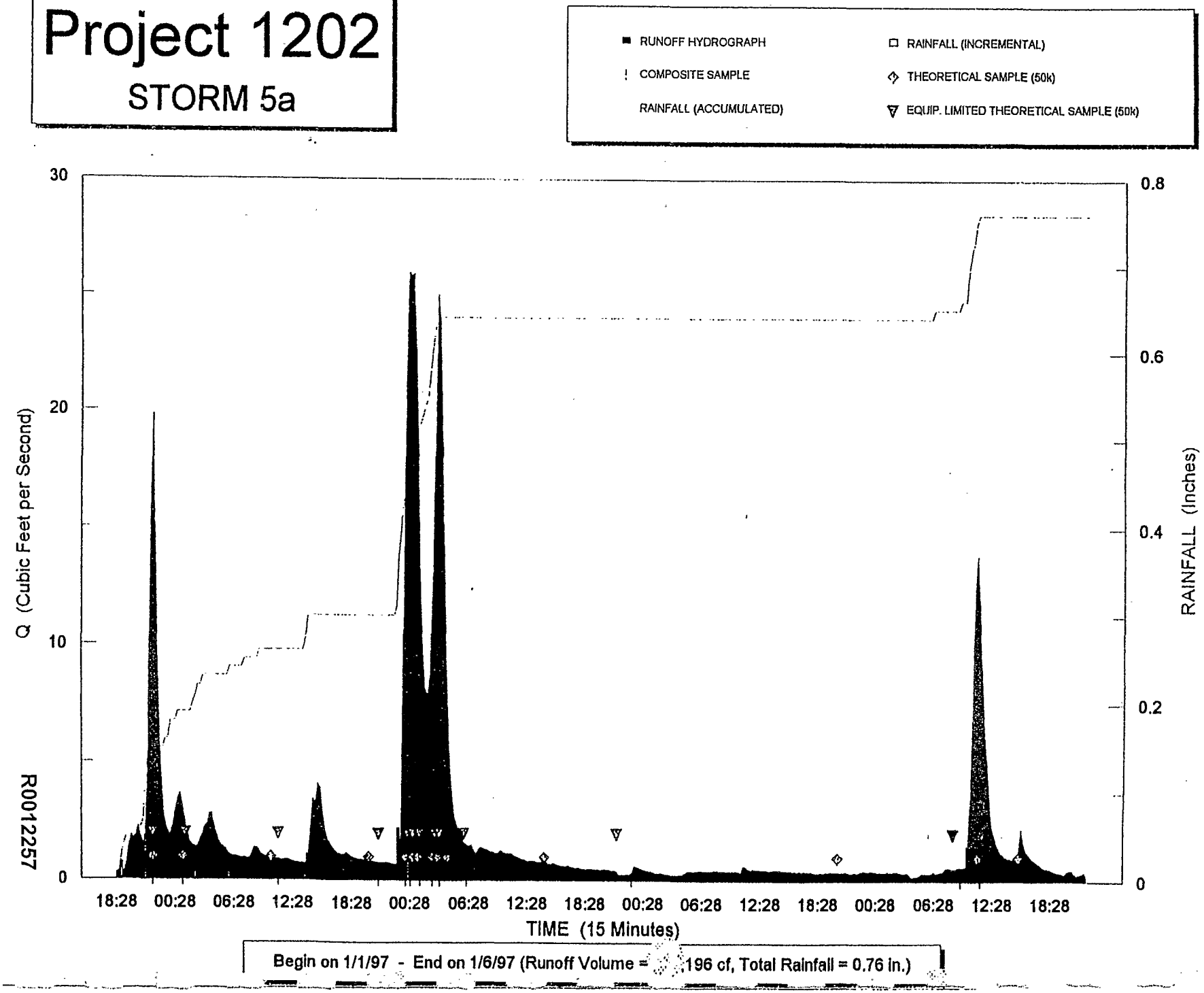
Project 1202

STORM 5a



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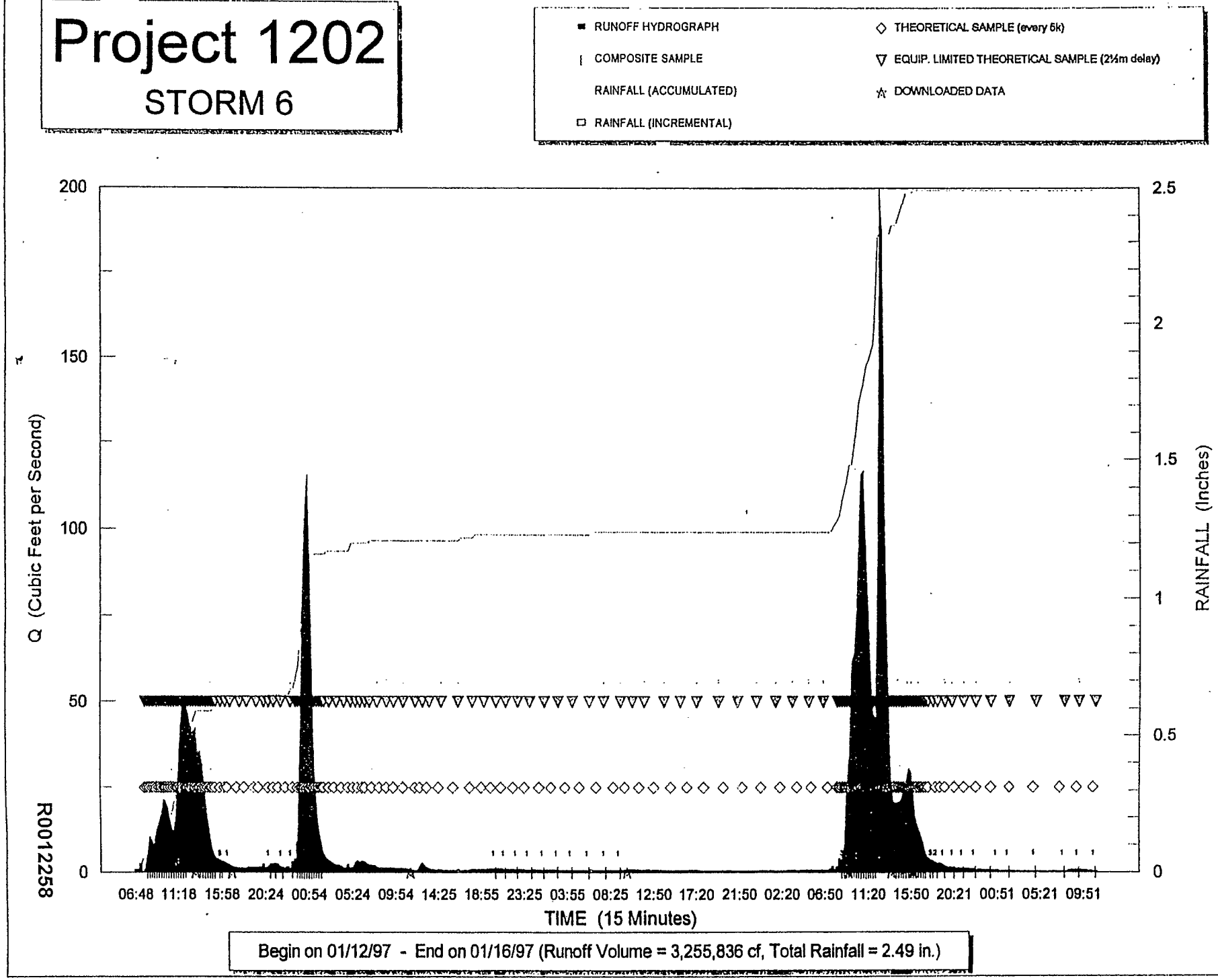
Project 1202

STORM 6



Begin on 01/12/97 - End on 01/16/97 (Runoff Volume = 3,255,836 cf, Total Rainfall = 2.49 in.)

Appendix E
Wide Channel Pilot Study

E.1 INTRODUCTION

The purpose of the Wide Channel Pilot Study is to evaluate the accuracy of a single point water quality intake in representing the water quality in wide channels. The primary focus of this study was the comparison of a series of surface water grab samples collected across the width of a representative channel to investigate horizontal variations in water quality within wide channels. The secondary focus was to compare the surface grab samples with water samples collected near the bottom of the channel by an automated sampling station to evaluate the vertical variability in water quality.

The pilot study was conducted at the Ballona Creek mass emission monitoring station, located between Sawtelle and Sepulveda Boulevards at LACDPW stream gage No. F38C-R. The Ballona Creek station was selected because it provided the most suitable conditions for conducting the pilot study.

E.2 EQUIPMENT AND METHODS

This section provides a summary of the Wide Channel Pilot Study methods. The complete methods for this pilot study are included in *Monitoring Plan for 1996-97 Wide Channel Pilot Study* (Woodward-Clyde, November 1996).

In order to characterize the lateral variability in water quality within Ballona Creek, water quality sampling was conducted at five stations across the channel. The sampling pattern included four sampling stations along the Sawtelle Boulevard bridge that were spaced equidistant from each other, and an automated sampling station at the existing monitoring station at the side of the channel. All samples obtained from the four bridge stations were taken from the water surface. Stations located along the bridge are identified as West-Out, West-In, East-In, and East-Out (the In/Out designation described whether the station was inside or outside of the low-flow channel). Grab samples were also collected from the automated monitoring station, which takes samples from the water at the bottom of the channel. These samples are identified as Bottom samples (Figure E-1).

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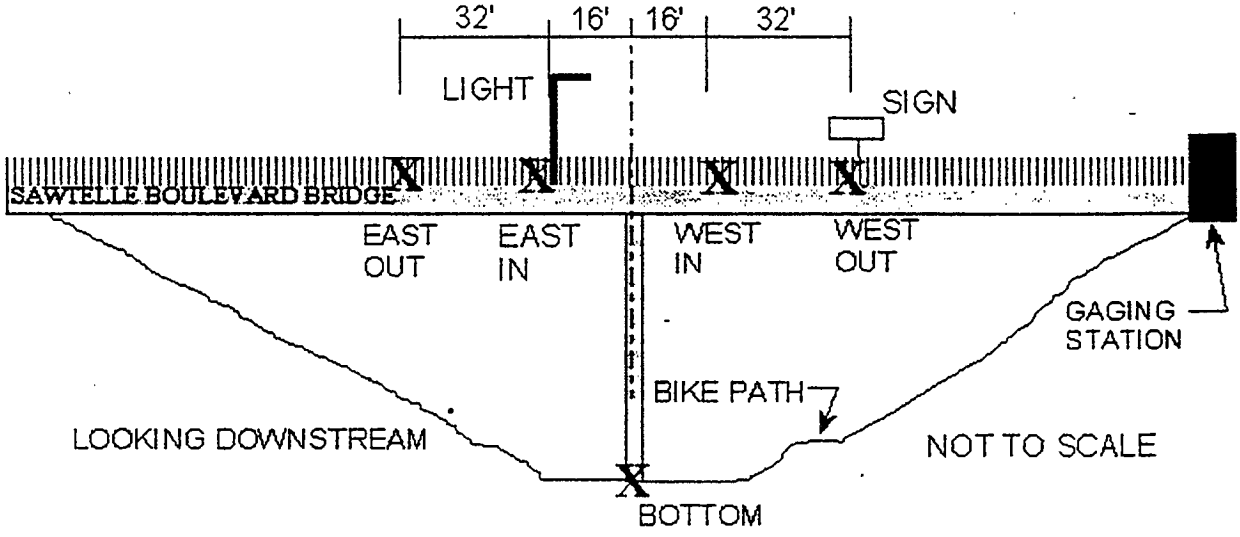
Figure E-1
Cross Section of Ballona Creek
At Sawtelle Blvd. looking downstream



Each station was sampled three times during each of three events at a 2-3 hour recurrence interval. Therefore, for each event a maximum of fifteen samples were collected if channel conditions allowed. The Monitoring Plan included the sampling of at least three events sampled, thereby potentially resulting in 45 data points.

Grab samples from the four stations along the bridge were taken manually from the water surface using a clean, polyethylene bucket and rope. One bucket was used for each station. Water temperature in all samples was measured in the field along with observations of water color, odor, and presence of oil sheen. All samples were analyzed at the Department of Agricultural Commissioner/Weights and Measure's Environmental Toxicology Laboratory for the following constituents: pH, nitrate-nitrogen, specific conductivity, total dissolved solids (TDS), total suspended solids (TSS), total and dissolved copper, and total and dissolved zinc. Analytical methods for the constituents analyzed are listed in Table E-1.

E.3 SUMMARY OF RESULTS

Sampling for the pilot study was conducted during three storms of the 1996-97 storm season. These events were:

Event No.	Date	Precipitation (in)
2	Nov. 20-22, 1996	1.77
3	Dec. 9-11, 1996	3.09
6	Jan. 12-16, 1997	2.16

Hydrographs for the sampled events, including grab sample collection times, are shown in Attachment E-1. Grab samples were taken at the required 2-3 hour intervals during the rising and falling limb portions of the hydrographs.

Table E-1. Analytical Methods for Constituents Analyzed in Wide Channel Pilot Study

Class	Constituent	Sample Type	Method	DL	PQL	Units	Preservation	Holding Time
General								
	pH	Comp	A150.1	na	na		-	immed.
	Nitrate-N	Comp	C4110B	0.1	0.5	mg/l	-	48 hours
	Specific Conductance	Comp	A120.1	1	1	umhos/cm	-	immed.
	Total Dissolved Solids	Comp	A160.1	2.0	2.0	mg/l	-	7 days
	Suspended Solids	Comp	A160.2	2.0	2.0	mg/l	-	7 days
Metals								
	Dissolved Copper	Comp	A220.1	1	5	ug/l	HNO_3	6 months
	Total Copper	Comp	A220.1	1	5	ug/l	HNO_3	6 months
	Dissolved Zinc	Comp	A289.1	10	50	ug/l	HNO_3	6 months
	Total Zinc	Comp	A289.1	10	50	ug/l	HNO_3	6 months

DL = Detection limit
PQL = Practical quantitation limit
na = Not applicable
"-" = No preservation required other than cooling the sample to 4° C.

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E.3.1 WATER QUALITY DATA SUMMARY

A total of 39 samples were taken for the pilot study during the three sampling events. There were potentially a maximum of 45 samples, however six samples could not be taken due to low stages in the creek at the time of sampling. Therefore all possible samples were collected, resulting in 100 percent completeness.

The field observations and measurements of water temperature, color, odor, and presence of oil sheen show little variability in both the horizontal and vertical direction (Table E-2). Water temperature did not vary by more than 2 degrees Fahrenheit, water color had little variability, and the presence of odors or oil films did not vary between the samples in each round.

The laboratory water quality results show little variability in the constituents analyzed (Table E-3). No sampling station, including the bottom sample, stands out as having consistently greater or lesser concentrations of any of the analytes.

E.3.2 CHANNEL CROSS-SECTIONAL TRENDS IN WATER QUALITY

Analysis of variance (ANOVA) is a statistical technique that is used to evaluate the relationship between one or more effects on a particular parameter and to determine if the different levels of the effects are significantly different from each other. For this pilot study the storm event (or date) and sample location are the effects and the constituents copper, zinc, TSS, and nitrate-N are the parameters of interest. A two-way ANOVA model was applied to the natural logs of the data. Natural logs were used since checks for normality indicated that the data follow a log normal distribution, with the exception of zinc.

There are two tests that must be checked prior to considering the results from the ANOVA valid. The tests serve to check major assumptions that are inherent in the ANOVA process. They are performed on the residuals from the ANOVA. The residuals are calculated from the dataset by the ANOVA and represent the part of the data that are not explained by the effects used in the model. The residuals are tested for normal distribution and homogeneity of variance. If these assumptions are not met, the ANOVA is invalid as

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Table E-2. Field observations and measurements from the 1996/97 Wide Channel Pilot Study.

EVENT	ROUND	DATE	TIME	SAMPLE STATION	TEMP (F)	WATER COLOR	ODOR PRESENT?	OIL SHEEN?	NOTES
2	1	11/21/96	12:10	Bottom	64	Light Brown	No	NA	
2	1	11/21/96		West Out					Not enough flow to sample.
2	1	11/21/96	12:10	West In	64	Light Brown	No	No	
2	1	11/21/96	12:10	East In	64	Light Brown	No	No	
2	1	11/21/96		East Out					Not enough flow to sample.
2	2	11/21/96	14:20	Bottom	64	Light Brown	No	NA	
2	2	11/21/96	14:20	West Out	64	Light Brown	No	No	
2	2	11/21/96	14:20	West In	64	Light Brown	No	No	
2	2	11/21/96	14:20	East In	64	Light Brown	No	No	
2	2	11/21/96	14:20	East Out	64	Light Brown	No	No	
2	3	11/21/96	16:30	Bottom	62	Light Brown	No	NA	
2	3	11/21/96	16:30	West Out	62	Light Brown	No	No	
2	3	11/21/96	16:30	West In	62	Light Brown	No	No	
2	3	11/21/96	16:30	East In	62	Light Brown	No	No	
2	3	11/21/96	16:31	East Out	62	Light Brown	No	No	
3	1	12/09/96	15:30	Bottom	54	Clear/Tan	No	NA	
3	1	12/09/96	15:30	West Out	56	Tan	No	No	
3	1	12/09/96	15:30	West In	54	Tan	No	No	
3	1	12/09/96	15:30	East In	56	Tan	No	No	
3	1	12/09/96	15:30	East Out	54	Tan	No	No	
3	2	12/09/96	17:45	Bottom	58	Light Brown	No	NA	
3	2	12/09/96	17:45	West Out	58	Light Brown	No	No	
3	2	12/09/96	17:45	West In	58	Light Brown	No	No	
3	2	12/09/96	17:45	East In	58	Light Brown	No	No	
3	2	12/09/96	17:45	East Out	58	Light Brown	No	No	
3	3	12/09/96	19:45	Bottom	58	Light Brown	No	NA	
3	3	12/09/96	19:45	West Out	57	Light Brown	No	No	
3	3	12/09/96	19:45	West In	59	Light Brown	No	No	
3	3	12/09/96	19:45	East In	59	Light Brown	No	No	
3	3	12/09/96	19:45	East Out	58	Light Brown	No	No	
6	1	01/15/97	11:15	Bottom	48	Light Grey	Yes	NA	
6	1	01/15/97		West Out					Not enough flow to sample.
6	1	01/15/97	11:15	West In	48	Light Grey	Yes	No	
6	1	01/15/97	11:15	East In	48	Light Grey	Yes	No	
6	1	01/15/97		East Out					Not enough flow to sample.
6	2	01/15/97	13:15	Bottom	48	Light Brown	No	NA	
6	2	01/15/97	13:15	West Out	48	Light Grey	No	Yes	
6	2	01/15/97	13:15	West In	48	Light Brown	No	Yes	
6	2	01/15/97	13:15	East In	48	Light Grey	No	Yes	
6	2	01/15/97	13:15	East Out	48	Light Grey	No	Yes	
6	3	01/15/97	15:15	Bottom	50	Light Grey	No	NA	
6	3	01/15/97		West Out					Not enough flow to sample.
6	3	01/15/97	15:15	West In	50	Light Grey	No	No	
6	3	01/15/97	15:15	East In	50	Light Grey	No	No	
6	3	01/15/97		East Out					Not enough flow to sample.

Notes: NA = Not Applicable

Table E-3. Summary of Results from the 1996-1997 Wide Channel Pilot Study

Constituent	Method	DL	PQL	Units	Storm Event 2 on 11/21/96						Storm Event 3 on 12/9/96						Storm Event 6 on 1/15/97					
						Sample Location						Sample Location						Sample Location				
pH	A150.1				Time	West Out	West In	Bottom	East In	East Out	Time	West Out	West In	Bottom	East In	East Out	Time	West Out	West In	Bottom	East In	East Out
					12:10		6.64	6.67	6.59		15:30	6.92	6.89	7.21	6.79	7.17	11:15		6.91	6.79	7.07	
					14:20	6	6.6	6.59	6.6	6.56	17:45	6.97	7.05	7.07	6.95	6.96	13:15	7.12	7.04	7.21	7.8	7.03
					16:30	6.6	6.54	6.57	6.53	6.55	19:45	7.07	6.99	7.1	6.98	7.02	15:15		7.04	7.05	7.15	
Nitrate-N	C4110B	0.1	0.5	mg/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		3.65	2.19	2.33		15:30	1.7	2.36	2.66	2.75	2.45	11:15		1.29	1.37	1.33	
					14:20	2.22	2.28	3.95	2.11	2.04	17:45	1.92	1.82	1.92	1.94	1.9	13:15	1.38	1.53	1.43	1.39	1.25
					16:30	1.85	1.81	2.06	1.69	1.61	19:45	2.38	2.27	2.68	2.18	2.23	15:15		2.46	3.15	2.65	
Conductivity	A120.1	1	1	umhos/cm		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		174	186	183		15:30	44	66	85	66	67	11:15		71	73	74	
					14:20	82	85	84	95	98	17:45	59	62	72	59	58	13:15	139	82	68	61	79
					16:30	87	87	87	88	101	19:45	85	81	87	80	98	15:15		140	96	133	
TDS	A160.1	2.0	2	mg/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		134	140	150		15:30	30	42	52	44	42	11:15		48	50	50	
					14:20	64	76	66	82	82	17:45	40	42	46	40	38	13:15	48	44	42	40	54
					16:30	64	62	68	68	72	19:45	56	50	58	54	66	15:15		98	96	90	
TSS	A160.2	2.0	2	mg/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		110	81	94		15:30	192	143	133	106	144	11:15		92	88	97	
					14:20	117	117	89	99	107	17:45	188	255	290	173	188	13:15	255	238	317	216	193
					16:30	65	66	95	68	64	19:45	127	131	161	127	155	15:15		150	192	158	
Copper, dissolved	A220.1	1.0	5	ug/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		21	24	21		15:30	0	1	2	1	0	11:15		0	0	0	
					14:20	12	13	13	12	12	17:45	0	0	0	0	0	13:15	0	0	2	5	0
					16:30	12	12	12	11	15	19:45	0	0	0	3	0	15:15		4	2	0	
Copper, total	A220.1	1.0	5	ug/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		52	47	39		15:30	16	18	11	17	16	11:15		22	23	19	
					14:20	30	24	35	22	33	17:45	11	19	20	18	17	13:15	31	8	39	20	45
					16:30	33	31	29	21	28	19:45	16	11	14	11	10	15:15		23	16	27	
Zinc, dissolved	A269.1	10	50	ug/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		90	100	90		15:30	120	140	130	110	140	11:15		40	40	40	
					14:20	60	70	70	60	60	17:45	130	120	130	110	100	13:15	20	0	30	30	30
					16:30	60	50	60	60	0	19:45	110	80	120	110	80	15:15		40	0	30	
Zinc, total	A289.1	10	50	ug/l		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out		West Out	West In	Bottom	East In	East Out
					12:10		210	190	190		15:30	130	150	130	110	140	11:15		110	140	150	
					14:20	150	120	160	120	180	17:45	150	180	220	130	130	13:15	210	10	220	120	220
					16:30	160	140	140	120	140	19:45	110	80	170	110	80	15:15		130	20	140	

DL - Detection limit
PQL - Practical quantitation limit

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performed and must be performed on the ranked averages of the data rather than the natural logs. Both zinc and nitrate-N failed to meet these assumptions. While an ANOVA using a ranked average dataset does not need to meet any assumptions, it is generally less sensitive.

The results of the two-way ANOVAs are presented in Tables E-4 through E-7. Each table includes: the sum of squares for the whole model and for each effect examined; the probability that the null hypothesis is correct; and profile plots for both effects (date and location). In addition, the least square mean, the standard error, and the mean for each level of each effect is also given.

For example, Table E-4 reveals that the whole model explains 67 percent of the variability and is significant (Prob>F less than 0.05). The date explains 54 percent of the variability and is significant while the location is not significant. This means that the concentration differences due to sample location are much less than the concentration differences due to characteristics of individual storm events.

In the end the ANOVA model indicated that concentrations of all constituents analyzed (copper, zinc, TSS, and nitrate-N) were significantly related to the storm event (or date) and not to sample location (including the bottom sample). In some cases the data suggest that additional samples might reveal a significant difference. However, using the existing data to make a projection indicates that approximately 1300 samples would be required to determine if the observed difference is in fact significant.

E.4 CONCLUSIONS AND RECOMMENDATIONS

The ANOVA analysis revealed that the water quality data did not vary significantly with respect to sample station. This shows that the water quality appears to be homogeneous across the channel and that the single point sampler at the bottom of the channel represents the water in the channel as a whole. It is therefore recommended that no modifications be made to the wide channel monitoring stations.

Table E-4. Results of Two-Way ANOVA for Total Copper by Date and Location

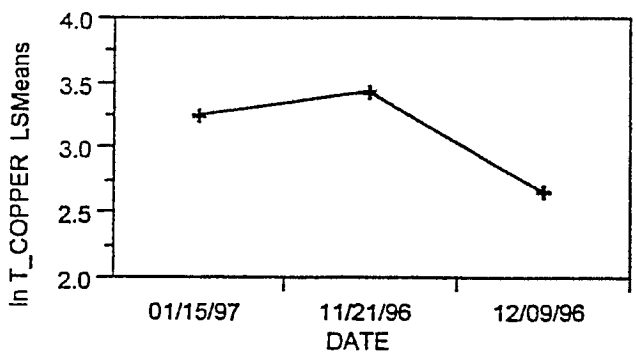
Analysis of Variance

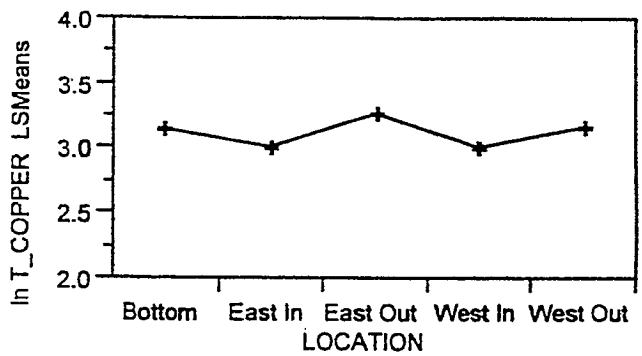
Source	DF[a]	Sum of Squares[b]	Mean Square	F Ratio
Model	14	5.28	0.377	3.41
Error	24	2.66	0.111	Prob>F
C Total	38	7.94		0.0041

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Date[d]	2	2	4.25	19.22	<0.0001
Location[e]	4	4	0.33	0.75	0.566
Date*Location[f]	8	8	1.00	1.13	0.3777

[a] DF = Degrees of Freedom
[b] Model explains 67% of total variability = (Model-Sum of Squares)/(Total Sum of Squares)
[c] Model significant (Prob>F less than 0.05)
[d] Date explains 54% of variability and is significant.
[e] Location is not significant.
[f] Date*Location is not significant.





Least Squares Means

Level	Least Sq Mean	Std Error	Mean
1/15/97	3.26	0.115	3.12
11/21/96	3.44	0.094	3.44
12/9/96	2.68	0.086	2.68

Least Squares Means

Level	Least Sq Mean	Std Error	Mean
Bottom	3.15	0.111	3.15
East In	3.01	0.111	3.02
East Out	3.27	0.150	3.08
West In	3.01	0.111	3.01
West Out	3.18	0.150	3.05

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Table E-5. Results of Two-Way ANOVA for Total Zinc by Date and Location

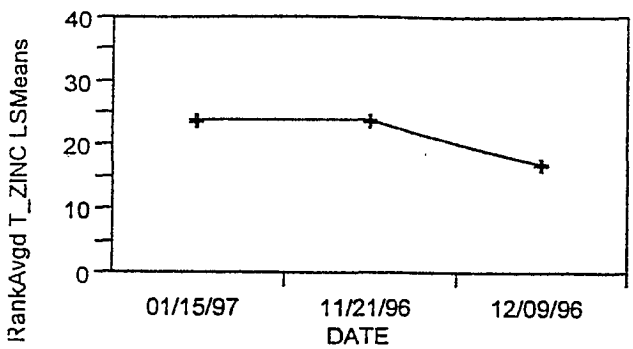
Analysis of Variance

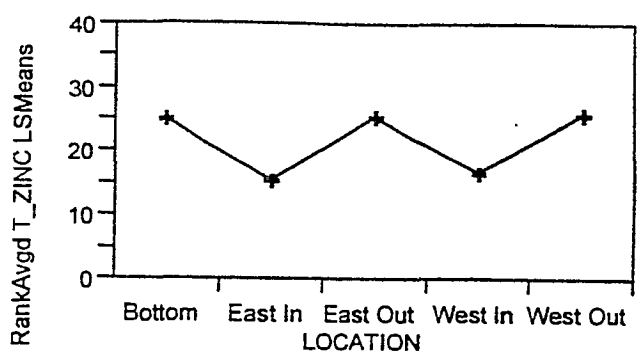
Source	DF[a]	Sum of Squares[b]	Mean Square	F Ratio
Model	14	2121.2	151.5	1.31
Error	24	2771.8	115.5	Prob>F
C Total	38	4893.0		0.2706

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Date[d]	2	2	419.36	1.82	0.1844
Location[e]	4	4	835.01	1.81	0.1603
Date*Location[f]	8	8	1200.20	1.30	0.2906

[a] DF = Degrees of Freedom
[b] Model explains 43% of total variability = (Model Sum of Squares)/(Total Sum of Squares)
[c] Model is not significant.
[d] Date is not significant.
[e] Location is not significant.
[f] Date*Location is not significant.





Least Squares Means

Level	Least Sq Mean	Std Error	Mean
1/15/97	24.00	3.72	19.36
11/21/96	24.17	3.04	23.81
12/9/96	17.17	2.77	17.17

Least Squares Means

Level	Least Sq Mean	Std Error	Mean
Bottom	25.11	3.58	25.11
East In	15.44	3.58	15.44
East Out	25.67	4.85	21.50
West In	16.61	3.58	16.61
West Out	26.06	4.85	22.75

Table E-6. Results of Two-Way ANOVA for TSS by Date and Location

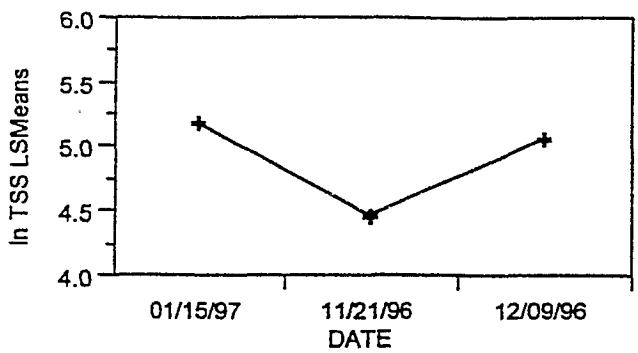
Analysis of Variance

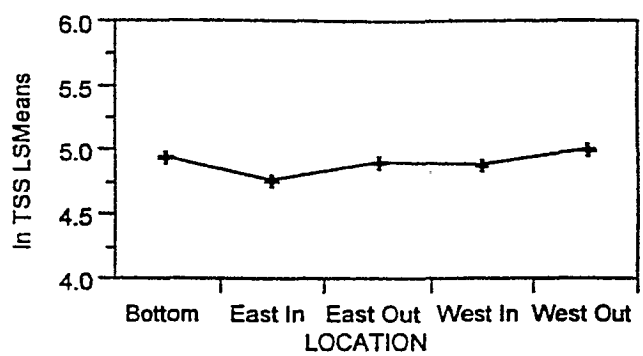
Source	DF[a]	Sum of Squares[b]	Mean Square	F Ratio
Model	14	3.79	0.271	2.13
Error	24	3.05	0.127	Prob>F
C Total	38	6.85		0.0498

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Date[d]	2	2	3.47	13.65	0.0001
Location[e]	4	4	0.23	0.46	0.7631
Date*Location[f]	8	8	0.31	0.31	0.9554

[a] DF = Degrees of Freedom
[b] Model explains 55% of total variability = (Model Sum of Squares)/(Total Sum of Squares)
[c] Model significant (Prob>F less than 0.05)
[d] Date explains 51% of variability and is significant.
[e] Location is not significant.
[f] Date*Location is not significant.





Least Squares Means

Level	Least Sq Mean	Std Error	Mean
1/15/97	5.19	0.124	5.12
11/21/96	4.47	0.101	4.48
12/9/96	5.08	0.092	5.08

Least Squares Means

Level	Least Sq Mean	Std Error	Mean
Bottom	4.95	0.119	4.95
East In	4.78	0.119	4.78
East Out	4.92	0.161	4.89
West In	4.89	0.119	4.89
West Out	5.03	0.161	4.91

Table E-7. Results of Two-Way ANOVA for Nitrate-N by Date and Location

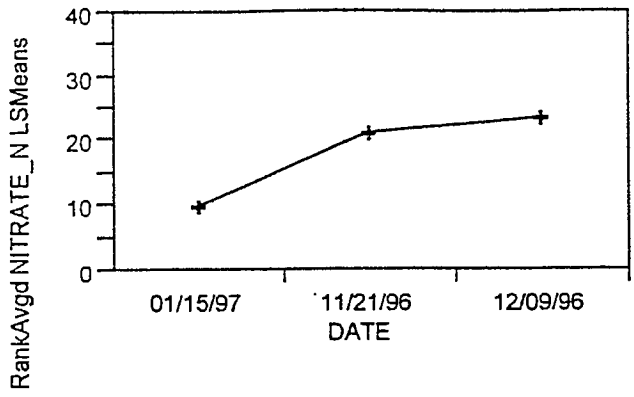
Analysis of Variance

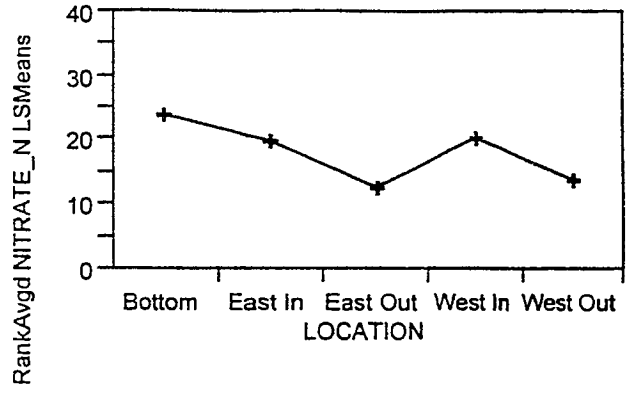
Source	DF[a]	Sum of Squares[b]	Mean Square	F Ratio
Model	14	1539.0	109.9	0.78
Error	24	3400.5	141.7	Prob>F
C Total	38	4939.5		0.6837

Effect Test

Source	Nparm	DF	Sum of Squares	F Ratio	Prob>F
Date[d]	2	2	1057.5	3.73	0.0388
Location[e]	4	4	547.9	0.97	0.4438
Date*Location[f]	8	8	181.6	0.16	0.9943

[a] DF = Degrees of Freedom
[b] Model explains 31% of total variability = (Model Sum of Squares)/(Total Sum of Squares)
[c] Model is not significant.
[d] Date explains 21% of variability and is significant.
[e] Location is not significant.
[f] Date*Location is not significant.





Least Squares Means

Level	Least Sq Mean	Std Error	Mean
1/15/97	10.00	4.12	12.5
11/21/96	21.23	3.37	22.0
12/9/96	23.73	3.07	23.7

Least Squares Means

Level	Least Sq Mean	Std Error	Mean
Bottom	23.94	3.97	23.9
East In	20.11	3.97	20.1
East Out	12.89	5.37	16.7
West In	20.56	3.97	20.6
West Out	14.11	5.37	16.4

R0012271

REFERENCES

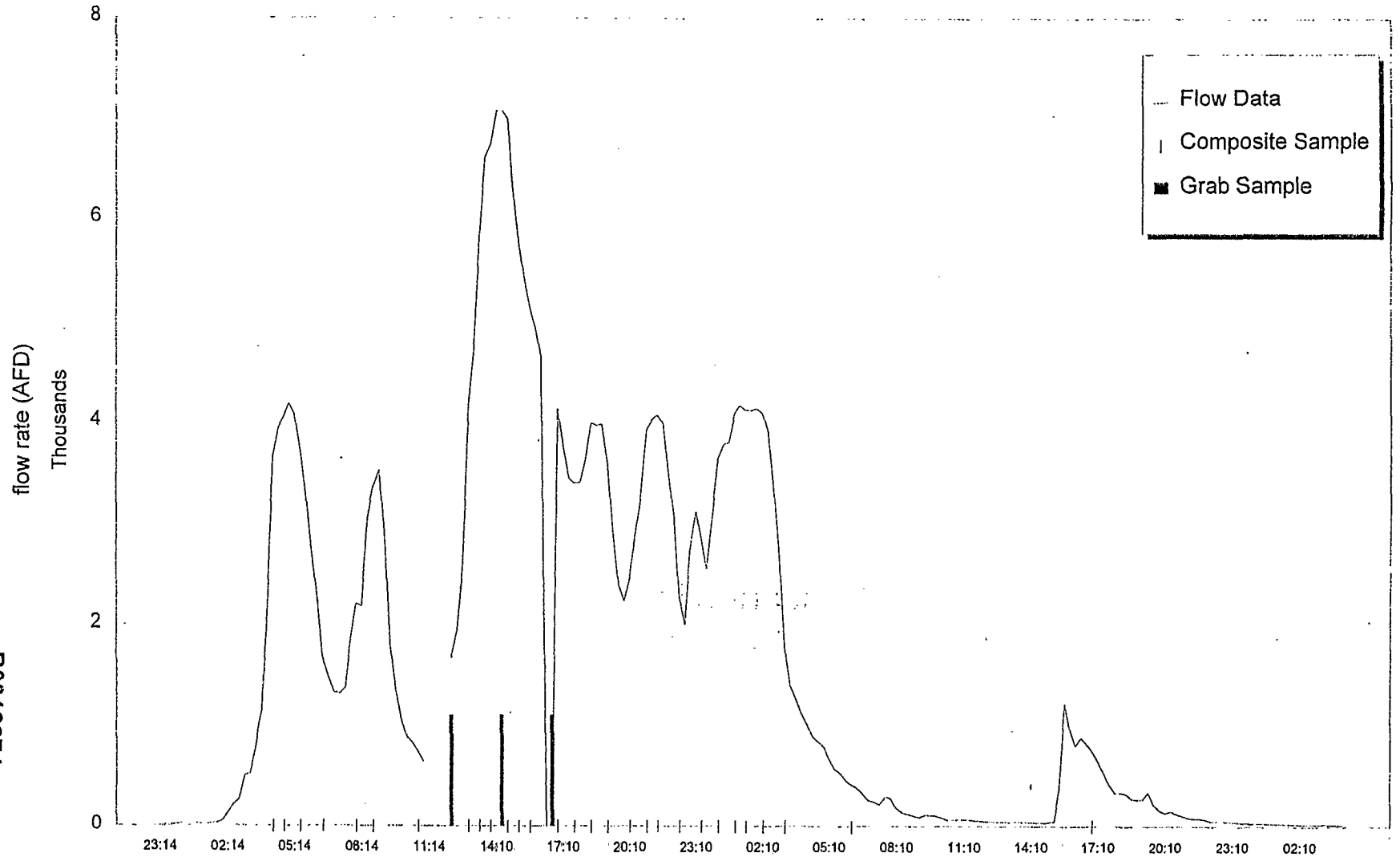
Woodward Clyde Consultants, 1996. Evaluation of analytes and QA/QC specifications for monitoring program. Report prepared for Los Angeles County Department of Public Works, Alhambra, CA, December 1996.

Woodward Clyde Consultants and Camp Dresser & McKee. 1996. Monitoring plan for 1996-97 wide channel pilot study. Prepared for Los Angeles County Department of Public Works, Alhambra, CA, November 1996.

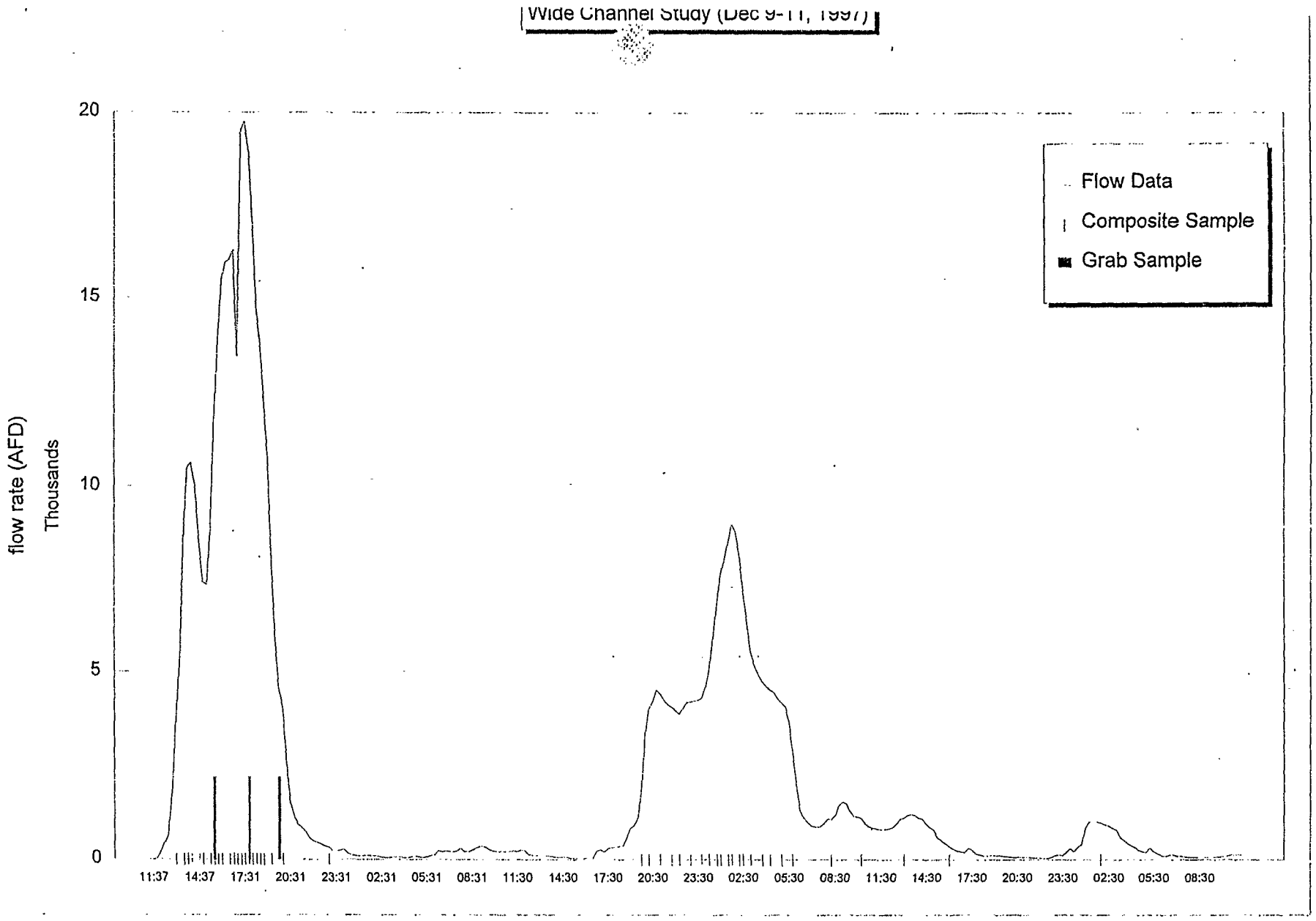
Attachment E-1 Hydrographs of the events

Ballona Creek

Wide Channel Study (Nov 20-22, 1996)



R0012274

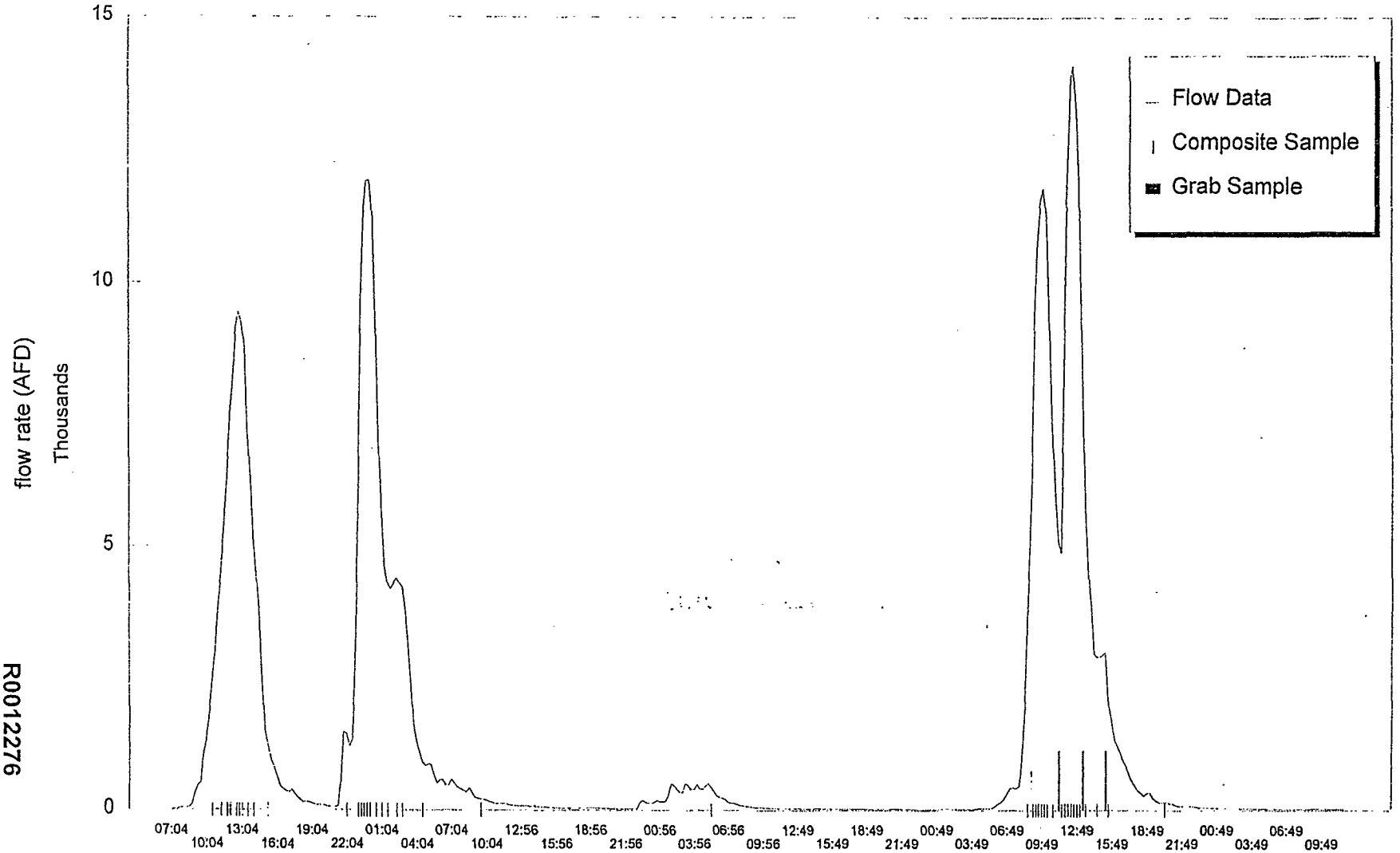


R0012275

07/19/2000 P:\EPPUB\WATER\MONITOR\SAMPLE\FLOWDATA\01\01WCFLOW.WK4 [laptop]

Ballona Creek

Wide Channel Study (Jan 12-16, 1997)



R0012276

Attachment E-2 Field Data Sheets.

BALLONA CREEK WIDE CHANNEL MONITORING PROGRAM DATA SHEET

Date 11-21-96

WEST IN & OUT SAMLE NOT COLLECTED

Grab Sample # 1

Current Weather: ☐ Sunny ☐ Partly Cloudy ☒ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☒ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☒ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	12:10 PM				
WATER TEMP.	64°	64°	64°	64°	64°
WATER COLOR**	Light Brown				
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
LAB SAMPLE	58969	58972	NOT COLLECTED		58963

PW # →

Grab Sample #2

Current Weather: ☐ Sunny ☐ Partly Cloudy ☒ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☐ Light Rain ☒ Moderate Rain ☐ Heavy Rain
Current Wind: ☒ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	2:20PM	2:20PM			
WATER TEMP.	64°	64°	64°	64°	64°
WATER COLOR**	Light Brown				
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
LAB SAMPLE	58970	58973	58967	58976	58964

Grab Sample #3

Current Weather: ☐ Sunny ☐ Partly Cloudy ☒ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☒ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☒ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	4:30	PM			
WATER TEMP.	62°	62°	62°	62°	62°
WATER COLOR**	Light Brown				
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
LAB SAMPLE	58971	58974	58968	58977	58965

** Water Color may include : Clear / Tan / Light Brown / Brown / Dark Brown / Black / or, other

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BALLONA CREEK WIDE CHANNEL MONITORING PROGRAM DATA SHEET

Date 12/9/91

Grab Sample # 1

Current Weather: ☐ Sunny ☐ Partly Cloudy ☐ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☐ Light Rain ☑ Moderate Rain ☐ Heavy Rain
Current Wind: ☑ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	3:30	3:30	3:30	3:30	3:30
WATER TEMP.	54°	56°	56°	54°	54°
WATER COLOR**	TAN	TAN	TAN	TAN	CLEAR/TAN
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
LAB SAMPLE	59052	59055	59049	59058	59046

Grab Sample #2

Current Weather: ☐ Sunny ☐ Partly Cloudy ☐ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☐ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☐ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	5:45	5:45	5:45	5:45	5:45
WATER TEMP.	55°	58°	55°	58°	58°
WATER COLOR**	LIGHT BROWN	LIGHT BROWN	LIGHT BROWN	LIGHT BROWN	LIGHT BROWN
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO *
LAB SAMPLE	59053	59056	59050	59057	59047

* ALGN T. DARK TO SEI

Grab Sample #3

Current Weather: ☐ Sunny ☐ Partly Cloudy ☐ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☐ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☐ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	7:45	7:45	7:45	7:45	7:45
WATER TEMP.	59°	57°	57°	58°	58°
WATER COLOR**	LIGHT BROWN	LIGHT BROWN	LIGHT BROWN	LIGHT BROWN	LIGHT BROWN
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
LAB SAMPLE	59054	59057	59051	59060	59045

** Water Color may include : Clear / Tan / Light Brown / Brown / Dark Brown / Black / or, other

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BALLONA CREEK WIDE CHANNEL MONITORING PROGRAM DATA SHEET

Date 1-15-97

Grab Sample # 1

Current Weather: ☐ Sunny ☐ Partly Cloudy ☒ Cloudy
Current Precipitation: ☐ None ☐ Drizzle ☒ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☒ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	11:15 AM	11:15 AM			11:15 AM
WATER TEMP.	48°F Grey	48°F			48°F
WATER COLOR**	Light Brown Grey	Light Brown Grey			Light Grey
WATER ODOR	☒ YES ☐ NO	☒ YES ☐ NO	☐ YES ☐ NO	☐ YES ☐ NO	☒ YES ☐ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☒ NO
LAB SAMPLE #	59110	59113	Not taken	Not taken	59104

Grab Sample #2

Current Weather: ☐ Sunny ☐ Partly Cloudy ☒ Cloudy
Current Precipitation: ☐ None ☒ Drizzle ☐ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☒ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	1:15 PM	1:15 PM	1:15 PM	1:15 PM	1:15
WATER TEMP.	45°F	48° F	45° F	48° F	48°F
WATER COLOR**	Light brown	Light Grey	Light Grey	Light Grey	Light brown
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☒ NO
OIL SHEEN	☒ YES ☐ NO	☒ YES ☐ NO	☒ YES ☐ NO	☒ YES ☐ NO	☐ YES ☒ NO
LAB SAMPLE #	59111	59114	59108	59117	59105

Grab Sample #3

Current Weather: ☐ Sunny ☒ Partly Cloudy ☐ Cloudy
Current Precipitation: ☒ None ☐ Drizzle ☐ Light Rain ☐ Moderate Rain ☐ Heavy Rain
Current Wind: ☐ Light ☐ Moderate ☐ Strong

	WEST IN	EAST IN	WEST OUT	EAST OUT	BOTTOM
TIME	3:15	3:15			3:15
WATER TEMP.	50°	50°			50°
WATER COLOR**	LIGHT BROWN	LIGHT GRAY			LIGHT GRAY
WATER ODOR	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☒ NO
OIL SHEEN	☐ YES ☒ NO	☐ YES ☒ NO	☐ YES ☐ NO	☐ YES ☐ NO	☐ YES ☒ NO
LAB SAMPLE	59112	59115			59106

** Water Color may include : Clear / Tan / Light Brown / Brown / Dark Brown / Black / or, other

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during the El Niño study period rapidly dispersed the stormwater plumes to nontoxic concentrations within 24 hours.

Toxicant characteristics

The results of the surface water toxicity characterization studies (using phase I TIE procedures) were similar to data from samples analyzed before the El Niño. In all cases, addition of the metal chelating agent EDTA eliminated most or all of the toxicity. Filtration of the sample was also highly effective in reducing toxicity. The TIE results over three years of study are consistent with a conclusion that trace metals, especially zinc, are responsible for the toxicity measured with the sea urchin test. Other stormwater constituents may also be present in toxic amounts in Ballona Creek stormwater, as there is some uncertainty associated with biological variability, chemical methods, and species-specific differences in toxicant sensitivity.

Chemical composition of the plume

This study has produced the first measurements of chemical concentrations in both the dissolved and particulate fractions of the Ballona Creek stormwater plume. The results indicate that stormwater produced increased concentrations of trace metals and organics in the receiving water near Ballona Creek. More data are needed before the variability in composition can be examined in relation to weather conditions.

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Appendix F
Executive Summary of El Niño Study
by Southern California Coastal Waters Research Project

Effects of El Niño on Stormwater Impacts to Santa Monica Bay

Final Report
May 27, 1999

Prepared for: Los Angeles County Department of Public Works
Alhambra, California

Submitted by: Steven Bay, Darrin Greenstein, and Andrew Jirik

Southern California Coastal Water Research Project
Westminster, California

R0012283

EXECUTIVE SUMMARY

Introduction

Urban stormwater runoff constitutes one of the largest inputs of chemical constituents to southern California's coastal waters. Substantial resources are spent monitoring the constituents in stormwater runoff, yet little is known about the effects of these inputs once they enter the ocean. Understanding the effects of stormwater on the marine environment is essential, because it provides the information needed to justify management action and to identify the most effective actions to improve environmental quality.

In 1996, a three-year research project sponsored by the Los Angeles County Department of Public Works, USC Sea Grant and the Southern California Coastal Water Research Project (SCCWRP) was initiated to examine the impacts of urban stormwater runoff on the beneficial uses of Santa Monica Bay. This study, the first integrated assessment of the impacts of stormwater discharges on coastal receiving water, investigated the effects of stormwater discharge from the two largest watersheds draining into Santa Monica Bay: Ballona Creek and Malibu Creek. The results of this investigation have shown that stormwater discharges produce particle-laden plumes that are concentrated in the upper 5-10 m of the water column and extend up to 10 km offshore. The plume from the discharge of stormwater from the highly urbanized Ballona Creek watershed was found to contain dissolved constituents that were toxic to marine life. Toxicity identification studies indicated that the toxicity was due to trace metals, with zinc the element of greatest concern. Studies of the sediments offshore of Ballona Creek also detected alterations in physical and chemical characteristics. Although elevated concentrations of some contaminants (lead, DDTs, PCBs, PAHs) were measured, biological impairment of sediment-dwelling animals was not detected.

While the types of impacts associated with stormwater discharge from Ballona Creek, have been identified, relatively few storm events have been studied. Early in 1997, forecasters began predicting that an El Niño condition in the Southern Hemisphere would bring increased rainfall to southern California in the 1997-98 wet season. In anticipation of an extreme winter season, studies were conducted to determine the effect of El Niño on urban stormwater. The objective of this research was to determine whether the unusual oceanographic conditions and storm events produced by El Niño conditions had an influence on the toxicity of Ballona Creek stormwater or the characteristics of the stormwater discharge plume in Santa Monica Bay.

The physical and optical characteristics of the Ballona Creek stormwater discharge plume and its toxicity were measured for three storm events occurring in February and March. Selected samples of the runoff plume were also analyzed for chemical constituents. All samples of stormwater from the Ballona Creek channel and surface water from the discharge plume were tested for toxicity using the sea urchin fertilization test. Selected surface water samples were further evaluated using toxicity

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identification evaluation (TIE) methods in order to characterize the toxicants present. The sampling and measurement methods were similar to those used in previous years so that the data could be compared. The results were examined to evaluate the effect of El Niño storms on three aspects of toxicity: magnitude of stormwater toxicity, spatial extent of the toxic portion of the plume, and the characteristics of the toxicants.

Southern California received record or near record rainfall during the 1997-1998 storm season. All of the anomalous rainfall occurred after the beginning of February. The Los Angeles civic center recorded over 20 in. of rain between February and the end of May; the annual average rainfall for this area is 14.8 in.

Magnitude of stormwater toxicity

The 1998 El Niño event did not have an unusual influence on the magnitude of Ballona Creek stormwater toxicity. The toxicity of the three stormwater samples measured in this study were typical of previous Ballona Creek samples analyzed. The results indicated that storm size and cumulative amount of prior rainfall had little influence on stormwater toxicity. The magnitude of toxicity was found to be affected by the number of antecedent dry days, however. Stormwater from rainfall preceded by more than 20 days of dry weather was found to have the highest toxicity. This relationship produced a seasonal pattern of greater toxicity in the first storm of the year that appeared to be independent of El Niño weather patterns.

Spatial extent of receiving water toxicity

The 1998 El Niño produced changes water temperature and salinity throughout Santa Monica Bay as a result of the presence of a large warm water mass from the south. The increased rainfall that occurred in 1998 altered the typical wet weather salinity structure of Santa Monica Bay. Reductions in salinity associated with freshwater inputs, normally confined to the upper few meters of the water column, were observed to extend 10-30 m below the surface following February's heavy rainfall. Coastal freshwater inputs to the surface layer were also detected much further offshore of Ballona Creek.

In contrast to these changes in water column characteristics, the spatial extent of receiving water toxicity within stormwater discharge plumes was similar to that observed during non El Niño storms. Surface water toxicity associated with runoff plumes in 1998 was limited to an area within 2 km of Ballona Creek, with most of the toxic samples located within 1 km of the creek mouth. The similarity in spatial distribution of the toxic portion of the plume is not surprising, considering that the characteristics of El Niño storms (rainfall volume and intensity) were similar to previous storms.

Evaluation of the toxicity data collected over the past three years indicates that two factors, storm size and time after the storm, are important determinants of the spatial extent of receiving water toxicity. The toxic portion of the stormwater plume extends further offshore following larger storms. The strong winds and large swells encountered

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Appendix G
River Toxicity Tests
by Southern California Coastal Waters Research Project

LOS ANGELES COUNTY RIVER TOXICITY REPORT: NOVEMBER AND DECEMBER WET WEATHER SAMPLES

Prepared for
Los Angeles County Department of Public Works

Prepared by
Southern California Coastal Water Research Project
7171 Fenwick Lane
Westminster, CA 92683

January 6, 1997

R0012287

TOXICITY MEASUREMENT OF NOVEMBER AND DECEMBER 1997 WET WEATHER RIVER SAMPLES

INTRODUCTION

This report presents results for the toxicity analysis of samples of wet weather flow from the Los Angeles and San Gabriel Rivers. The tests were conducted as partial fulfillment of the monitoring requirements mandated by NPDES Permit No. CAS614001 from the California Regional Water Quality Control Board (Los Angeles Region).

METHODS

Sampling was conducted during wet weather flow conditions at the Los Angeles and San Gabriel Rivers. The test samples were composites collected by autosampler on November 26 and December 6, 1997. Sampling locations were LACDPW mass emission stations S-10 (Los Angeles River) and S-14 (San Gabriel River). Samples were stored under refrigeration until tested on November 29 and December 9, respectively.

Toxicity was measured using the purple sea urchin fertilization test as described by Chapman *et al.*, 1995. Sea urchin gametes were obtained from specimens collected from a relatively uncontaminated area in northern Santa Monica Bay. In the test, sea urchin sperm are exposed to various concentrations of the test sample for 20 minutes at a temperature of 15 °C. Sea urchin eggs are then added to each sample and given 20 minutes for fertilization to occur. Preservative is then added to the samples, which are later examined with a microscope to determine the percentage of fertilized eggs.

Since the toxicity test uses a marine organism, the salinity of the river samples was adjusted to a typical seawater value by addition of hypersaline brine. Addition of the brine diluted the samples, restricting the highest concentration of sample tested to 50%. Additional test concentrations (25, 12, 6, 3, and 1.5%) were prepared by adding laboratory seawater (filtered natural seawater collected from offshore Redondo Beach) to the samples. A brine control was included in the experiment to check for toxicity introduced by the salinity adjustment procedure. The brine control consisted of deionized water, laboratory seawater, and brine at the same concentration found in the 50% and 25% river samples.

A reference toxicant test was conducted at the same time in order to document variability in test sensitivity. This test consisted of five concentrations of dissolved copper, ranging from 10 µg/L to 65 µg/L.

Water quality measurements (pH, dissolved oxygen, conductivity, and total ammonia) were made on the test samples at the beginning of the toxicity test. Due to a malfunctioning ammonia electrode, total ammonia measurements were not made on the November 26 samples.

R0012288

For the river samples, water quality was measured on the 50%, 12% and 3% concentrations. All measurements were made using electrodes. Sample salinity was calculated from the conductivity and temperature data. Un-ionized ammonia (NH_3) concentration was calculated from the total ammonia, pH, salinity, and temperature data.

A tiered approach was used to examine the river test samples. First, selected samples from the four highest concentrations (50, 25, and 12%) were examined to determine the pattern of dose response. Additional samples were then examined as needed to provide sufficient data for calculation of the EC_{50} (concentration producing a 50% reduction in fertilization) and NOEC (highest test concentration that does not produce a statistically significant reduction in fertilization). This procedure eliminated wasted effort spent examining samples that did not provide useful information about the level of toxicity.

RESULTS

Sea urchin fertilization was significantly reduced by exposure to the November samples from the Los Angeles and San Gabriel Rivers, as shown in Figure 1. The NOEC for each river was 25% sample, which represents 4 chronic toxicity units (TU_c=100/NOEC). The EC_{50} for the San Gabriel River was 32%, while the Los Angeles River was 27% (Table 1). There was no significant difference between the EC_{50} values, indicating that the magnitude of toxicity was similar for both sites.

Toxicity was again detected in samples from both rivers in December (Figure 2). While the NOEC was again 25% for each river, the EC_{50} data indicated a lower magnitude of toxicity was present. The EC_{50} for the Los Angeles River was 50%. The San Gabriel River could not be calculated since none of the samples produced less than 50% fertilization (Table 2).

Summaries of the fertilization counts for each experiment are shown in Tables 3 and 4. For the first sampling, the control seawater fertilization percentage averaged 87% and the 50% brine control averaged 89%, well above the minimum acceptable value of 70%. The second sampling also had good control results with the seawater control averaging 98% and the 50% brine control 99%.

The results of water quality measurements are shown in Tables 3 and 4. For the first exposure, we were unable to make ammonia measurements. The pH, dissolved oxygen, and salinity of the samples were within acceptable ranges. All parameters were within acceptable ranges for the second exposure. Total ammonia in the San Gabriel River sample was elevated relative to the control, but was less than 1% of that measured in a non-toxic dry weather sample from the same site.

The reference toxicant tests associated with each exposure produced a fairly typical dose response. An EC50 of 13 µg/L was calculated for the first test and 32 ug/L for the second. The data for the second test is within the range typically found in our laboratory. The results for the

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first exposure may indicate a slightly more sensitive test, but is within the range seen by other laboratories using the same methods (Chapman *et al.*, 1995).

LITERATURE CITED

Chapman, G.A., D.L. Denton, and J.M. Lazorchak. 1995. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to west coast marine and estuarine organisms. EPA/600/R-95/136, National Exposure Research Laboratory, U. S. Environmental Protection Agency, Cincinnati, OH. 661p.

R0012290

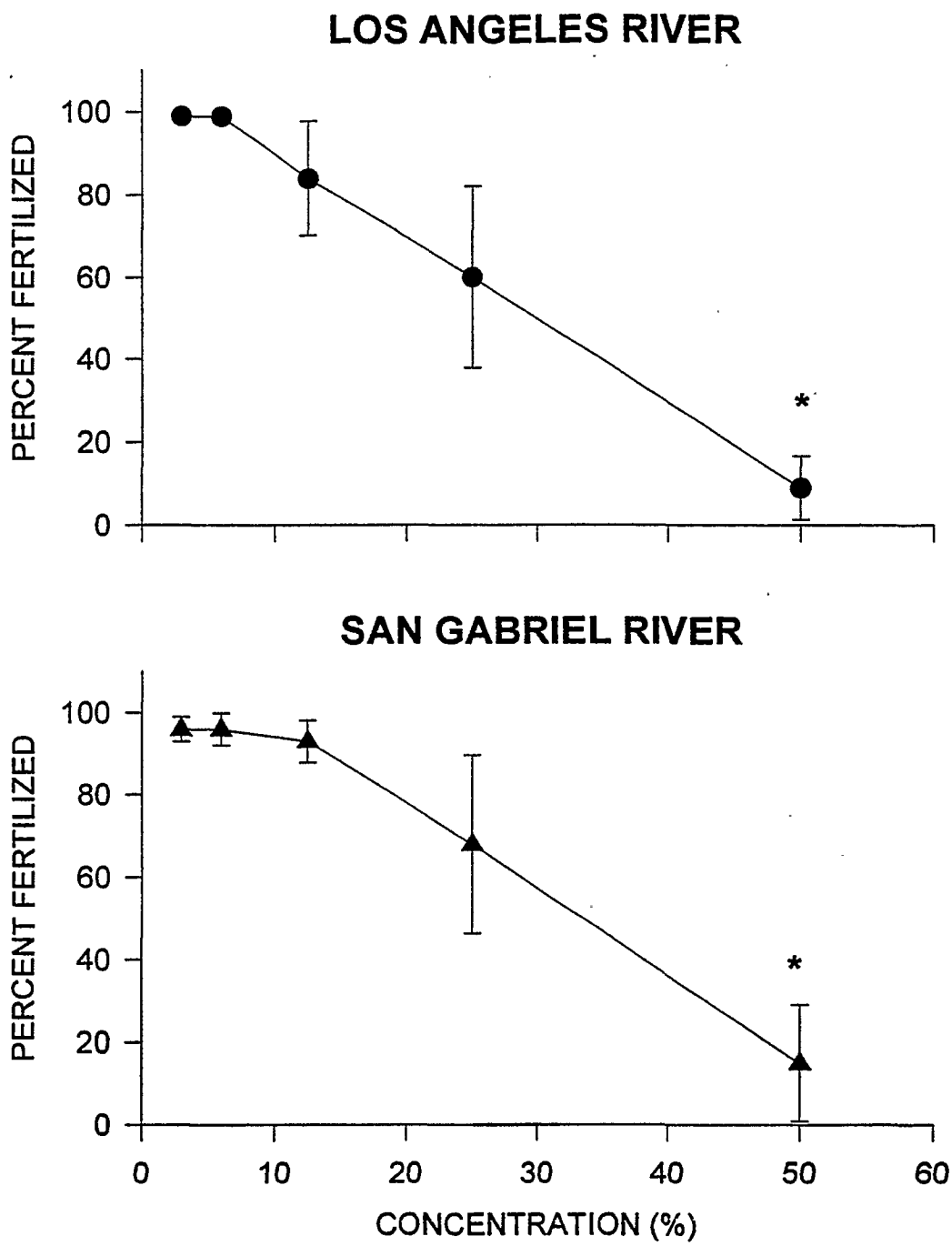

Figure 1. Dose-response plots of sea urchin fertilization test results for wet weather flow composites collected November 26, 1997. Symbols represent the mean of 5 replicates and the standard deviation. Asterisks indicate samples with a statistically significant reduction in fertilization.

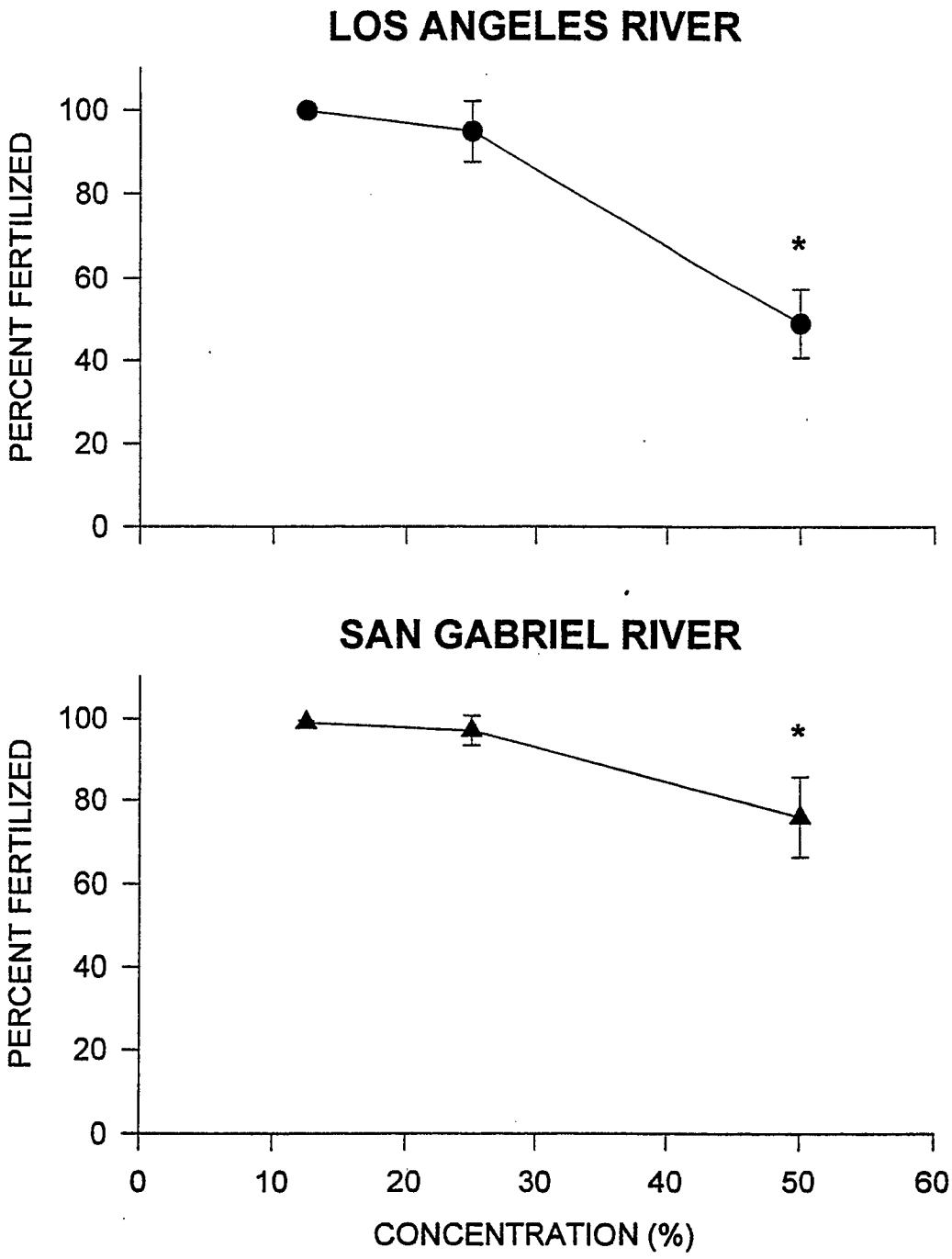

Figure 2. Dose-response plots of sea urchin fertilization test results for wet weather flow composites collected December 6, 1997. Symbols represent the mean of 5 replicates and the standard deviation. Asterisks indicate samples with a statistically significant reduction in fertilization.

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Table 3. Sea Urchin Fertilization Results

Experiment No.: S349 Test Date: 11/29/97

Log No.	Description	Concentration	Percent Fertilized	Mean	Std Dev	N
USSW11291	Seawater Control		81	87	13.1	10
USSW11291	Seawater Control		83			
USSW11291	Seawater Control		59			
USSW11291	Seawater Control		100			
USSW11291	Seawater Control		85			
USSW11291	Seawater Control		99			
USSW11291	Seawater Control		99			
USSW11291	Seawater Control		78			
USSW11291	Seawater Control		85			
USSW11291	Seawater Control		100			
USBK11292	Brine Control	50	99	89	17.8	5
USBK11292	Brine Control	50	58			
USBK11292	Brine Control	50	100			
USBK11292	Brine Control	50	90			
USBK11292	Brine Control	50	98			
USBK11292	Brine Control	25	72	81	10.0	5
USBK11292	Brine Control	25	98			
USBK11292	Brine Control	25	79			
USBK11292	Brine Control	25	76			
USBK11292	Brine Control	25	79			
USLA11261	LA River	50	23	9	7.7	5
USLA11261	LA River	50	7			
USLA11261	LA River	50	5			
USLA11261	LA River	50	5			
USLA11261	LA River	50	7			
USLA11261	LA River	25	36	60	22.2	5
USLA11261	LA River	25	42			
USLA11261	LA River	25	85			
USLA11261	LA River	25	81			
USLA11261	LA River	25	58			
USLA11261	LA River	12	98	84	13.9	5
USLA11261	LA River	12	79			
USLA11261	LA River	12	78			
USLA11261	LA River	12	98			
USLA11261	LA River	12	66			
USLA11261	LA River	6	100	99	1.6	5
USLA11261	LA River	6	99			
USLA11261	LA River	6	100			
USLA11261	LA River	6	99			
USLA11261	LA River	6	96			
USLA11261	LA River	3	99	99	0.0	5
USLA11261	LA River	3	99			
USLA11261	LA River	3	99			
USLA11261	LA River	3	99			
USLA11261	LA River	3	99			
USSG11261	San Gabriel River	50	9	15	14.2	5
USSG11261	San Gabriel River	50	9			
USSG11261	San Gabriel River	50	10			
USSG11261	San Gabriel River	50	40			
USSG11261	San Gabriel River	50	6			
USSG11261	San Gabriel River	25	93	66	24.6	5
USSG11261	San Gabriel River	25	36			
USSG11261	San Gabriel River	25	60			
USSG11261	San Gabriel River	25	89			
USSG11261	San Gabriel River	25	51			
USSG11261	San Gabriel River	12	87	93	5.2	5
USSG11261	San Gabriel River	12	98			
USSG11261	San Gabriel River	12	90			
USSG11261	San Gabriel River	12	91			
USSG11261	San Gabriel River	12	99			
USSG11261	San Gabriel River	6	100	96	3.9	5
USSG11261	San Gabriel River	6	100			
USSG11261	San Gabriel River	6	94			
USSG11261	San Gabriel River	6	91			
USSG11261	San Gabriel River	6	96			
USSG11261	San Gabriel River	3	94	96	3.0	5
USSG11261	San Gabriel River	3	99			
USSG11261	San Gabriel River	3	94			
USSG11261	San Gabriel River	3	100			
USSG11261	San Gabriel River	3	94			

Table 4. Sea urchin fertilization test results.

Experiment No.: S351 Test Date: 12/9/97

Log Number	Description	Concentration	Percent Fertilized	Mean	Std Dev	N
USSW12091	Seawater Control		94	98	2.5	5
USSW12091	Seawater Control		99			
USSW12091	Seawater Control		98			
USSW12091	Seawater Control		100			
USSW12091	Seawater Control		100			
USBK12091	Brine Control	50	99	99	0.9	5
USBK12091	Brine Control	50	97			
USBK12091	Brine Control	50	99			
USBK12091	Brine Control	50	99			
USBK12091	Brine Control	50	99			
USBK12091	Brine Control	25	99	100	0.5	5
USBK12091	Brine Control	25	99			
USBK12091	Brine Control	25	100			
USBK12091	Brine Control	25	100			
USBK12091	Brine Control	25	100			
USLA12061	LA River	50	62	49	8.3	5
USLA12061	LA River	50	47			
USLA12061	LA River	50	45			
USLA12061	LA River	50	51			
USLA12061	LA River	50	40			
USLA12061	LA River	25	98	95	7.3	5
USLA12061	LA River	25	82			
USLA12061	LA River	25	99			
USLA12061	LA River	25	96			
USLA12061	LA River	25	99			
USLA12061	LA River	12	100	100	0.4	5
USLA12061	LA River	12	100			
USLA12061	LA River	12	100			
USLA12061	LA River	12	100			
USLA12061	LA River	12	99			
USSG12061	San Gabriel River	50	67	76	9.7	5
USSG12061	San Gabriel River	50	77			
USSG12061	San Gabriel River	50	78			
USSG12061	San Gabriel River	50	68			
USSG12061	San Gabriel River	50	91			
USSG12061	San Gabriel River	25	98	97	3.7	5
USSG12061	San Gabriel River	25	100			
USSG12061	San Gabriel River	25	98			
USSG12061	San Gabriel River	25	100			
USSG12061	San Gabriel River	25	91			
USSG12061	San Gabriel River	12	100	99	0.5	5
USSG12061	San Gabriel River	12	99			
USSG12061	San Gabriel River	12	99			
USSG12061	San Gabriel River	12	100			
USSG12061	San Gabriel River	12	99			

Table 1. Summary of sea urchin fertilization test results for river samples collected on November 26, 1997.

Location	EC50 (%)	NOEC (%)	Toxic units (TU_c)
Los Angeles River	27	25	4
San Gabriel River	32	25	4

Table 2. Summary of sea urchin fertilization test results for river samples collected on December 6, 1997.

Location	EC50 (%)	NOEC (%)	Toxic units (TU_c)
Los Angeles River	50	25	4
San Gabriel River	>50	25	4

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Table 5. Water quality summary for November sample fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/KG)
USSW11291	Seawater Control		Initial	7.2		15.4	7.96	51.5	19.2	33.3
USBK11292	Brine Control	25	Initial	6.9		15.4	8.17	50.2	22.3	32.7
USLA11261	LA River	50	Initial	7.3		15.4	8.23	50.8	19.3	32.8
USLA11261	LA River	12.5	Initial	7.1		15.4	8.07	48.3	22.1	31.3
USLA11261	LA River	3	Initial	7.2		15.4	8.02	48.1	22.0	31.1
USSG11261	San Gabriel River	50	Initial	7.3		15.4	8.20	48.3	22.0	31.3
USSG11261	San Gabriel River	12.5	Initial	7.2		15.4	8.08	48.7	22.0	31.5
USSG11261	San Gabriel River	3	Initial	7.2		15.4	8.04	48.6	22.1	31.5

Table 6. Water quality summary for December sample fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/KG)
USSW12091	Seawater Control		Initial	7.2	<0.06		14.5	7.75	49.8	20.7	32.2
USBK12091	Brine Control	50	Initial	7.2	0.02	0.001	14.5	8.11	50.1	20.9	32.5
USLA12061	LA River	50	Initial	7.0	0.25	0.008	14.5	8.16	50.1	19.4	32.3
USLA12061	LA River	12.5	Initial	7.0	0.09	0.001	14.5	7.86	49.4	20.9	31.9
USLA12061	LA River	3	Initial	6.9	<0.06		14.5	7.79	49.2	21.1	31.8
USSG12061	San Gabriel River	50	Initial	7.1	1.52	0.045	14.5	8.15	51.1	18.2	32.9
USSG12061	San Gabriel River	12.5	Initial	7.2	0.35	0.006	14.5	7.89	50.3	20.6	32.6
USSG12061	San Gabriel River	3	Initial	7.0	0.08	0.001	14.5	7.85	50.1	20.5	32.4

R0012296

LOS ANGELES COUNTY RIVER TOXICITY REPORT: OCTOBER DRY WEATHER AND NOVEMBER WET WEATHER SAMPLES

Prepared for
Los Angeles County Department of Public Works

Prepared by
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November 24, 1998

R0012297

TOXICITY MEASUREMENT OF OCTOBER DRY WEATHER AND NOVEMBER 1998 WET WEATHER RIVER SAMPLES

INTRODUCTION

This report presents results for the toxicity analysis of samples of dry and wet weather flow from the Los Angeles and San Gabriel Rivers. The tests were conducted as partial fulfillment of the monitoring requirements mandated by NPDES Permit No. CAS614001 from the California Regional Water Quality Control Board (Los Angeles Region).

METHODS

Sampling was conducted during dry weather flow conditions at the Los Angeles and San Gabriel Rivers and during the first storm of the season on the San Gabriel River. The San Gabriel River dry weather sample was a 24 h, time weighted composite collected by autosampler on October 22, 1998. The Los Angeles River sample was a composite of 9 grabs collected manually by bucket over an 8 h period between 0800 and 1600 on October 22, 1998. The wet weather sample was collected by autosampler from the San Gabriel River on November 8, 1998. Sampling locations were LACDPW mass emission stations S-10 (Los Angeles River) and S-14 (San Gabriel River). Samples were stored under refrigeration until tested on October 23 and November 11, respectively.

Toxicity was measured using the purple sea urchin fertilization test as described by Chapman *et al.*, 1995. Sea urchin gametes were obtained from specimens collected from a relatively uncontaminated area in northern Santa Monica Bay. In the test, sea urchin sperm are exposed to various concentrations of the test sample for 20 minutes at a temperature of 15 °C. Sea urchin eggs are then added to each sample and given 20 minutes for fertilization to occur. Preservative is then added to the samples, which are later examined with a microscope to determine the percentage of fertilized eggs.

Since the toxicity test uses a marine organism, the salinity of the river samples was adjusted to a typical seawater value by addition of hypersaline brine. Addition of the brine diluted the samples, restricting the highest concentration of sample tested to 50%. Additional test concentrations (25, 12, 6, 3, and 1.5%) were prepared by adding laboratory seawater (filtered natural seawater collected from offshore Redondo Beach) to the samples. A brine control was included in the experiment to check for toxicity introduced by the salinity adjustment procedure. The brine control consisted of deionized water, laboratory seawater, and brine at the same concentration found in the 50% and 25% river samples.

A reference toxicant test was conducted at the same time in order to document variability in test sensitivity. This test consisted of five concentrations of dissolved copper, ranging from 10 µg/L to 65 µg/L.

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Water quality measurements (pH, dissolved oxygen, conductivity, and total ammonia) were made on the test samples at the beginning of the toxicity test. For the river samples, water quality was measured on the 50%, 12% and 3% concentrations. All measurements were made using electrodes. Sample salinity was calculated from the conductivity and temperature data. Un-ionized ammonia (NH_3) concentration was calculated from the total ammonia, pH, salinity, and temperature data.

For each experiment, we attempted to calculate an EC_{50} (concentration producing a 50% reduction in fertilization) and NOEC (highest test concentration that does not produce a statistically significant reduction in fertilization). The EC_{50} was calculated by probit analysis of the raw percent fertilized data. If there was less than a 50% reduction in fertilization success, then an EC_{50} could not be calculated. The NOEC was calculated by first arcsine transforming the percent fertilized data, then subjecting it a one way analysis of variance (ANOVA). If a significant difference between treatments was detected ($p \Leftrightarrow 0.05$), a Dunnett's multiple range test was performed to test for differences between the control value and each of the concentrations. If there was not a significant reduction in fertilization relative to the control, then a NOEC could not be calculated.

RESULTS AND DISCUSSION

Sea urchin fertilization was significantly reduced by exposure to the dry weather sample from the Los Angeles River (the 50% concentration had 64% of the eggs successfully fertilized), but no toxicity was detected for the San Gabriel River (the 50% concentration had 99% fertilization) (Figure 1). The NOEC for the Los Angeles River was 25% sample, which represents 4 chronic toxicity units (TU_c=100/NOEC). A NOEC could not be calculated for the San Gabriel River since there was no significant reduction in fertilization. Since samples from neither river caused a 50% reduction in fertilization, an EC_{50} could not be calculated (Table 1).

No toxicity was detected in the wet weather sample from San Gabriel River in November (Figure 2). Since there was no reduction in fertilization caused by this sample, neither a NOEC nor an EC_{50} could be calculated.

Summaries of the fertilization counts for each experiment are shown in Tables 3 and 4. For the first sampling, the control seawater fertilization percentage averaged 94% and the 50% brine control averaged 97%, well above the minimum acceptable value of 70%. The second sampling also had good control results with the seawater control averaging 89% and the 50% brine control greater than 99%.

The results of water quality measurements are shown in Tables 5 and 6. The pH, dissolved oxygen, and salinity of the samples were within acceptable ranges for both sets of experiments. Total ammonia in the San Gabriel River (3.51 mg /L) wet weather sample was

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elevated relative to the control, but was well below of the level (>20 mg /L) that would be expected to cause toxicity in the sea urchin fertilization test.

The reference toxicant tests associated with each exposure produced a fairly typical dose response. An EC_{50} of 52 µg/L was calculated for the first test and 19 µg /L for the second. The mean EC_{50} for our previous reference toxicant tests is 27.8 µg/L. The data for both tests is within the range for an acceptable test (3.2 to 52.4 µg/L). The results for the first exposure may indicate on average a slightly less sensitive test and the second exposure a slightly more sensitive test, but are both within the range seen by our laboratory and others using the same methods (Chapman *et al.*, 1995).

LITERATURE CITED

Chapman, G.A., D.L. Denton, and J.M. Lazorchak. 1995. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to west coast marine and estuarine organisms. EPA/600/R-95/136, National Exposure Research Laboratory, U. S. Environmental Protection Agency, Cincinnati, OH. 661p.

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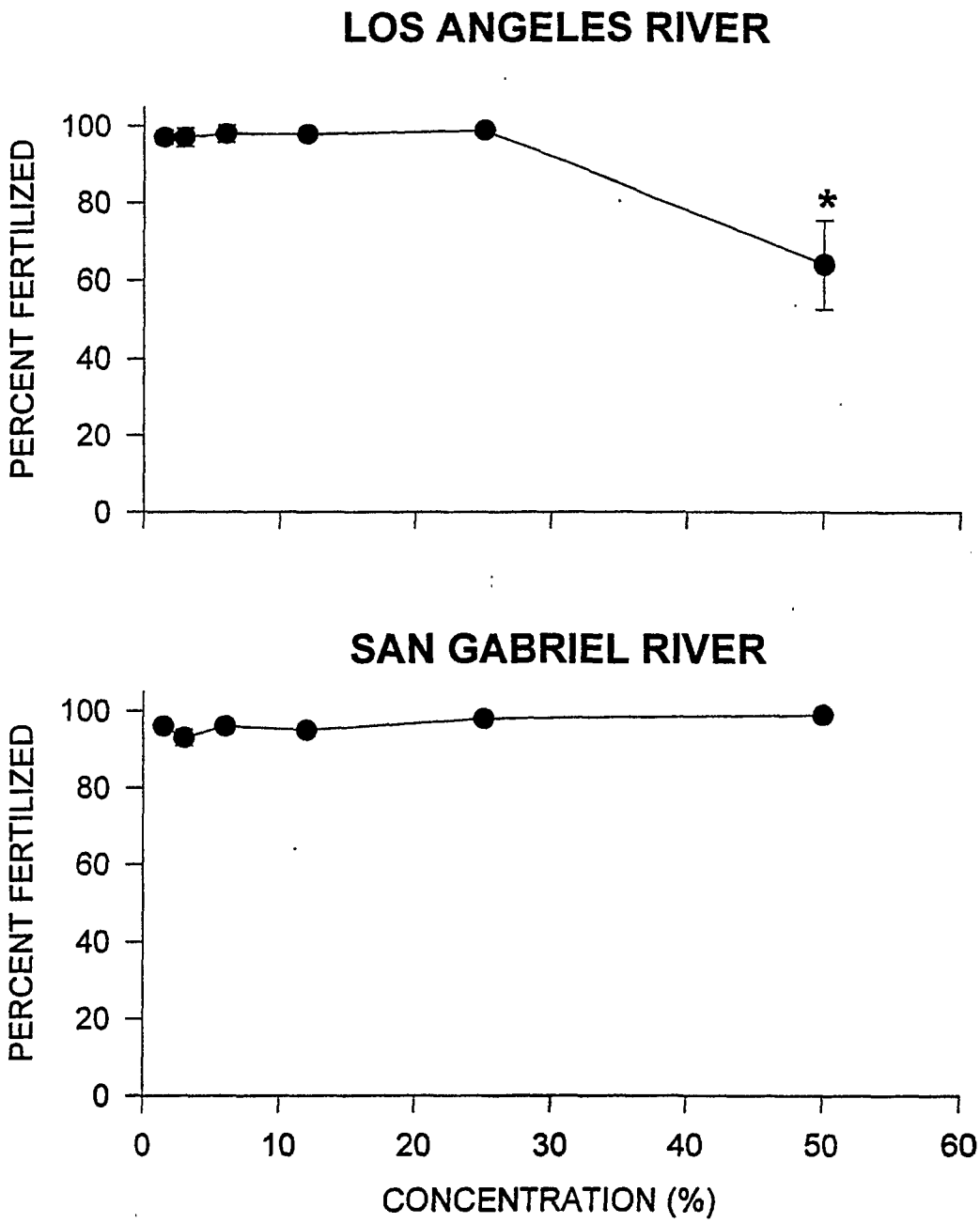

Figure 1. Dose-response plots of sea urchin fertilization test results for dry weather flow composites collected October 23, 1998. Symbols represent the mean of 5 and the standard deviation. Asterisks indicate samples with a statistically significant reduction in fertilization.

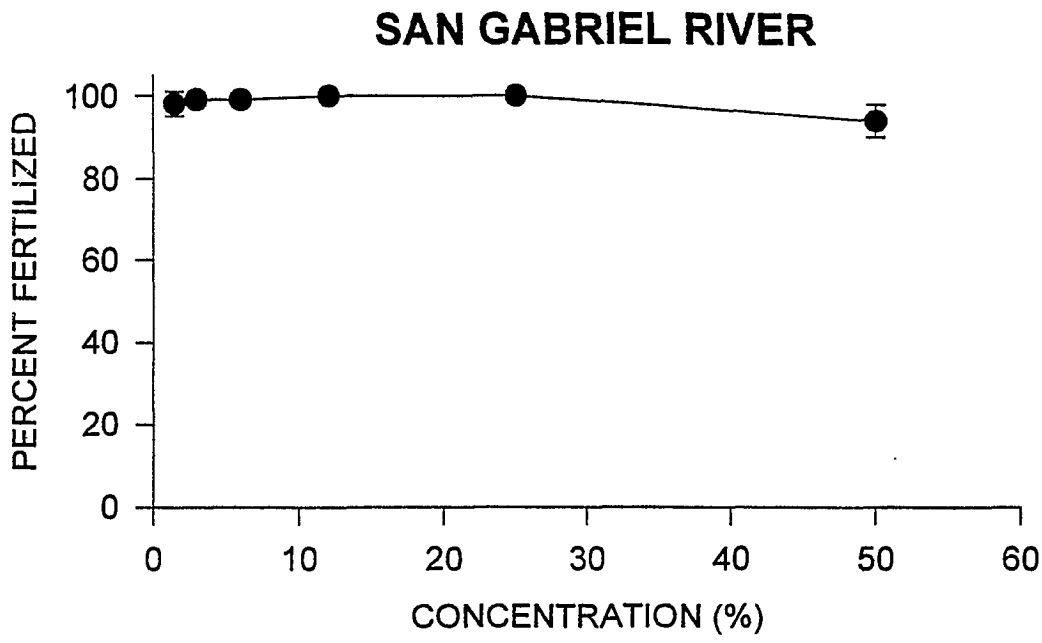

Figure 2. Dose-response plots of sea urchin fertilization test results for San Gabriel River wet weather flow composite collected November 8, 1998. Symbols represent the mean of 5 replicates and the standard deviation.

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Table 1. Summary of sea urchin fertilization test results for river samples collected on November 26, 1997.

Location	EC50 (%)	NOEC (%)	Toxic units (TU_c)
Los Angeles River	>50	25	4
San Gabriel River	>50	⇩50	⇔2

Table 2. Summary of sea urchin fertilization test results for river sample collected on November 8, 1998.

Location	EC50 (%)	NOEC (%)	Toxic units (TU_c)
San Gabriel River	>50	⇩50	⇔2

R0012303

Table 3. Sea Urchin Fertilization Results for Experiment No. S390 sampled on 10/22/98.

Log No.	Description	Concentration	Percent Fertilized	Mean	Std Dev	N
USSW10231	Seawater Control		98	94	2.7	5
USSW10231	Seawater Control		92			
USSW10231	Seawater Control		94			
USSW10231	Seawater Control		94			
USSW10231	Seawater Control		91			
USBK10232	Brine Control	50	93	97	2.7	5
USBK10232	Brine Control	50	100			
USBK10232	Brine Control	50	98			
USBK10232	Brine Control	50	99			
USBK10232	Brine Control	50	97			
USBK10232	Brine Control	25	96	95	2.2	5
USBK10232	Brine Control	25	93			
USBK10232	Brine Control	25	93			
USBK10232	Brine Control	25	98			
USBK10232	Brine Control	25	96			
USLA10231	LA River Flow	50	48	64	11.5	5
USLA10231	LA River Flow	50	61			
USLA10231	LA River Flow	50	74			
USLA10231	LA River Flow	50	59			
USLA10231	LA River Flow	50	76			
USLA10231	LA River Flow	25	96	99	1.5	5
USLA10231	LA River Flow	25	99			
USLA10231	LA River Flow	25	100			
USLA10231	LA River Flow	25	99			
USLA10231	LA River Flow	25	99			
USLA10231	LA River Flow	12	99	98	0.9	5
USLA10231	LA River Flow	12	97			
USLA10231	LA River Flow	12	99			
USLA10231	LA River Flow	12	99			
USLA10231	LA River Flow	12	98			
USLA10231	LA River Flow	6	99	98	2.3	5
USLA10231	LA River Flow	6	97			
USLA10231	LA River Flow	6	94			
USLA10231	LA River Flow	6	98			
USLA10231	LA River Flow	6	100			
USLA10231	LA River Flow	3	97	97	2.5	5
USLA10231	LA River Flow	3	96			
USLA10231	LA River Flow	3	93			
USLA10231	LA River Flow	3	99			
USLA10231	LA River Flow	3	99			
USLA10231	LA River Flow	1.5	98	97	1.9	5
USLA10231	LA River Flow	1.5	100			
USLA10231	LA River Flow	1.5	97			
USLA10231	LA River Flow	1.5	96			
USLA10231	LA River Flow	1.5	95			
USSG10231	San Gabriel Flow	50	99	99	1.0	5
USSG10231	San Gabriel Flow	50	98			
USSG10231	San Gabriel Flow	50	100			
USSG10231	San Gabriel Flow	50	100			
USSG10231	San Gabriel Flow	50	98			
USSG10231	San Gabriel Flow	25	96	98	1.5	5
USSG10231	San Gabriel Flow	25	98			
USSG10231	San Gabriel Flow	25	99			
USSG10231	San Gabriel Flow	25	98			
USSG10231	San Gabriel Flow	25	100			
USSG10231	San Gabriel Flow	12	97	95	1.1	5
USSG10231	San Gabriel Flow	12	94			
USSG10231	San Gabriel Flow	12	95			
USSG10231	San Gabriel Flow	12	96			
USSG10231	San Gabriel Flow	12	95			
USSG10231	San Gabriel Flow	6	98	96	1.8	5
USSG10231	San Gabriel Flow	6	95			
USSG10231	San Gabriel Flow	6	94			
USSG10231	San Gabriel Flow	6	98			
USSG10231	San Gabriel Flow	6	96			
USSG10231	San Gabriel Flow	3	92	93	2.1	5
USSG10231	San Gabriel Flow	3	93			
USSG10231	San Gabriel Flow	3	91			
USSG10231	San Gabriel Flow	3	96			
USSG10231	San Gabriel Flow	3	95			
USSG10231	San Gabriel Flow	1.5	96	95	2.2	5
USSG10231	San Gabriel Flow	1.5	95			
USSG10231	San Gabriel Flow	1.5	94			
USSG10231	San Gabriel Flow	1.5	98			
USSG10231	San Gabriel Flow	1.5	92			

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Table 4. Sea Urchin Fertilization Results for Experiment No. S393 sampled on 11/8/98.

Log Number	Description	Concentration	Percent Fertilized	Mean	Std Dev	N
USSW11111	Seawater Control		94	89	12.7	5
USSW11111	Seawater Control		99			
USSW11111	Seawater Control		95			
USSW11111	Seawater Control		90			
USSW11111	Seawater Control		67			
USBK11111	Brine Control	50	100	100	0.5	5
USBK11111	Brine Control	50	100			
USBK11111	Brine Control	50	100			
USBK11111	Brine Control	50	99			
USBK11111	Brine Control	50	99			
USBK11111	Brine Control	25	99	97	3.7	5
USBK11111	Brine Control	25	96			
USBK11111	Brine Control	25	91			
USBK11111	Brine Control	25	99			
USBK11111	Brine Control	25	100			
USSG11081	San Gabriel Flow	50	93	94	4.0	5
USSG11081	San Gabriel Flow	50	94			
USSG11081	San Gabriel Flow	50	92			--
USSG11081	San Gabriel Flow	50	89			
USSG11081	San Gabriel Flow	50	100			
USSG11081	San Gabriel Flow	25	100	100	0.4	5
USSG11081	San Gabriel Flow	25	100			
USSG11081	San Gabriel Flow	25	99			
USSG11081	San Gabriel Flow	25	100			
USSG11081	San Gabriel Flow	25	100			
USSG11081	San Gabriel Flow	12	100	100	0.5	5
USSG11081	San Gabriel Flow	12	100			
USSG11081	San Gabriel Flow	12	100			
USSG11081	San Gabriel Flow	12	99			
USSG11081	San Gabriel Flow	12	99			
USSG11081	San Gabriel Flow	6	100	99	0.8	5
USSG11081	San Gabriel Flow	6	100			
USSG11081	San Gabriel Flow	6	99			
USSG11081	San Gabriel Flow	6	99			
USSG11081	San Gabriel Flow	6	98			
USSG11081	San Gabriel Flow	3	100	99	1.2	5
USSG11081	San Gabriel Flow	3	99			
USSG11081	San Gabriel Flow	3	97			
USSG11081	San Gabriel Flow	3	99			
USSG11081	San Gabriel Flow	3	100			
USSG11081	San Gabriel Flow	1.5	100	98	3.0	5
USSG11081	San Gabriel Flow	1.5	93			
USSG11081	San Gabriel Flow	1.5	100			
USSG11081	San Gabriel Flow	1.5	100			
USSG11081	San Gabriel Flow	1.5	99			

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Table 5. Water quality summary for October dry weather sample fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/Kg)
	Desired Range			>4.0	<20		14.0–16.0				32.0–34.0
USSW10231	Seawater Control		Initial	7.0	0.01	<0.001	15.0	7.96	50.5	21.3	32.8
USBK10232	Brine Control	50	Initial	6.9	0.01	<0.001	15.0	8.18	49.5	21.7	32.1
USLA10231	LA River	50	Initial	7.3	0.36	0.021	15.0	8.45	50.3	21.9	32.7
USLA10231	LA River	12.5	Initial	7.2	0.08	0.002	15.0	8.13	50.4	21.9	32.8
USLA10231	LA River	3	Initial	7.2	0.02	<0.001	15.0	7.99	50.3	21.6	32.7
USSG10231	San Gabriel River	50	Initial	6.9	0.02	0.001	15.0	8.13	50.8	21.9	33.1
USSG10231	San Gabriel River	12.5	Initial	6.9	0.03	0.001	15.0	8.01	50.4	22.1	32.8
USSG10231	San Gabriel River	3	Initial	6.8	0.03	0.001	15.0	7.98	50.2	22.2	32.6

Table 6. Water quality summary for November sample fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/Kg)
	Desired Range			>4.0	<20		14.0–16.0				32.0–34.0
USSW11111	Seawater Control		Initial	7.2	0.02	<0.001	15.4	8.01	51.5	20.4	33.4
USBK11111	Brine Control	50	Initial	6.9	0.02	0.001	15.4	8.19	51.4	20.2	33.3
USSG11081	San Gabriel River	50	Initial	6.6	3.51	0.089	15.4	8.05	50.8	21.0	33.0
USSG11081	San Gabriel River	12.5	Initial	7.0	0.81	0.020	15.4	8.04	51.3	20.5	33.3
USSG12061	San Gabriel River	3	Initial	7.1	0.18	0.004	15.4	8.03	51.4	20.8	33.4

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Table 7. Sea urchin fertilization results for reference toxicant experiment No. S392 conducted on 10/22/98.

Log Number	Description	Percent Fertilized	Mean	Std Dev	N Counted
USSW10233	Seawater Control	99	98	1.3	5
USSW10233	Seawater Control	96			
USSW10233	Seawater Control	98			
USSW10233	Seawater Control	99			
USSW10233	Seawater Control	99			
USRF10231	9.5 ug/l Cu	96	96	2.7	5
USRF10231	9.5 ug/l Cu	98			
USRF10231	9.5 ug/l Cu	92			
USRF10231	9.5 ug/l Cu	99			
USRF10231	9.5 ug/l Cu	96			
USRF10232	13.9 ug/l Cu	94	95	2.2	5
USRF10232	13.9 ug/l Cu	95			
USRF10232	13.9 ug/l Cu	94			
USRF10232	13.9 ug/l Cu	92			
USRF10232	13.9 ug/l Cu	98			
USRF10233	20.4 ug/l Cu	93	95	1.6	5
USRF10233	20.4 ug/l Cu	94			
USRF10233	20.4 ug/l Cu	96			
USRF10233	20.4 ug/l Cu	95			
USRF10233	20.4 ug/l Cu	97			
USRF10234	30.0 ug/l Cu	92	92	0.8	5
USRF10234	30.0 ug/l Cu	93			
USRF10234	30.0 ug/l Cu	92			
USRF10234	30.0 ug/l Cu	91			
USRF10234	30.0 ug/l Cu	91			
USRF10235	44.0 ug/l Cu	82	66	23.2	5
USRF10235	44.0 ug/l Cu	26			
USRF10235	44.0 ug/l Cu	69			
USRF10235	44.0 ug/l Cu	81			
USRF10235	44.0 ug/l Cu	74			
USRF10236	65.0 ug/l Cu	31	22	6.8	5
USRF10236	65.0 ug/l Cu	13			
USRF10236	65.0 ug/l Cu	18			
USRF10236	65.0 ug/l Cu	22			
USRF10236	65.0 ug/l Cu	25			

Table 8. Sea urchin fertilization results for reference toxicant experiment No. S394, conducted on 11/8/98.

		Percent Fertilized			
Log Number	Description		Mean	Std Dev	N Counted
USSW11112	Seawater Control	99	97	3.5	5
USSW11112	Seawater Control	99			
USSW11112	Seawater Control	93			
USSW11112	Seawater Control	93			
USSW11112	Seawater Control	100			
USRF11111	9.5 ug/l Cu	93	83	17.8	5
USRF11111	9.5 ug/l Cu	75			
USRF11111	9.5 ug/l Cu	56			
USRF11111	9.5 ug/l Cu	99			
USRF11111	9.5 ug/l Cu	94			
USRF11112	13.9 ug/l Cu	96	63	25.2	5
USRF11112	13.9 ug/l Cu	62			
USRF11112	13.9 ug/l Cu	65			
USRF11112	13.9 ug/l Cu	65			
USRF11112	13.9 ug/l Cu	25			
USRF11113	20.4 ug/l Cu	77	42	25.0	5
USRF11113	20.4 ug/l Cu	40			
USRF11113	20.4 ug/l Cu	55			
USRF11113	20.4 ug/l Cu	20			
USRF11113	20.4 ug/l Cu	17			
USRF11114	30.0 ug/l Cu	17	9	6.3	5
USRF11114	30.0 ug/l Cu	13			
USRF11114	30.0 ug/l Cu	2			
USRF11114	30.0 ug/l Cu	4			
USRF11114	30.0 ug/l Cu	7			
USRF11115	44.0 ug/l Cu	5	6	10.0	5
USRF11115	44.0 ug/l Cu	0			
USRF11115	44.0 ug/l Cu	1			
USRF11115	44.0 ug/l Cu	24			
USRF11115	44.0 ug/l Cu	2			
USRF11116	65.0 ug/l Cu	0	0	0.0	5
USRF11116	65.0 ug/l Cu	0			
USRF11116	65.0 ug/l Cu	0			
USRF11116	65.0 ug/l Cu	0			
USRF11116	65.0 ug/l Cu	0			

R0012308

LOS ANGELES COUNTY RIVER TOXICITY REPORT: JANUARY THROUGH MARCH, 1999 WET WEATHER SAMPLES

Prepared for
Los Angeles County Department of Public Works

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R0012309

TOXICITY MEASUREMENT OF JANUARY THROUGH MARCH 1999 WET WEATHER RIVER SAMPLES

INTRODUCTION

This report presents results for the toxicity analysis of samples of wet weather flow from the Los Angeles and San Gabriel Rivers. The tests were conducted as partial fulfillment of the monitoring requirements mandated by NPDES Permit No. CAS614001 from the California Regional Water Quality Control Board (Los Angeles Region).

METHODS

Sampling was conducted by LACDPW personnel during wet weather flow conditions at the Los Angeles and San Gabriel Rivers. Samples were taken during two storms for the Los Angeles River and one storm for the San Gabriel. The wet weather sample was collected by autosampler from the San Gabriel River on January 26, 1999. A single grab sample was taken from the Los Angeles River during storms on March 15 and March 20, 1999. Sampling locations were LACDPW mass emission stations S-10 (Los Angeles River) and S-14 (San Gabriel River). Samples were stored under refrigeration until tested on January 27, March 16 and March 22, respectively.

Toxicity was measured using the purple sea urchin fertilization test as described by Chapman *et al.*, 1995. Sea urchin gametes were obtained from specimens collected from a relatively uncontaminated area in northern Santa Monica Bay. In the test, sea urchin sperm are exposed to various concentrations of the test sample for 20 minutes at a temperature of approximately 15 °C. Sea urchin eggs are then added to each sample and given 20 minutes for fertilization to occur. Preservative is then added to the samples, which are later examined with a microscope to determine the percentage of fertilized eggs.

Since the toxicity test uses a marine organism, the salinity of the river samples was adjusted to a typical seawater value by addition of hypersaline brine. Addition of the brine diluted the samples, restricting the highest concentration of sample tested to 50%. Additional test concentrations (25, 12, 6, 3, and 1.5%) were prepared by adding laboratory seawater (filtered natural seawater collected from offshore Redondo Beach) to the samples. A brine control was included in the experiment to check for toxicity introduced by the salinity adjustment procedure. The brine control consisted of deionized water, laboratory seawater, and brine at the same concentration found in the 50% and 25% river samples.

A reference toxicant test was conducted concurrently with the river tests in order to document variability in test sensitivity. This test consisted of five concentrations of dissolved copper, ranging from 10 µg/L to 65 µg/L.

R0012310

Water quality measurements (pH, dissolved oxygen, conductivity, and total ammonia) were made on the test samples at the beginning of the toxicity test. For the river samples, water quality was measured on the 50%, 12% and 3% concentrations. All measurements were made using electrodes. Sample salinity was calculated from the conductivity and temperature data. Un-ionized ammonia (NH_3) concentration was calculated from the total ammonia, pH, salinity, and temperature data.

For each experiment, we attempted to calculate an EC_{50} (concentration producing a 50% reduction in fertilization) and NOEC (highest test concentration that does not produce a statistically significant reduction in fertilization). The EC_{50} was calculated by probit analysis of the raw percent fertilized data. If there was less than a 50% reduction in fertilization success, then an EC_{50} could not be calculated. The NOEC was calculated by first arcsine transforming the percent fertilized data, then testing for homogenity of variance and normal distribution of the data. Data that passed these tests were then subjected to a one way analysis of variance (ANOVA). If a significant difference between treatments was detected ($p \leq 0.05$), a Dunnett's multiple range test was performed to test for differences between the control value and each of the concentrations. Data that did not pass the test for homogenity of variance and/or normal distribution were subjected to a non-parametric Steel's Many-One Rank test. If there was not a significant reduction in fertilization relative to the control, then a NOEC could not be calculated.

RESULTS AND DISCUSSION

No toxicity was detected in the wet weather sample from San Gabriel River taken in January (Figure 1). Since there was no reduction in fertilization caused by this sample, neither a NOEC nor an EC_{50} could be calculated (Table 1). The lack of toxicity from this sample is consistent with the results of testing from another San Gabriel River sample taken earlier in the storm season (SCCWRP 1998).

Sea urchin fertilization was significantly reduced by exposure to samples from the Los Angeles River for both storms in (Figures 2 and 3). The greatest toxicity was present in the March 15 storm sample. The NOEC for this storm was 12.5%, which represents 8 chronic toxicity units (TU_c=100/NOEC). The March 20 sample had a NOEC of 25% (4 TU_c). The EC_{50} for the first storm was 24% sample. Since the sample from the second storm did not cause a 50% reduction in fertilization, an EC_{50} could not be calculated (Table 1).

All of the experiments met the test acceptability criteria. For the San Gabriel River sampling, the control seawater fertilization percentage averaged 91% and the 50% brine control averaged 98%, well above the minimum acceptable value of 70%. The Los Angeles River samples also had good control results with the seawater control averaging 89% and 100% respectively and the 50% brine control greater than 83% and 100%. Summaries of the fertilization counts for each experiment are shown in Tables 2-4.

R0012311

The results of water quality measurements are shown in Tables 5-7. The pH, dissolved oxygen, and salinity of the samples were within acceptable ranges for all of the experiments. Total ammonia in the San Gabriel River (2.01 mg /L) wet weather sample was elevated relative to the control, but was well below the level (>20 mg /L) that would be expected to cause toxicity in the sea urchin fertilization test.

The copper reference toxicant tests conducted with each experiment also met performance standards. The EC_{50} values for these tests ranged from 27-48 µg/L, which are similar to the historical average for our laboratory (27.6 µg/L). The data for all three of the tests are within the range for an acceptable test (4.2 to 51.0 µg/L) (Figure 4). The relatively high EC_{50} for the March 22 experiment may indicate a somewhat less sensitive test than we would normally achieve.

LITERATURE CITED

Chapman, G.A., D.L. Denton, and J.M. Lazorchak. 1995. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to west coast marine and estuarine organisms. EPA/600/R-95/136, National Exposure Research Laboratory, U. S. Environmental Protection Agency, Cincinnati, OH. 661p.

SCCWRP. 1998. Los Angeles County river toxicity report: October dry weather and November wet weather samples. Submitted to Los Angeles County Department of Public Works. Southern California Coastal Water Research, Westminster, CA. 11p.

R0012312

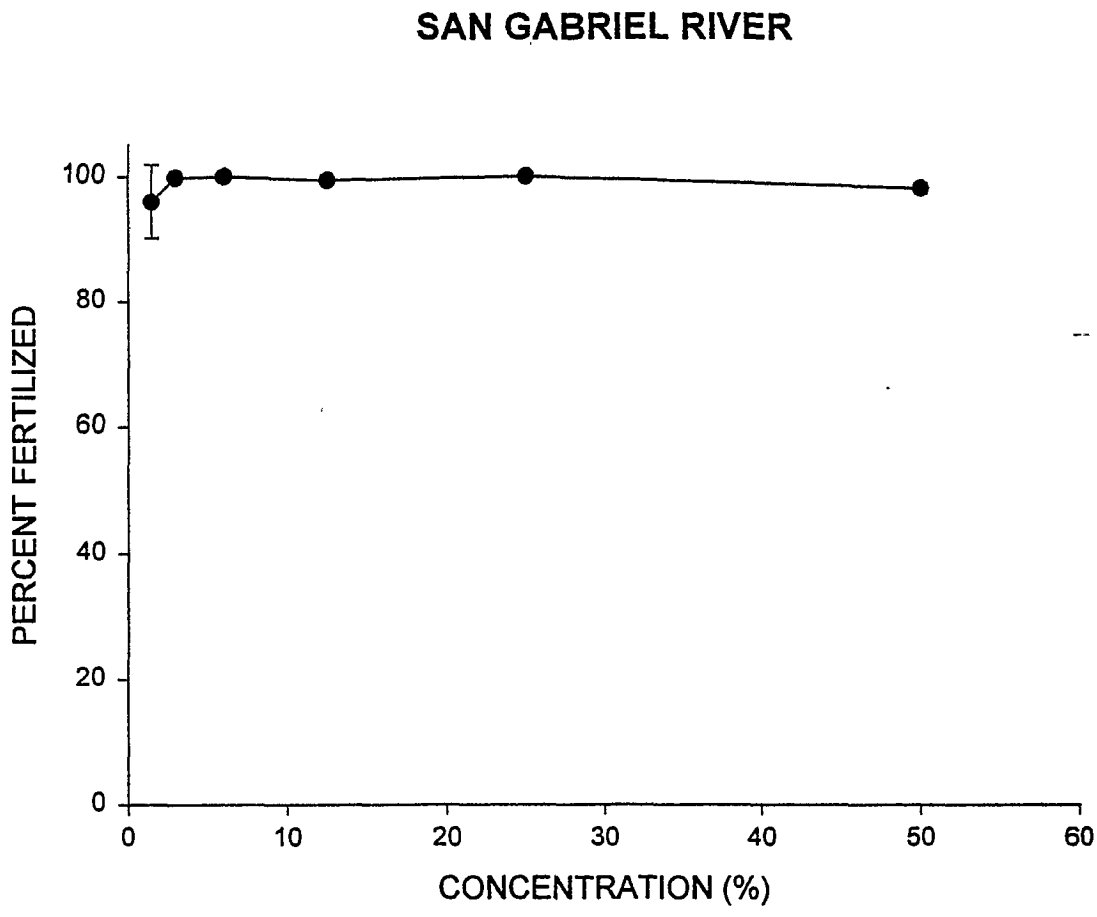

Figure 1. Dose-response plot of sea urchin fertilization test results for San Gabriel River wet weather flow composite collected January 26, 1999. Symbols represent the mean of 5 replicates and the standard deviation.

R0012313

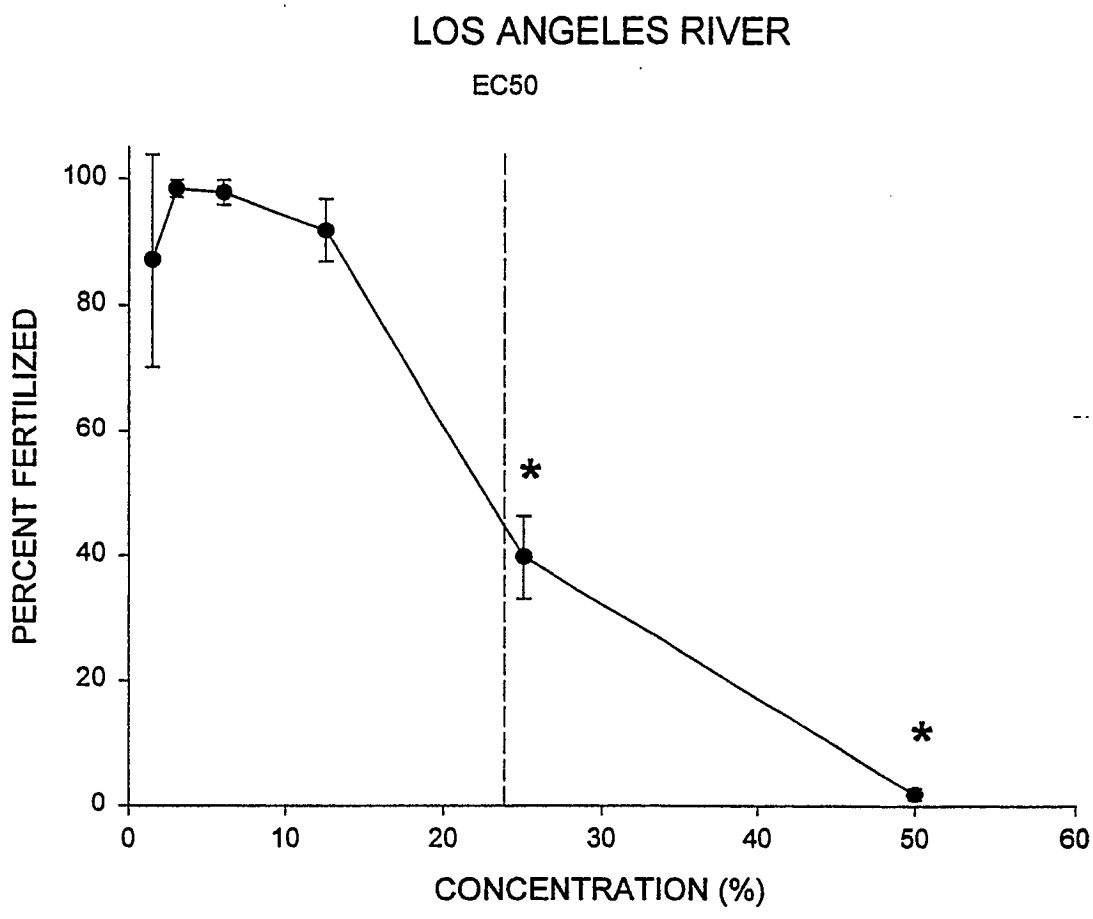

Figure 2. Dose-response plot of sea urchin fertilization test results for Los Angeles River wet weather flow grab collected March 15, 1999. Symbols represent the mean of 5 replicates and the standard deviation. Asterisks indicate concentrations that were significantly different from control ($p \leq 0.05$).

R0012314

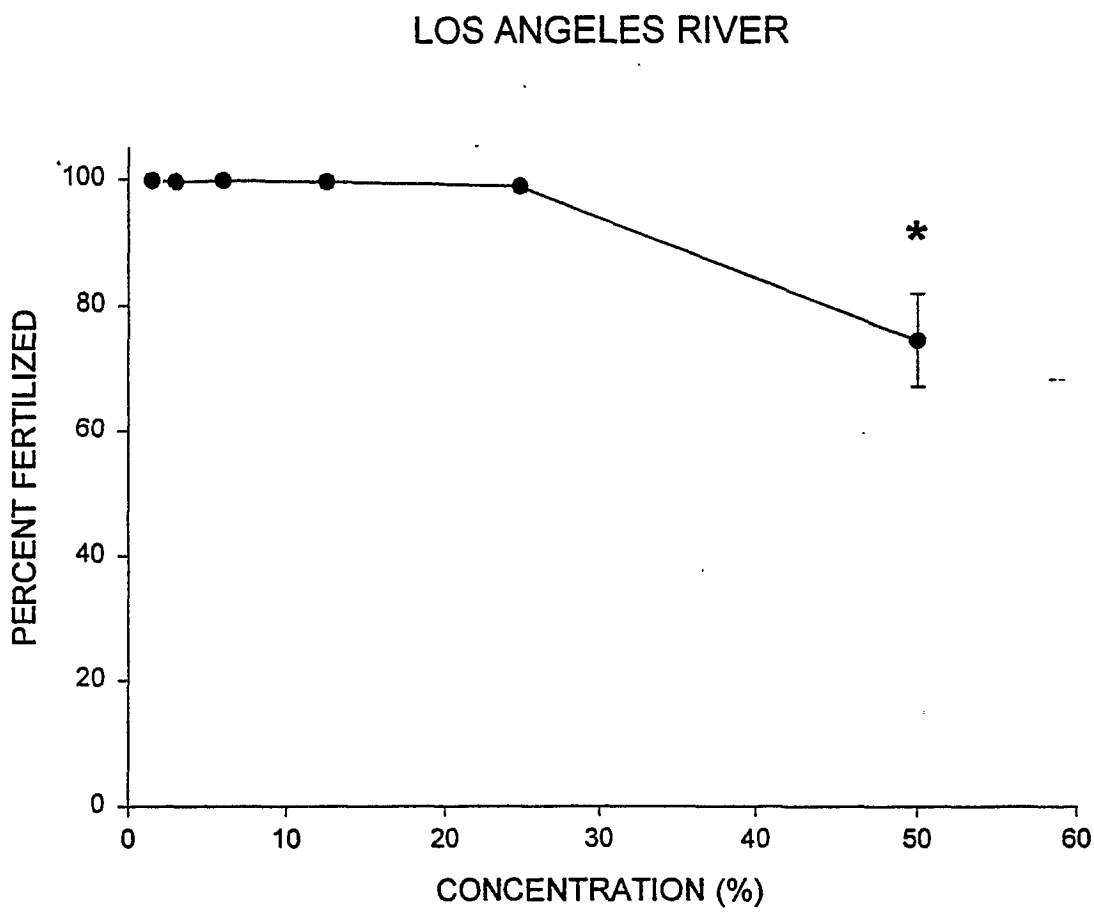

Figure 3. Dose-response plot of sea urchin fertilization test results for Los Angeles River wet weather flow grab collected March 20, 1999. Symbols represent the mean of 5 replicates and the standard deviation. Asterisk indicates concentration that was significantly different from control ($p \leq 0.05$).

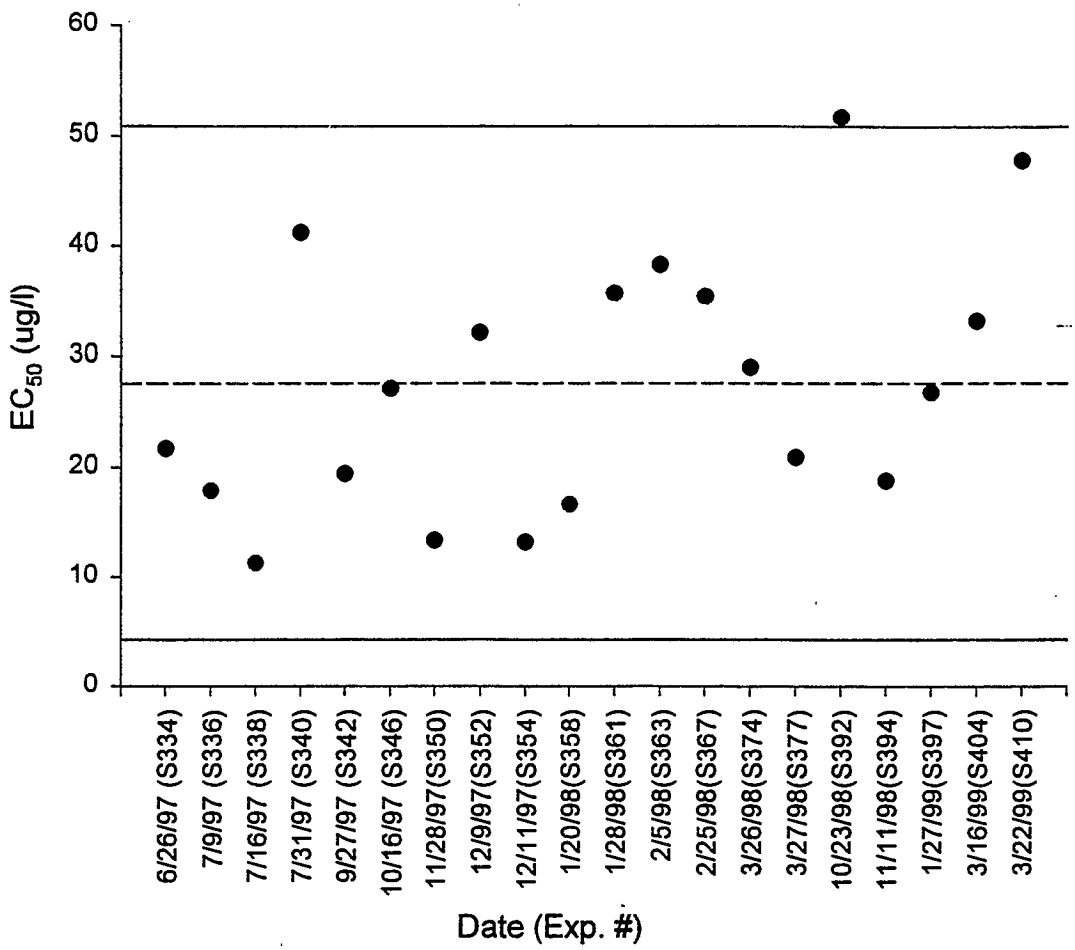

Figure 4. Control chart for purple sea urchin fertilization test of copper reference toxicant samples. Control lines represent two standard deviations of mean EC_{50} (concentration producing a 50% reduction in fertilization).

R0012316

Table 1. Summary of sea urchin fertilization test results for San Gabriel River and Los Angeles River. Rainfall data is from Los Angeles Civic Center and is total for entire storm.

Location	Date	Rainfall (in)	EC50 (%)	NOEC (%)	Toxic units (TU_c)
San Gabriel River	1/26/99	1.15	>50	≥50	≤2
Los Angeles River	3/15/99	0.45	24	12.5	8
Los Angeles River	3/20/99	0.24	>50	25	4

R0012317

Table 2. Sea urchin fertilization results for experiment No. S396. Sample collected on 1/26/99 and tested on 1/27/99.

			Percent Fertilized			
Log No.	Description	Concentration (%)		Mean	Std Dev	N
USSW01271	Seawater Control		100	91	14.2	5
USSW01271	Seawater Control		68			
USSW01271	Seawater Control		85			
USSW01271	Seawater Control		100			
USSW01271	Seawater Control		100			
USBK01271	Brine Control	50	100	98	2.7	5
USBK01271	Brine Control	50	99			
USBK01271	Brine Control	50	96			
USBK01271	Brine Control	50	100			
USBK01271	Brine Control	50	94			
USBK01271	Brine Control	25	71	87	10.5	5
USBK01271	Brine Control	25	88			
USBK01271	Brine Control	25	91			
USBK01271	Brine Control	25	100			
USBK01271	Brine Control	25	87			
USSG01261	San Gabriel Flow	50	98	98	0.8	5
USSG01261	San Gabriel Flow	50	97			
USSG01261	San Gabriel Flow	50	99			
USSG01261	San Gabriel Flow	50	98			
USSG01261	San Gabriel Flow	50	99			
USSG01261	San Gabriel Flow	25	100	100	0.0	5
USSG01261	San Gabriel Flow	25	100			
USSG01261	San Gabriel Flow	25	100			
USSG01261	San Gabriel Flow	25	100			
USSG01261	San Gabriel Flow	25	100			
USSG01261	San Gabriel Flow	12	100	99	0.5	5
USSG01261	San Gabriel Flow	12	100			
USSG01261	San Gabriel Flow	12	99			
USSG01261	San Gabriel Flow	12	99			
USSG01261	San Gabriel Flow	12	99			
USSG01261	San Gabriel Flow	6	100	100	0.0	5
USSG01261	San Gabriel Flow	6	100			
USSG01261	San Gabriel Flow	6	100			
USSG01261	San Gabriel Flow	6	100			
USSG01261	San Gabriel Flow	6	100			
USSG01261	San Gabriel Flow	3	100	100	0.4	5
USSG01261	San Gabriel Flow	3	100			
USSG01261	San Gabriel Flow	3	100			
USSG01261	San Gabriel Flow	3	99			
USSG01261	San Gabriel Flow	3	100			
USSG01261	San Gabriel Flow	1.5	99	96	5.8	5
USSG01261	San Gabriel Flow	1.5	86			
USSG01261	San Gabriel Flow	1.5	100			
USSG01261	San Gabriel Flow	1.5	96			
USSG01261	San Gabriel Flow	1.5	99			

R0012318

Table 3. Sea urchin fertilization results for experiment No. S403. Sample collected on 3/15/99 and tested on 3/16/99.

			Percent Fertilized			
Log No.	Description	Concentration (%)		Mean	Std Dev	N
USSW03161	Seawater Control		99	89	15.6	5
USSW03161	Seawater Control		98			
USSW03161	Seawater Control		91			
USSW03161	Seawater Control		62			
USSW03161	Seawater Control		97			
USBK03161	Brine Control	25	100	98	1.7	5
USBK03161	Brine Control	25	100			
USBK03161	Brine Control	25	98			
USBK03161	Brine Control	25	96			
USBK03161	Brine Control	25	98			
USBK03161	Brine Control	50	99	83	31.0	5
USBK03161	Brine Control	50	98			
USBK03161	Brine Control	50	96			
USBK03161	Brine Control	50	28			
USBK03161	Brine Control	50	96			
USLA03151	LA River Flow	1.5	99	87	16.8	5
USLA03151	LA River Flow	1.5	98			
USLA03151	LA River Flow	1.5	64			
USLA03151	LA River Flow	1.5	74			
USLA03151	LA River Flow	1.5	100			
USLA03151	LA River Flow	3	99	98	1.3	5
USLA03151	LA River Flow	3	96			
USLA03151	LA River Flow	3	99			
USLA03151	LA River Flow	3	99			
USLA03151	LA River Flow	3	99			
USLA03151	LA River Flow	6	99	98	1.9	5
USLA03151	LA River Flow	6	97			
USLA03151	LA River Flow	6	95			
USLA03151	LA River Flow	6	98			
USLA03151	LA River Flow	6	100			
USLA03151	LA River Flow	12.5	95	92	5.1	5
USLA03151	LA River Flow	12.5	94			
USLA03151	LA River Flow	12.5	85			
USLA03151	LA River Flow	12.5	88			
USLA03151	LA River Flow	12.5	97			
USLA03151	LA River Flow	25	36	40	6.6	5
USLA03151	LA River Flow	25	30			
USLA03151	LA River Flow	25	43			
USLA03151	LA River Flow	25	44			
USLA03151	LA River Flow	25	46			
USLA03151	LA River Flow	50	2	2	1.0	5
USLA03151	LA River Flow	50	3			
USLA03151	LA River Flow	50	3			
USLA03151	LA River Flow	50	1			
USLA03151	LA River Flow	50	1			

R0012319

Table 4. Sea urchin fertilization results for experiment No. S409. Sample collected on 3/20/99 and tested on 3/22/99.

			Percent Fertilized			
Log No.	Description	Concentration (%)		Mean	Std Dev	N
USSW03221	Seawater Control		100	100	0.0	5
USSW03221	Seawater Control		100			
USSW03221	Seawater Control		100			
USSW03221	Seawater Control		100			
USSW03221	Seawater Control		100			
USBK03221	Brine Control	25	99	99	0.8	5
USBK03221	Brine Control	25	98			
USBK03221	Brine Control	25	100			
USBK03221	Brine Control	25	100			
USBK03221	Brine Control	25	99			
USBK03221	Brine Control	50	100	100	0.0	5
USBK03221	Brine Control	50	100			
USBK03221	Brine Control	50	100			
USBK03221	Brine Control	50	100			
USBK03221	Brine Control	50	100			
USLA03221	LA River Flow	1.5	100	100	0.4	5
USLA03221	LA River Flow	1.5	100			
USLA03221	LA River Flow	1.5	100			
USLA03221	LA River Flow	1.5	99			
USLA03221	LA River Flow	1.5	100			
USLA03221	LA River Flow	3	100	100	0.5	5
USLA03221	LA River Flow	3	100			
USLA03221	LA River Flow	3	99			
USLA03221	LA River Flow	3	99			
USLA03221	LA River Flow	3	100			
USLA03221	LA River Flow	6	99	100	0.4	5
USLA03221	LA River Flow	6	100			
USLA03221	LA River Flow	6	100			
USLA03221	LA River Flow	6	100			
USLA03221	LA River Flow	6	100			
USLA03221	LA River Flow	12.5	100	99	0.9	5
USLA03221	LA River Flow	12.5	98			
USLA03221	LA River Flow	12.5	100			
USLA03221	LA River Flow	12.5	100			
USLA03221	LA River Flow	12.5	99			
USLA03221	LA River Flow	25	100	99	0.8	5
USLA03221	LA River Flow	25	98			
USLA03221	LA River Flow	25	99			
USLA03221	LA River Flow	25	99			
USLA03221	LA River Flow	25	98			
USLA03221	LA River Flow	50	67	74	7.3	5
USLA03221	LA River Flow	50	75			
USLA03221	LA River Flow	50	80			
USLA03221	LA River Flow	50	67			
USLA03221	LA River Flow	50	83			

R0012320

Table 5. Water quality summary for January 27, 1999 San Gabriel River fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/Kg)
	Desired Range			>4.0	<20		14.0–16.0				32.0–34.0
USSW01271	Seawater Control		Initial	7.3	0.02	<0.001	14.2	7.78	50.6	21.0	32.8
USBK01271	Brine Control	50	Initial	7.4	0.09	0.001	14.2	7.75	50.6	20.2	32.7
USSG01261	San Gabriel River	50	Initial	7.0	2.01	0.028	14.2	7.83	51.4	19.7	33.3
USSG01261	San Gabriel River	12.5	Initial	7.2	0.48	0.008	14.2	7.89	51.5	20.5	33.4
USSG01261	San Gabriel River	3	Initial	6.9	0.11	0.002	14.2	7.91	51.6	20.4	33.5

Table 6. Water quality summary for March 16, 1999 LA River fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/Kg)
	Desired Range			>4.0	<20		14.0–16.0				32.0–34.0
USSW03161	Seawater Control		Initial	7.2	0.02	<0.001	14.5	7.93	51.8	21.5	33.7
USBK03161	Brine Control	50	Initial	7.1	0.02	<0.001	14.5	7.99	49.9	21.7	32.4
USLA03151	Los Angeles River	50	Initial	7.4	0.03	0.001	14.5	7.96	51.5	21.6	33.5
USLA03151	Los Angeles River	12.5	Initial	7.3	0.10	0.002	14.5	8.00	51.1	21.5	33.2
USLA03151	Los Angeles River	3	Initial	7.5	0.45	0.014	14.5	8.16	49.9	21.5	32.4

Table 7. Water quality summary for March 22, 1999 LA River fertilization test.

Log Number	Sample Name	Conc. (%)	Time Point	DO (mg/l)	Total Ammonia (mg/l)	Un-ionized Ammonia (mg/l)	Temperature (°C)	pH	Conductivity (mS/cm)	Cond. Sample Temp.	Salinity (g/Kg)
	Desired Range			>4.0	<20		14.0–16.0				32.0–34.0
USSW03221	Seawater Control		Initial	7.4	0.02	<0.001	14.3	7.96	51.7	23.0	33.8
USBK03221	Brine Control	50	Initial	6.9	0.02	<0.001	14.3	8.00	50.0	23.3	32.6
USLA03221	Los Angeles River	50	Initial	6.8	0.04	0.001	14.3	7.94	51.3	23.3	33.5
USLA03221	Los Angeles River	12.5	Initial	6.8	0.11	0.002	14.3	7.98	50.8	23.4	33.2
USLA03221	Los Angeles River	3	Initial	6.7	0.41	0.010	14.3	8.15	49.7	23.3	32.4

R0012321

Table 8. Sea urchin fertilization results for reference toxicant experiment No. S397 conducted on 1/27/99.

		Percent Fertilized			
Log Number	Description		Mean	Std Dev	N
USSW01272	Seawater Control	100	87	16.0	5
USSW01272	Seawater Control	100			
USSW01272	Seawater Control	90			
USSW01272	Seawater Control	85			
USSW01272	Seawater Control	61			
USRF01271	9.5 ug/l Cu	42	62	22.1	5
USRF01271	9.5 ug/l Cu	62			
USRF01271	9.5 ug/l Cu	98			
USRF01271	9.5 ug/l Cu	46			
USRF01271	9.5 ug/l Cu	63			
USRF01272	13.9 ug/l Cu	100	100	0.0	5
USRF01272	13.9 ug/l Cu	100			
USRF01272	13.9 ug/l Cu	100			
USRF01272	13.9 ug/l Cu	100			
USRF01272	13.9 ug/l Cu	100			
USRF01273	20.4 ug/l Cu	5	63	38.0	5
USRF01273	20.4 ug/l Cu	76			
USRF01273	20.4 ug/l Cu	88			
USRF01273	20.4 ug/l Cu	45			
USRF01273	20.4 ug/l Cu	99			
USRF01274	30.0 ug/l Cu	84	36	43.5	5
USRF01274	30.0 ug/l Cu	5			
USRF01274	30.0 ug/l Cu	6			
USRF01274	30.0 ug/l Cu	3			
USRF01274	30.0 ug/l Cu	84			
USRF01275	44.0 ug/l Cu	38	12	15.4	5
USRF01275	44.0 ug/l Cu	15			
USRF01275	44.0 ug/l Cu	1			
USRF01275	44.0 ug/l Cu	5			
USRF01275	44.0 ug/l Cu	2			
USRF01276	65.0 ug/l Cu	0	8	9.3	5
USRF01276	65.0 ug/l Cu	2			
USRF01276	65.0 ug/l Cu	4			
USRF01276	65.0 ug/l Cu	22			
USRF01276	65.0 ug/l Cu	14			

R0012322

Table 9. Sea urchin fertilization results for reference toxicant experiment No. S404, conducted on 3/16/99.

		Percent Fertilized			
Log Number	Description		Mean	Std Dev	N
USSW03163	Seawater Control	98	98	1.2	5
USSW03163	Seawater Control	98			
USSW03163	Seawater Control	99			
USSW03163	Seawater Control	96			
USSW03163	Seawater Control	99			
USRF03161	9.5 ug/l Cu	99	96	2.9	5
USRF03161	9.5 ug/l Cu	92			
USRF03161	9.5 ug/l Cu	95			
USRF03161	9.5 ug/l Cu	99			
USRF03161	9.5 ug/l Cu	96			
USRF03162	13.9 ug/l Cu	98	94	3.0	5
USRF03162	13.9 ug/l Cu	92			
USRF03162	13.9 ug/l Cu	95			
USRF03162	13.9 ug/l Cu	93			
USRF03162	13.9 ug/l Cu	90			
USRF03163	20.4 ug/l Cu	75	83	6.8	5
USRF03163	20.4 ug/l Cu	78			
USRF03163	20.4 ug/l Cu	85			
USRF03163	20.4 ug/l Cu	86			
USRF03163	20.4 ug/l Cu	92			
USRF03164	30.0 ug/l Cu	76	72	8.5	5
USRF03164	30.0 ug/l Cu	82			
USRF03164	30.0 ug/l Cu	60			
USRF03164	30.0 ug/l Cu	67			
USRF03164	30.0 ug/l Cu	74			
USRF03165	44.0 ug/l Cu	3	12	17.5	5
USRF03165	44.0 ug/l Cu	7			
USRF03165	44.0 ug/l Cu	4			
USRF03165	44.0 ug/l Cu	43			
USRF03165	44.0 ug/l Cu	2			
USRF03166	65.0 ug/l Cu	1	1	0.7	5
USRF03166	65.0 ug/l Cu	1			
USRF03166	65.0 ug/l Cu	1			
USRF03166	65.0 ug/l Cu	2			
USRF03166	65.0 ug/l Cu	0			

R0012323

Table 10. Sea urchin fertilization results for reference toxicant experiment No. S409, conducted on 3/22/99.

		Percent Fertilized			
Log Number	Description		Mean	Std Dev	N
USSW03223	Seawater Control	100	100	0.0	5
USSW03223	Seawater Control	100			
USSW03223	Seawater Control	100			
USSW03223	Seawater Control	100			
USSW03223	Seawater Control	100			
USRF03221	9.5 ug/l Cu	100	99	1.2	5
USRF03221	9.5 ug/l Cu	100			
USRF03221	9.5 ug/l Cu	99			
USRF03221	9.5 ug/l Cu	99			
USRF03221	9.5 ug/l Cu	97			
USRF03222	13.9 ug/l Cu	99	99	1.7	5
USRF03222	13.9 ug/l Cu	98			
USRF03222	13.9 ug/l Cu	100			
USRF03222	13.9 ug/l Cu	96			
USRF03222	13.9 ug/l Cu	100			
USRF03223	20.4 ug/l Cu	98	98	1.9	5
USRF03223	20.4 ug/l Cu	99			
USRF03223	20.4 ug/l Cu	95			
USRF03223	20.4 ug/l Cu	100			
USRF03223	20.4 ug/l Cu	97			
USRF03224	30.0 ug/l Cu	95	88	14.4	5
USRF03224	30.0 ug/l Cu	100			
USRF03224	30.0 ug/l Cu	85			
USRF03224	30.0 ug/l Cu	64			
USRF03224	30.0 ug/l Cu	95			
USRF03225	44.0 ug/l Cu	83	71	21.5	5
USRF03225	44.0 ug/l Cu	86			
USRF03225	44.0 ug/l Cu	53			
USRF03225	44.0 ug/l Cu	42			
USRF03225	44.0 ug/l Cu	89			
USRF03226	65.0 ug/l Cu	0	6	6.2	5
USRF03226	65.0 ug/l Cu	2			
USRF03226	65.0 ug/l Cu	6			
USRF03226	65.0 ug/l Cu	16			
USRF03226	65.0 ug/l Cu	8			

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Appendix H
Aerial Deposition Study Progress Reports
by Southern California Coastal Waters Research Project

Quarterly Report of Progress
May 11, 1999

ESTIMATES OF POLLUTANT INPUTS TO SANTA MONICA BAY VIA AERIAL DEPOSITION

This is the first year of a three-year project. The first year is funded by the US EPA, the Los Angeles County Department of Public Works and SCCWRP. The project is being conducted in collaboration with UCLA's Institute of the Environment, the Santa Monica Bay Restoration Project (SMBRP), the US EPA's Great Water Program, and in cooperation with the South Coast Air Quality Management District (AQMD). The first year of this project intends to estimate the annual pollutant loads to Santa Monica Bay via aerial deposition, both directly to Bay waters, and indirectly by depositing onto land surfaces then washing off into the Bay during storm events.

We have successfully completed the winter phase of our sampling program. The sampling program included measurements of contaminants on aerosol particles from the atmosphere, dry deposition (what lands on a surrogate surface), and wet deposition (rain). Our master sampling site is located within the Santa Monica Bay watershed at UCLA. The AQMD samples eight other locations within the airshed (LA air basin) that can contribute to loading in Santa Monica Bay. We also sampled the sea surface microlayer and bulk seawater at nine stations located throughout Santa Monica Bay to estimate direct deposition. Sample analysis is currently underway for all of these samples. During the next quarter, SCCWRP staff will be mobilizing for our summer sampling season scheduled to begin in July.

Quarterly Report of Progress
April, 2000

ESTIMATES OF POLLUTANT INPUTS TO SANTA MONICA BAY VIA AERIAL DEPOSITION

This is the first year of a three-year project. The first year is funded by the US EPA, the Los Angeles County Department of Public Works and SCCWRP. The project is being conducted in collaboration with UCLA's Institute of the Environment, the Santa Monica Bay Restoration Project (SMBRP), the US EPA's Great Water Program, and in cooperation with the South Coast Air Quality Management District (AQMD). The first year of this project intends to estimate the annual pollutant loads to Santa Monica Bay via aerial deposition, both directly to Bay waters and indirectly by depositing onto land surfaces, then washing off into the Bay during storm events.

We have made progress on two phases of our project over the last quarter. The first phase was reporting. We have compiled a Data Report that includes objectives, rationale, methods, quality assurance/quality control, information management, and raw data for the entire study. The second area of activity is data analysis and assessment. We have had three meetings with the UCLA Institute of the Environment that have been focused on data analysis, integration of project data with AQMD data sets, and atmospheric transport and deposition modeling.

During the next quarter, SCCWRP staff will continue to make progress on the data analysis and assessment report. The timeline for completion of the Data Assessment Report is for September 2000. We will also continue to make additional air measurements. We have received a $50,000 grant from the US EPA Great Waters Program to complete this work. The additional sampling and analysis will address data gaps identified during the first year's work. This provides an excellent opportunity for the LACDPW to leverage any additional resources in the upcoming year against those being provided by the US EPA and SCCWRP.

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Environmental Programs Division
Water Quality Section

Quarterly Report of Progress
February, 2000

ESTIMATES OF POLLUTANT INPUTS TO SANTA MONICA BAY VIA AERIAL DEPOSITION

This is the first year of a three-year project. The first year is funded by the US EPA, the Los Angeles County Department of Public Works and SCCWRP. The project is being conducted in collaboration with UCLA's Institute of the Environment, the Santa Monica Bay Restoration Project (SMBRP), the US EPA's Great Water Program, and in cooperation with the South Coast Air Quality Management District (AQMD). The first year of this project intends to estimate the annual pollutant loads to Santa Monica Bay via aerial deposition, both directly to Bay waters and indirectly by depositing onto land surfaces, then washing off into the Bay during storm events.

We have made progress on four different phases of our project over the last quarter. The first phase was sampling. Sampling for the year is now completed. We conducted two additional sampling cruises over the last quarter than was required in order to capture Santa Ana wind conditions, an event that moves the urban air mass offshore. The second phase of our project was completing sample analysis. We anticipate having all samples analyzed by early February including aerosol particulates, dry deposition surfaces, wet deposition, sea-surface microlayer, and bulk seawater samples. The third phase of our project is information management. As we receive data from the laboratory, we are checking to ensure accuracy and completeness. Also, we have requested data from AQMD to obtain complimentary aerosol measurements outside of the Santa Monica Bay watershed, but inside of the Los Angeles airshed. A third phase of our project was quality assurance. We have met with AQMD twice and have analyzed a set of split samples. The goal of this interlaboratory calibration is to assess comparability prior to combining data sets.

During the next quarter, SCCWRP staff will make progress on two more phases of our project. The first phase will be data analysis. We intend to start preliminary examination of our results beginning in February. We also intend to begin integrating our results with the AQMD data set. The combined data set will be delivered to UCLA for continued work by the atmospheric transport and transformation modelers. The second phase of our project that we anticipate progress will be reporting. Our goal is to begin compiling a data report that includes the data generated under this project by April 2000. After the modelers have completed their tasks, an assessment report integrated our results, AQMD results, and modeled predictions will be constructed by July 2000.

An invited workshop entitled "Where air and water meet: Atmospheric deposition to the Pacific Coast" has been scheduled for February 9-10, 2000 at UCLA. The

workshop will be co-sponsored by the Ecological Society of America, the UCLA Institute of the Environment, and SCCWRP and will include nationally prominent atmospheric deposition scientists as well as National Estuary Program managers from around the country.

Appendix I
Contacts for More Information

Appendix I
Contacts for More Information

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Industrial Stormwater Permits	Robert Tom, LARWQCB	(213) 576-6789	rtom@rb4.swrcb.ca.gov

This report will soon be on the Web. Call Eduardo Escobar, above, for more information on Internet availability.

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FINAL REPORT

LOS ANGELES COUNTY 2000-2001 STORMWATER MONITORING REPORT

July 6, 2001

Prepared by

Los Angeles County Department of Public Works
900 South Fremont Avenue
Alhambra, California 91803

And

URS
500 12th Street, Suite 200
Oakland, California 94607

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LOS ANGELES COUNTY 2000-2001 STORMWATER MONITORING REPORT

2001 JUL 12 A 10:58

July 6, 2001

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Appendix A Hydrographs of Monitored Stations and Rainfall Contour Maps

Appendix B Stormwater Quality Data for the 2000-2001 Storm Season

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Appendix E Contacts

Upon 72 hours' notice, the Los Angeles County Department of Public Works (LACDPW) can provide program information and publications in alternate formats or make other accommodations for people with disabilities. In addition, program documents are available at the LACDPW main office in Alhambra (900 So. Fremont Ave.), which is accessible to individuals with disabilities. To request accommodations ONLY, or for more American with Disabilities Act (ADA) information, please contact the LACDPW's departmental ADA Coordinator at (626) 458-4081 or TDD (626) 282-7829, Monday through Thursday, from 7:00 a.m. to 5:30 p.m.

ACOE	Army Corps of Engineers
ACWM	Department of Agricultural Commissioner/Weights and Measures
ANOVA	analysis of variance
BMPs	Best Management Practices
BOD_5	biochemical oxygen demand (five day)
CIT	commercial/industrial/transportation
COD	chemical oxygen demand
CV	coefficient of variation
DDT	dichlorodiphenyltrichloroethane
DF	degrees of freedom
DL	detection limit
EC_{50}	effective concentration for 50% reduction in fertilization
EMCs	Event Mean Concentrations
GIS	Geographical Information Systems
HDSFR	high density single family residential
ID	identification
LACDPW	Los Angeles County Department of Public Works
LAX	Los Angeles International Airport
mg/l	milligrams per liter
μg/l	micrograms per liter
NOEC	no observed effects concentration
NPDES	National Pollutant Discharge Elimination System
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
pH	negative logarithm of hydrogen ion concentration
PQL	practical quantitation limit
QA/QC	quality assurance/quality control
RWQCB	Regional Water Quality Control Board
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SIC	Standard Industrial Classification
SID	statistically invalid data
SVD	statistically valid data

TKN	total Kjeldahl nitrogen
TPH	total petroleum hydrocarbons
TSS	total suspended solids
TU	toxicity units
USEPA	United States Environmental Protection Agency
WDR	waste discharge requirements
WMA	Watershed Management Area
WQC	water quality criteria
WY	water year

GOALS AND OBJECTIVES

The goal of the Los Angeles County Monitoring Program is to provide technical data and information to support effective watershed stormwater quality management programs in Los Angeles County. Specific objectives of the Program, as outlined in the Municipal Permit, are:

- tracking water quality status, pollutant trends and pollutant loads, and identifying pollutants of concern;
- monitoring and assessing pollutant loads from specific land uses and watershed areas;
- identifying, monitoring, and assessing significant water quality problems related to stormwater discharges within the watershed;
- identifying sources of pollutants in stormwater runoff;
- identifying and eliminating illicit discharges;
- evaluating the effectiveness of management programs, including pollutant reductions achieved by implementation of Best Management Practices; and
- assessing the impacts of stormwater runoff on receiving waters.

The 2000-2001 Monitoring Program was designed to address these objectives through the implementation of three elements: land use station monitoring, mass emission station monitoring, and critical source/BMP monitoring. The County also is addressing illicit discharges through an inspection program.

LAND USE AND MASS EMISSION STATION MONITORING

Stations and Equipment

Land use stations are defined as relatively small catchments (0.1 to over 5 square miles) that have one predominant land use. The objectives of land use monitoring are to evaluate possible effects of land use on water quality, to evaluate the relative importance of land uses as pollution sources; and to provide data that can be used, along with data from mass emission stations, to project watershed pollutant loads. Data were obtained from seven land use stations during the 2000-2001 storm season: one vacant, one single family high density residential, one multiple family residential, one mixed residential, one light industrial, one transportation, and one educational. Land use stations were equipped with automatic water samplers and stage (water depth) recorders so that flow composite samples could be obtained. Grab samples were not required from land use stations.

In contrast to land use stations, mass emission stations monitor relatively large (100 to 1000 square miles) mixed land use watersheds. Runoff from five mass emissions monitoring stations was sampled during the 2000-2001 storm season. These stations cumulatively represented a total of 1619 square miles of drainage area. The Permit requires mass emission monitoring of four major drainage areas, namely: Ballona Creek, Malibu Creek, Los Angeles River, and San Gabriel River. The purpose of the mass emission monitoring is to support stormwater load estimates and to provide a basis for long term water quality trend analysis. Therefore, the

monitoring stations are located as close as practical to where the creeks and rivers enter the ocean. Mass emission stations are equipped with automated water samplers and stage recorders to collect composite stormwater samples during storm events. Grab samples were also taken at these stations in accordance with the Municipal Permit. Composite samples only were collected from one additional mass emission station (Coyote Creek) to support loadings analyses for the San Gabriel River watershed. At least six storms were sampled at all the mass emission stations during the 2000-2001 storm season, satisfying the required five storm events per station minimum under the 1996 Permit.

Hydrologic Conditions and Sampling Success

Twelve storms were sampled during the season, compared to 13 last season.

Water Quality Chemical Analysis

Monitoring in Los Angeles County in 2000-2001 was performed in compliance with the Municipal Permit issued in July 1996 which requires a broad suite of chemical analyses, including solids, minerals, bacteria, metals, organics, and nutrients. The Los Angeles County Department of Agricultural Commissioner/Weights and Measures, Environmental Toxicology Laboratory provided the water quality laboratory and related services to the Department of Public Works. The laboratory implemented a Quality Assurance/Quality Control program to ensure that the analyses conducted are scientifically valid, defensible, and of known precision and accuracy.

Water Quality Results (Mass Emission Study)

- Malibu Creek had noticeably higher median concentrations of both total and dissolved phosphorus, while the San Gabriel River has the highest median concentration of nitrate.
- The median total dissolved solids concentration in Malibu Creek is more than twice that of any other mass emission site.
- Both total and fecal coliforms exhibited higher medians in the Los Angeles River. Ballona Creek had the greatest range of results for both total and fecal coliforms as well as fecal enterococcus, while the Los Angeles River had the greatest variability for fecal streptococcus results.
- Concentrations were similar among stations for a given metal. In other words, no station appeared to be "cleaner" or "dirtier" than any other with respect to metals.
- There were several individual exceedances of water quality objectives, either of the California Toxics Rule or of the Ocean Plan (or of both), for metals; and in fact, total aluminum, total copper, dissolved copper, and total zinc each had at least one seasonal mean or median exceed an objective.

Water Quality Results (Land Use Study)

- Runoff from the vacant catchment had high pH (8.0) and high alkalinity (median of 180 mg/l), while runoff from the light industrial, transportation, mixed residential, and high

density residential stations had lower median pH values (6.9, 6.8, 6.8, and 6.8 respectively) and lower median alkalinity concentrations (26, 21, 26, and 23 mg/l respectively). The educational and multiple family residential stations fell in between these two extremes with median pH values of 7.1 and 7.3 respectively, and median alkalinities of 31 and 48 mg/l respectively.

- Median hardness concentrations are similar to the alkalinity pattern: high (200 mg/l) at the vacant station; low in the transportation (30 mg/l), mixed residential (40 mg/l), and high density residential stations (20 mg/l); and in between (55, 60, and 75 mg/l) at the educational, light industrial, and multiple family residential stations.
- TSS results overlapped substantially among the different land uses; however, the light industrial station had the highest median for TSS (199 mg/l) being more than twice as high as the next highest median (84 mg/l for transportation).
- Total and dissolved copper concentrations overlapped among the different land uses, however, the dissolved copper median for the transportation station (31.6 μg/l) was more than twice as high as the next highest median (9.0 μg/l for mixed residential). Dissolved copper generally exceeds the 3.1 μg/l California Toxics Rule guideline while both mean and median concentrations of total copper exceed the Ocean Plan guideline in the transportation, light industrial, educational high density single family residential, and mixed residential stations.
- Total lead results are fairly consistent among land uses.
- Dissolved and total zinc exhibit similar patterns; there is substantial overlap among the different land uses although the mean and median for the light industrial station is highest in each case.

Water Quality Results (Critical Source/BMP Monitoring Study)

- Total and dissolved copper medians at the fabricated metal control sites (218 µg/l and 97 µg/l, respectively) were an order of magnitude higher than those at the motor freight sites (3 and 9 µg/l respectively).
- The highest concentrations of total and dissolved lead occurred at the fabricated metal control sites (medians of 109 µg/l and 42 µg/l, respectively) while there were "no meaningful" median values for the motor freight sites.
- The highest dissolved zinc concentration was observed at the auto repair test sites (median of 229 µg/l) as compared with the auto repair control sites (median of 56 µg/l). Total zinc had a median of 299 µg/l at the fabricated metal test sites and a median of 95 µg/l at the auto repair control sites.
- Dissolved nickel had a median of 18 µg/l at the fabricated metal control sites, and the median of dissolved nickel was not meaningful at the motor freight sites.

RECOMMENDATIONS

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events then that constituent may qualify for removal from the analytical suite for the associated station. For both mass emission and land use stations several constituents met this criterion. It is recommended that these constituents be removed from the analytical suite for the associated stations.

The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived at the 25% error rate. As mutually agreed upon with the RWQCB, it was decided to use the mean standard error as a substitute for error rate (Swamikannu, 1999). Eighty-nine station-constituent combinations met the criterion and it is recommended that monitoring be discontinued for these constituents at the associated stations.

1.1 PURPOSE

The goal of the Monitoring Program is to develop information to support effective watershed stormwater quality management programs. The purpose of these management programs is to reduce pollutants in stormwater discharges to the maximum extent practicable. The major objectives of the Monitoring Program outlined in the Municipal Permit are to:

- track water quality status, pollutant trends and pollutant loads, and identify pollutants of concern;
- monitor and assess pollutant loads from specific land uses and watershed areas;
- identify, monitor, and assess significant water quality problems related to stormwater discharges within the watershed;
- identify sources of pollutants in the stormwater runoff;
- identify and eliminate illicit discharges;
- evaluate the effectiveness of management programs, including pollutant reductions achieved by implementation of Best Management Practices (BMPs); and
- assess the impacts of stormwater runoff on receiving waters.

The Monitoring Program, developed to address these objectives, has several elements: Mass Emission runoff monitoring; Land Use runoff monitoring; and Critical Source runoff monitoring. Each element conducted in 2000-2001 is described in Section 1.3, including the Permit objectives it addressed.

1.2 REPORT ORGANIZATION

The station selection process and the stations used in the Monitoring Program are described in Section 2.1. Maps and tabular descriptions of the tributary areas of each monitored watershed are displayed as Figures 2-1 through 2-13. The field and laboratory methods used in the program are presented in Section 3. The hydrologic and water quality results of the 2000-2001 storm season monitoring are described in Section 4, and the conclusions and recommendations based on the 2000-2001 results are presented in Section 5.

Runoff hydrographs from all the monitoring stations and rainfall contour maps are presented in Appendix A. The complete water quality data for the 2000-2001 season are provided in Appendix B and Appendix C contains tables of available data from the Los Angeles Regional Water Quality Control Board of the Industrial Stormwater Sampling Program. Appendix D is a table of monitoring costs incurred, and Appendix E contains a list of people to contact for more information.

Appendices C and D, though not specifically required by the Municipal Stormwater permit, are included here in the interest of information sharing.

Los Angeles County was the primary author of this report having performed the bulk of the data and statistical analyses and writing much of the report. URS's role was primarily to compile and edit text and assist with conclusions and recommendations.

1.3 BACKGROUND

The 1994-95 storm season was the first for which stormwater monitoring was required under the 1990 Los Angeles County NPDES Municipal Stormwater Permit No. CA0061654. During the 1994-95 and 1995-96 seasons, automated and manual sampling was conducted to characterize stormwater quality and quantity in accordance with the 1990 Municipal Permit. The 1994-95 monitoring data is summarized in *Report of Stormwater Monitoring, Winter of 1994-95* (LACDPW, 1996).

The 1996-97 season was the first storm season in which stormwater monitoring was conducted under the new 1996 Municipal Permit (No. CAS614001). The Permit area is depicted in Figure 1-1. For the 1996-97 season the scope of the Monitoring Program was expanded to incorporate further data collection and new pilot studies. The one-year pilot studies, consisting of "Wide Channel" and "Low Flow" analyses, were completed and reported in the *Los Angeles County 1996-97 Stormwater Monitoring Report, July 15, 1997* (LACDPW and Woodward-Clyde, 1997).

The monitoring program, including the Mass Emission, Land Use, and Critical Source elements continued in the 1997-98, 1998-99, 1999-2000, and 2000-2001 storm seasons.

At the request of the National Resources Defense Council, this report includes the latest results (Appendix C) of the industrial stormwater permit sampling within the county.

1.3.1 Mass Emission Monitoring Program

Five mass emission-monitoring stations were utilized for the Monitoring Program during the 2000-2001 storm season. Mass emission stations capture runoff from major Los Angeles County watersheds that generally have heterogeneous land use. These stations monitor flow and have automated samplers to collect composite samples during storm events. Grab samples are also taken at these stations in accordance with the Municipal Permit. At least six storms were sampled at each mass emission site. The objectives of the mass emissions stations are to update estimated pollutant loads to the ocean and to identify long term trends in pollutant concentrations, if possible.

1.3.2 Land Use Monitoring Program

Seven land use stations were monitored during the 2000-2001 storm season. The land use monitoring program is a result of a site selection study entitled *Evaluation of Land Use Monitoring Stations* (Woodward-Clyde and Psomas and Associates, 1996). The study identified the most significant land use categories within the permit area regarding stormwater quality. The drainage area tributary to each land use monitoring station is comprised predominantly of a single land use and is relatively homogeneous. The eight land use stations that were monitored up to the 1998-99 storm season represent over 86% of all the land use within the permit area. These stations monitor flow and have automated samplers to collect flow-weighted composite stormwater samples during storm events. The major objectives of this monitoring effort are to evaluate the effects of certain land uses on water quality, to identify the relative importance of specific land uses as pollution sources, and to provide data that can be used to project watershed loads from watersheds that do not have mass emission stations.

The 12 storms of the 2000-2001 season yielded 71 land use station-events.

The retail/commercial sampling site on Pier Drain in Santa Monica (S08) was dismantled and not in use in the 1999-2000 and 2000-2001 seasons, with prior approval from the RWQCB, to accommodate construction by the City of Santa Monica of its stormwater treatment plant.

1.3.3 Critical Source/BMP Program

The Critical Source/BMP Monitoring Study was designed to analyze baseline stormwater quality and assess the effectiveness of BMP implementation for critical industries and businesses. A number of critical source industries were identified and ranked by their potential significance to stormwater quality (Woodward-Clyde, 1997) and are listed in the following table:

Industrial Category	SIC Code	Industrial Stormwater Permits*
• Wholesale trade (including scrap yards and auto dismantling)	50	Yes
• Automotive repair/parking	75	No
• Fabricated metal products (including electroplating)	34	Yes
• Motor freight (including trucking)	42	Yes
• Chemical manufacturing facilities	28	Yes
• Automotive dealers/gas stations	55	No
• Electric/gas/sanitary	49	No
• Miscellaneous manufacturing	39	Yes

* Industrial facilities requiring general industrial stormwater permits.

Each critical source industry monitoring plan involves a multi-year study of stormwater runoff from six sites (three test sites and three control sites). During the first year of each study, runoff is sampled and analyzed from five storms to establish background levels. During subsequent years, BMPs are installed at three of the six sites (test sites). BMP effectiveness is estimated from monitoring data gathered from the pooled test sites and pooled control sites during ten additional storms. A complete study plan is included in *Critical Source Selection and Monitoring Report* (Woodward-Clyde, 1997). Sites at six automotive repair shops, six auto dismantlers, six fabricated metal shops, six motor freight companies, six auto dealers, four chemical manufacturing facilities, four industrial machinery manufacturing facilities, and five rubber and plastics manufacturers were monitored during the 2000-2001 storm season.

The required minimum of 5 storms to characterize runoff were not sampled at the industrial machinery manufacturing facilities and rubber and plastics manufacturers. Therefore, additional storms will need to be monitored in 2001-2002 in order to characterize runoff.

To characterize the quality of stormwater runoff in Los Angeles County, a combination of single land use sites and large area mass emissions sites have been selected for monitoring.

2.1 SITE SELECTION

2.1.1 Mass Emission Site Selection

The Department of Public Works monitored four major drainage areas near their outfalls to the ocean. Four of the mass emission monitoring stations installed under the original 1990 Permit were retained under the 1996 Permit; specifically the Los Angeles River, San Gabriel River, Ballona Creek, and Malibu Creek. The Coyote Creek mass emission station, which was required under the 1990 Permit but not under the 1996 Permit, was also monitored during the 2000-2001 season. This station was retained in the program to provide data for the calculation of mass loading in the San Gabriel River watershed. The five mass emission monitoring stations were used to collect water quality data from over 1619 square miles and have produced the data used to calculate total loading to the ocean from these watersheds.

For mass emission sites, the Permit requires sampling a minimum of five events per station per year. These sampling events may be either dry weather or wet weather events.

2.1.2 Land Use Site Selection

The following is a brief summary of the land use site selection process completed between the spring and fall of 1996. The complete methods and results of this study are provided in *Evaluation of Land Use Monitoring Stations* (Woodward-Clyde and Psomas and Associates, 1996).

An initial list of 104 land use types based on the Southern California Association of Governments (SCAG) database was sorted into 37 categories. Of these, the top 12 urban uses based on total area were chosen for a field survey. The survey was performed to identify characteristics that would assist in the aggregation or subdivision of the 12 top land use categories. For each of the 12 land uses, 8 representative areas no larger than a city block were selected for the field survey during the spring of 1996. One issue investigated in the field surveys was whether the age of a development of high density single family residential areas warranted additional monitoring sites. However, the survey indicated that there were no apparent differences between the five different age categories for high density single-family residential land use so this land use was considered one category.

A loading model for all land uses was applied for four constituents (copper, phosphorus, COD, and TSS). The model used local and regional field-derived estimates of imperviousness and water quality. For each constituent, the land use categories were ranked by total loading. A marginal benefit analysis was applied to the ranked land uses to determine the most important for monitoring. The top land use types that ranked above or equal to the land use with the maximum marginal benefit were identified for monitoring. They were:

- Vacant
- High Density Single Family Residential (HDSFR)
- Light Industrial

- Transportation
- Retail/Commercial
- Multifamily Residential
- Educational Facilities

The first 5 of the 7 land use types listed above (Vacant, High Density Single Family Residential, Light Industrial, Transportation, and Retail/Commercial) were already being monitored under the 1990 Municipal Permit. To comply with the terms of the 1996 Permit, one site for each of these land uses was retained for continued sampling; the remaining sites were dismantled. New stations to monitor the last two land use types, Multifamily Residential and Educational Facilities, were installed in February 1997 and were operational for the 1997-98, 1998-99, 1999-2000, and 2000-2001 storm seasons.

In addition to the pollutant loading analysis, land uses were also ranked by total area within each of the six major Los Angeles County watershed management areas. Four land use types not already on the list were then identified as having significant area in one or more of the watersheds (i.e., ranking in the top five land uses), as follows:

- Heavy Industrial
- Rural Residential
- Utility Facilities
- Mixed Residential

On the basis of this analysis, one mixed residential land use station was installed in October 1997 and was operational for the 1997-98, 1998-99, 1999-2000, and 2000-2001 storm seasons; seven land use monitoring stations were operational during the 2000-2001 season. The retail/commercial sampling site on Pier Drain in Santa Monica (S08) was dismantled and not in used in either the 1999-2000 or 2000-2001 season, with prior approval from the RWQCB, to accommodate construction by the City of Santa Monica of its stormwater treatment plant.

2.1.3 Critical Source Site Selection

The following is a brief summary of the Critical Source selection process undertaken to identify industrial and/or commercial critical source categories/types to be monitored. Each selected critical source type is to be monitored for a minimum of two years, the first year without BMPs, and subsequent years with BMPs. The complete site selection methods and results of this study are provided in *Critical Source Selection and Monitoring Report* (Woodward-Clyde, 1997).

Similar to the land use monitoring evaluation process, the County undertook a five-step process to identify and prioritize a list of critical industries within the county that may contribute significant pollutants to stormwater runoff. Standard Industrial Classification (SIC) codes played a major role in the selection process. Once selected, appropriate sites would be monitored over a minimum two-year period for the duration of the permit to measure runoff quality with and without remedial cleanup actions. These remedial actions are referred to as Best Management Practices, or BMPs.

The first step was to develop an initial list of candidate industries. This list contained industries both included and excluded under the State's General Industrial Activities Stormwater permit process. Initial candidate selection was based on prevalence in the county and the extent of outdoor activities. The resulting list yielded a group of 30 candidate industries ranked by the number of facilities.

The next step involved developing a set of criteria to prioritize the list. A number of empirical factors were used to assign levels of significance to each SIC category. Loading (Q) would be addressed by the number of sources at a site and the likelihood of release. Imperviousness (R) of a site would be represented by the percent of paved area. Pollutant toxicity (T) would be denoted by the number of toxic pollutants and the inherent toxicity of the mix. An exposure factor (E) signifies if activities are exposed to rainfall. And finally, number (N) would represent the total number of sites in the county. Each variable would be assigned a qualitative number from 1 to 10, with 10 representing the worst condition. The pollutant potential (P) used to rank the results would thus be the product of all the factors, or

$$P = Q \times R \times T \times E \times N$$

Based on this ranking scheme, some "critical source" industries are selected to be monitored as follows:

- Wholesale Trade (scrap and auto dismantling)
- Automotive Repair/Parking
- Fabricated Metal Products
- Motor Freight
- Automobile Dealers
- Chemical Manufacturing
- Electric/Gas/Sanitary
- Miscellaneous Manufacturing.

A literature search was simultaneously conducted to identify what "critical source" industries, if any, have already been analyzed. The search revealed that similar stormwater studies had yet to be performed.

After the identification and prioritization, the Department then had the task of finding six companies out of the selected critical source industries to enlist for monitoring runoff from five storms during the 1996-97 storm season. However, all six companies could not be enlisted until the end of that storm season, too late for the collection of runoff data. In 1997-98, twelve companies from two industries, automobile repair and auto dismantling, were enlisted. In the 1998-99 storm season, six companies from the metal fabrication industry were added. In the 1999-2000 storm season, nine of the eighteen companies from the automotive repair, auto dismantling, and metal fabrication industries were fitted with BMPs at the Department's expense. The remaining nine companies remained as control sites in order to evaluate BMP

effectiveness. Twelve companies from two industries, motor freight and automobile dealerships were added to the monitoring program in the 1999-2000 storm season.

Of the twelve companies from the motor freight and automobile dealership industries, six were fitted with BMPs in the 2000-2001 storm season. The remaining six companies remained as control sites for evaluating BMP effectiveness. In addition, 13 companies from three industries, chemical manufacturing, industrial machinery manufacturing, rubber/miscellaneous plastics manufacturing were added to the monitoring program in the 2000-2001 storm season. Sampling will continue into the sixth year of monitoring until the eight critical source industries and remedial BMPs are tested and evaluated.

2.2 LOCATION AND DRAINAGE AREA DESCRIPTIONS

Figure 2-1 is an overview of the study area with all mass emission and land use monitoring sites shown. Table 2-1 also indicates the dominant land use associated with each monitoring site and the total drainage area.

2.2.1 Mass Emission Monitoring Sites

Provided below is a description of the four mass emission stations required by the 1996 Municipal Permit (Ballona Creek, Malibu Creek, Los Angeles River, and San Gabriel River) and one additional mass emission station (Coyote Creek) which is not specifically required. Figures 2-2 through 2-6 show the location of each monitoring station along with a description of its land use and 1990 population.

Ballona Creek Monitoring Station (S01)

The Ballona Creek monitoring station is located at the existing stream gage station (Stream Gage No. F38C-R) between Sawtelle Boulevard and Sepulveda Boulevard in the City of Los Angeles. At this location, which was chosen to avoid tidal influences, the upstream tributary watershed of Ballona Creek is 88.8 square miles. The entire Ballona Creek Watershed is 211.6 square miles. At the gauging station, Ballona Creek is a concrete lined trapezoidal channel.

Malibu Creek Monitoring Station (S02)

The Malibu Creek monitoring station is located at the existing stream gage station (Stream Gage No. F130-9-R) near Malibu Canyon Road, south of Piuma Road. At this location, the tributary watershed to Malibu Creek is 104.9 square miles. The entire Malibu Creek Watershed is 202.9 square miles.

Los Angeles River Monitoring Station (S10)

The Los Angeles River Monitoring Station is located at the existing stream gage station (Stream Gage No. F319-R) between Willow Street and Wardlow Road in the City of Long Beach. At this location, which was chosen to avoid tidal influences, the total upstream tributary drainage area for the Los Angeles River is 822.5 square miles. This river is the largest watershed outlet to the Pacific Ocean in Los Angeles County. At the site, the river is a concrete lined trapezoidal channel.

San Gabriel River Monitoring Station (S14)

The San Gabriel River Monitoring Station is located at an historic stream gage station (Stream Gage No. F263C-R), below San Gabriel River Parkway in Pico Rivera. At this location the upstream tributary area is 450.6 square miles. The San Gabriel River, at the gauging station, is a grouted rock-concrete stabilizer along the western levee and a natural section on the eastern side. Flow measurement and water sampling are conducted in the grouted rock area along the western levee of the river. The length of the concrete stabilizer is nearly 70 feet. The San Gabriel River sampling location has been an active stream gauging station since 1968.

Coyote Creek Monitoring Station (S13)

The Coyote Creek Monitoring Station is located at the existing ACOE stream gage station (Stream Gage No. F354-R) below Spring Street in the lower San Gabriel River watershed. Although this site is not required for monitoring per the NPDES Permit, the site was added to assist in determining mass loading for the San Gabriel River watershed. At this location, the upstream tributary area is 148.6 square miles (extending into Orange County). The sampling site was chosen to avoid backwater effects from the San Gabriel River. Coyote Creek, at the gauging station, is a concrete lined trapezoidal channel. The Coyote Creek sampling location has been an active stream gauging station since 1963.

2.2.2 Land Use Monitoring Sites

The following is a description of the locations selected to monitor runoff from land-use specific drainage areas. Figures 2-7 through 2-13 show the location and drainage area of each monitoring station along with a description of its land use and 1990 population.

Sawpit Creek Monitoring Station (S11)

The Sawpit Creek Monitoring Station is located in the Los Angeles River Watershed in the City of Monrovia. The monitoring station is in Sawpit Creek, downstream of Monrovia Creek. Sawpit Creek is a natural watercourse at this location. The overall watershed land use is predominantly vacant.

Project 620 Monitoring Station (S18)

The Project 620 Monitoring Station is located in the Los Angeles River Watershed in the City of Glendale. The monitoring station is at the intersection of Glenwood Road and Cleveland Avenue. The overall watershed land use is predominantly high density residential.

Dominguez Channel Monitoring Station (S23)

The Dominguez Channel Monitoring Station is located within the Dominguez Channel/ Los Angeles Harbor Watershed in Lennox, near Los Angeles International Airport (LAX). The monitoring station is near the intersection of 116th Street and Isis Avenue. The overall watershed land use is predominantly transportation, and includes areas of LAX and Interstate 105.

Project 1202 Monitoring Station (S24)

The Project 1202 Monitoring Station is located in the Dominguez Channel/Los Angeles Harbor Watershed in the City of Carson. The monitoring station is near the intersection of Wilmington Avenue and 220th Street. The overall watershed land use is predominantly industrial.

Project 474 Monitoring Station (S25)

The Project 474 Monitoring Station is located in the Los Angeles River Watershed in the Northridge section of the City of Los Angeles. The monitoring station is located along Lindley Avenue, one block south of Nordhoff Street. The station monitors runoff from the California State University of Northridge. The land use of the drainage area is primarily education.

Project 404 Monitoring Station (S26)

The Project 404 Monitoring Station is located within the Los Angeles River Watershed in the City of Arcadia. The monitoring station is located along Duarte Road, between Holly Avenue and La Cadena Avenue. The land use of the drainage area is primarily multi-family residential.

Project 156 Monitoring Station (S27)

The Project 156 Monitoring Station is located within the Los Angeles Watershed in the City of Glendale. The monitoring station is located along Wilson Avenue, near the intersection of Concord Street and Wilson Avenue. The land use of the drainage area is classified as mixed residential.

2.2.3 Critical Source Monitoring Sites

The general locations of the critical source monitoring sites are shown in Figure 2-14. For purposes of anonymity, the agreement reached with each of the businesses prohibits us from revealing the exact locations.

Sites C01, C02, and C03 are the control sites for the wholesale trade (auto dismantlers); T01, T02, and T03 are the sites where Best Management Practices (BMPs) have been installed for the wholesale trade industry. Similarly, C04, C05, and C06 are the control sites for automotive repair, while T04, T05, and T06 are the sites where the BMPs were installed for the automotive repair industry. Sites C07, C08, and C09 are the control sites for fabricated metal products industry; T07, T08, and T09 are the sites where BMPs were installed for the fabricated metal products industry. Sites C10, C11, and C12 are the control sites for motor freight companies; T10, T11, and T12 are the sites where the BMPs were installed for the motor freight companies. Sites C13, C14, and C15 are the control sites for auto dealership industry; T13, T14, and T15 are the sites where the BMPs were installed for the auto dealership industry.

During the 2000-2001 season, three new industries were added as follows: C16 and C17 are the control sites for chemical manufacturing industry; T16 and T17 are the BMPs sites for the chemical manufacturing industry. Sites C19 and C20 are the control sites for the industrial machinery manufacturing companies, while T19 and T20 are the BMPs sites for the industrial machinery manufacturing companies. Sites C22 and C23 are the control sites for the rubber and

miscellaneous plastics industry; T22, T23 and T24 are the BMPs sites for the rubber and miscellaneous plastics industry.

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This section describes the field and laboratory methods used to conduct the Monitoring Program, which includes precipitation and flow monitoring, stormwater sampling, and laboratory analyses.

3.1 PRECIPITATION AND FLOW MEASUREMENT

3.1.1 Precipitation Monitoring

For every monitoring station, a minimum of one automatic tipping bucket (intensity measuring) rain gage is located nearby or within the tributary watershed. Large watersheds may require multiple rain gages to accurately characterize the rainfall. The Los Angeles County Department of Public Works operates various automatic rain gages throughout the county. Existing gages near the monitored watersheds are also utilized in calculating stormwater runoff and are essential to develop runoff characteristics for these watersheds.

3.1.2 Flow Monitoring

Flow monitoring equipment is needed to trigger the automated samplers because the Monitoring Program requires flow-weighted composites for many constituents. Flows are determined from measurements of water elevation as described below.

The water elevation in a storm drain is measured by the stage monitoring equipment, and the flow rate is derived from a previously established rating table for the site or calculated with an equation such as Manning's. The Los Angeles County Department of Public Works uses rating tables generated from analysis of storm drain cross sections and upstream/downstream flow characteristics. The rating tables are modified if it is demonstrated in the field through stream velocity measurements that calculated table values are incorrect. Previous stormwater flow measurement efforts indicates that all stations will require multiple storm events to gather the data necessary for calibration of the measurement devices.

The automatic samplers utilize pressure transducers as the stage measurement device. However, pressure transducers are only accurate as flow measurement devices in open channel flow regimes. Therefore, for stations monitoring flows in underground storm drains, efforts were made to select drains that do not surcharge (flow under pressure) during events smaller than a 10-year storm event.

3.2 STORMWATER SAMPLING

3.2.1 Sample Collection Methods

Grab and composite sample collection methods, defined below, were used during the 2000-2001 storm season.

- **Grab Sample** - a discrete, individual sample taken within a short period of time, usually less than 15 minutes. This method is used to collect samples for constituents that have very short holding times and specific collection or preservation needs. For example, samples for coliforms are taken directly into a sterile container to avoid non-resident bacterial contamination.

- **Composite Sample** - a mixed or combined sample created by combining a series of discrete samples (aliquots) of specific volume, collected at specific flow-volume intervals. Composite sampling is ideally conducted over the duration of the storm event.

During a storm event, grab samples were collected during the initial portion of the storm (on the rising limb of the hydrograph) and taken directly to the laboratory.

Flow composite storm samples were obtained using an automated sampler to collect samples at flow-paced intervals. Samples collected at each station were combined in the laboratory to create a single flow-weighted sample for analysis.

During the storm season, the sampler was programmed to start automatically when the water level in the channel or storm drain exceeded the maximum annual dry weather stage. A sample was collected each time a set volume of water had passed the monitoring point (this volume is referred to as the pacing volume or trigger volume). The sample was stored in glass containers within the refrigerated sampler. A minimum of eight liters of sample was required to conduct the necessary laboratory analyses for all the constituents. The automated sampler was deactivated by field personnel when the water level in the channel or storm drain fell to about 120 percent of the observed maximum annual dry weather flow stage.

Samples were retrieved from the automated samplers as soon as possible to meet laboratory analysis holding time requirements. As samples were collected, rainfall and runoff data were logged and stored for transfer to the office.

3.2.2 Field Quality Assurance/Quality Control Plan

Properly performed monitoring station set up, water sample collection, sample transport, and laboratory analyses are vital to the collection of accurate data. Quality Assurance/Quality Control (QA/QC) is an essential component of the monitoring program.

Evaluation of Analytes and QA/QC Specifications for Monitoring Program (Woodward-Clyde, 1996a) describes the procedures used for bottle labeling, chain-of-custody tracking, sampler equipment checkout and setup, sample collection, field blanks to assess field contamination, field duplicate samples, and transportation to the laboratory.

An important part of the QA/QC Plan is the continued education of all field personnel. Field personnel were adequately trained from the onset and informed about new information on stormwater sampling techniques on a continuing basis. Field personnel also evaluate the field activities required by the QA/QC Plan, and the Plan is updated if necessary.

Bottle Preparation

For each monitoring station, a minimum of three sets of bottles was available so that up to two complete bottle change-outs could be made for each storm event. Bottle labels contained the following information:

- LADPW Sample ID Number
- Station Number
- Station Name

- Sample Type (Grab or Composite)
- Laboratory Analysis Requested
- Date
- Time
- Preservative
- Temperature
- Sampler's Name

Bottles were cleaned at the laboratory prior to use, then they were labeled and stored in sets. Each station was provided with the same number, types, and volumes of bottles for each rotation unless special grab samples were required. Clean composite sample bottles were placed in the automated sampler when samples were collected. This practice ensured readiness for the next storm event. All bottles currently not in use were stored and later transported in plastic ice chests. Composite sample bottles were limited to a maximum of 2-1/2 gallons each, to ensure ease of handling.

Chain-of-Custody Procedure

Chain-of-custody forms were completed to ensure and document sample integrity. These procedures establish a written record which tracks sample possession from collection through analysis.

Field Setup Procedures

All field sampling locations were fixed sites, with the sampler placed on a public road or flood control right-of-way. After sample collection, field staff prepared the sampler for collection of the next set of samples either in storm mode or in dry weather mode. Inspection of visible hoses and cables was performed to ensure proper working conditions according to the site design. Inspection of the strainer, pressure transducer, and auxiliary pump was performed during daylight hours in non-storm conditions.

The automated sampler was checked at the beginning of the storm (during grab sample collection) to ensure proper working condition and to see if flow composite samples were being collected properly. Dry weather collection techniques were similar, with grab and 24-hour composite samples being collected.

Bottles were collected after each event and packed with ice and foam insulation inside individually marked ice chests. Chain-of-custody forms were completed by field staff before transportation of the samples to the laboratory. Under no circumstance were samples removed from the ice chest during transportation from the field to the laboratory.

Travel Blanks and Field Duplicates

Potential field contamination was assessed through analysis of travel blanks and duplicate grab samples. Field travel blanks were collected for each monitoring station during every sampling event to quantify post sampling contamination. The monitoring program also included field

duplicates to assess the precision of laboratory results. A field duplicate, the origin of which was unknown to the laboratory, was collected for each sampling event. This methodology for assessing post sampling contamination and laboratory testing procedures provided data to measure the precision and accuracy of the laboratory results.

3.2.3 Sampling Frequency

During the 2000-2001 storm season, the Permit required the Department to sample up to 200 "station events" for the land use sites. A station event is defined as collection of one sample at one station. The Municipal Permit specifies sampling at mass emission stations to total five events per year during dry weather, storm, or a combination of both.

3.3 LABORATORY ANALYSES

The Department of Agricultural Commissioner/Weights and Measures (ACWM) Environmental Toxicology Laboratory provides water quality laboratory and related services to the LACDPW. The ACWM lab is state certified to perform the water quality analyses contracted by LACDPW. The ACWM Lab maintains a laboratory analysis program that includes Quality Assurance and Quality Control protocols consistent with the objectives of the monitoring program required by the Permit (Section 3.3.3).

3.3.1 Possible Constituents of Concern

Possible constituents of concern for each element of the Monitoring Program are specified in the Municipal Permit. The constituents of concern for land use station monitoring are:

- Total Suspended Solids
- Total Nitrogen
- Total Phosphorus
- Cadmium
- Chromium
- Copper
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc
- Chlordane
- Chlorpyrifos
- Diazinon
- Malathion
- Simazine
- Total DDT
- Total PAHs
- Total PCBs

Constituents of concern for mass emission monitoring include those listed above plus:

- Bacteria
- Total Phenols
- TPH
- Oil and Grease
- Cyanide

3.3.2 Analytical Suite and Analytical Methods

The suite of analytes and associated detection limits for samples collected at the land use stations and mass emission stations are specified in the Municipal Permit. Constituents of concern for derivation of event mean concentrations are also specified by the Permit. All the laboratory methods used for analysis of the stormwater samples are approved by the California Department of Health Services and are in conformance with USEPA approved methods.

Table 3-1 shows all the constituents monitored during the 2000-2001 season at the mass emissions and land use stations, including constituents analyzed with composite or grab samples. The table lists the method number, the detecting limit, the data quality objectives, and other relevant information for each constituent. The table also shows which constituents were monitored at the land use sites versus the mass emission sites. It should be noted that detection limits of many semi-volatile organic compounds (SVOCs) were lowered, including all PAHs, for the land use and mass emission studies at the request of the Los Angeles Regional Water Quality Control Board.

Analyses of constituents in samples collected for the Critical Source/BMP Monitoring Study were performed using the methods and reporting limits given in Table 3-2.

The laboratory made an effort to provide the lowest detection limits attainable without compromising the reliability of the data. "Detection limit" (DL) is defined by the USEPA as "the concentration above which we are 99% confident that the analyte is present at a concentration greater than zero" (40 CFR Part 136 Appendix B). For this project the laboratory made some allowance for interference in the analysis due to the complex nature of the sample matrix by performing a DL study using a water sample collected from a channel during dry weather. These 'matrix specific' DLs are the reported DLs in the data tables. Data below the DL are reported as zero. The Practical Quantitation Limit (PQL) is the concentration above which the analyte can be accurately quantified. Reported PQLs were developed by the laboratory during the analysis of stormwater runoff samples using professional judgment to account for matrix interferences. Data that fall between the DL and PQL are reported by the laboratory at the apparent concentrations. When reviewing these data it should be noted that the concentrations below the PQL are estimated.

3.3.3 Quality Assurance and Quality Control

The primary objective of the laboratory quality assurance/quality control program is to ensure that the analyses are scientifically valid, defensible, and of known precision and accuracy. The ACWM laboratory maintains quality assurance/quality control procedures (as described in their Quality Assurance Manual) in accordance with requirements of the California Department of Health Services. The ACWM laboratory standard operation procedures include method validation, equipment calibration, preventive maintenance, data validation procedures,

assessment of accuracy and precision, corrective actions, and performance and system audits. The QA/QC review and data validation for the 2000-2001 monitoring data was conducted by ACWM Lab, and the QA/QC documentation is available within the ACWM Lab files. The validated data as provided by the ACWM Lab were used for data analysis and interpretation with no further QA/QC review.

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4.1 HYDROLOGY: PRECIPITATION AND FLOW

Total annual rainfall during the 2000-2001 storm season in LA County was just below normal. The long term average annual rainfall at Station # 716, Ducommun Street in downtown Los Angeles is about 15.60 inches. For water year (WY) 2000-2001 the total rainfall from October 2000 through May 2001 was about 15.09 inches.

Figures 4-1a and 4-1b show the rainfall pattern for WY 2000-2001 compared to the long term pattern of rainfall. About 78% of the annual total fell during the month of January. This is reflected by the timing of the storms that were monitored. Seven of the 12 storms monitored occurred in January and February. The months of November and December were practically dry this season while February had more than twice the amount of rainfall compared to the long term average for that month.

Table 4-1 summarizes the hydrologic and meteorologic conditions of each station-event monitored this season. Table 4-2 summarizes total precipitation and runoff volume for each station on a seasonal basis from 1994 through 2001. These data will help define hydrologic and water quality trends after subsequent years of data are compiled. A collection of 2000-2001 season hydrographs for each storm event from the monitored sites and rainfall contour maps is included in Appendix A. Each hydrograph includes the time of grab sample collection when applicable, the time of the first and last composite sample aliquot collection, the number of aliquots per composite, the sample volume interval, and the percent of storm sampled.

Also included in Appendix A are contour maps of total rainfall for the 2000-2001 storm season. The dates given as "Storm Event Date" are the dates each storm began.

4.2 STORMWATER QUALITY

A summary of the composite and grab samples taken during the 2000-2001 season is included as Table 4-3.

4.2.1 Determination of Constituents of Concern for Analysis

The County analyzes for some 209 individual water quality constituents, the results of which are included in Appendix B. But while the Municipal Stormwater permit lists 25 of them as constituents of concern, some constituents were not detected or were detected at levels below a number of common water quality guidelines. Therefore, a comparison was made between mass emission water quality results and the water quality objectives outlined in the Ocean Plan, Basin Plan, and California Toxics Rule. If either the mean or median concentration of a constituent from mass emission sampling exceeded the objective, it was selected for further analysis. The 2000-2001 mass emission results were compared with the standards in Table 4-4a, while information about each site is included in Table 4-4b. A comparison was made of the 1994-2001 water quality concentrations, and 17 pollutants were identified (see Table 4-4c). A complete description of the comparison study is included in *Los Angeles County 1994-2000 Integrated Stormwater Monitoring Report* (Los Angeles County Department of Public Works). Thirteen additional constituents (total suspended solids, diazinon, chlorpyrifos, total coliform, fecal coliform, fecal streptococcus, fecal enterococcus, dissolved phosphorus, total phosphorus, ammonia nitrogen, nitrate nitrogen, nitrite nitrogen and TKN, which may have not exceeded

standards or did not have standards defined) were also included. The constituents used for analysis are:

- Total Aluminum
- Dissolved Cadmium
- Dissolved Copper
- Total Copper
- Dissolved Nickel
- Total Nickel
- Dissolved Lead
- Total Lead
- Total Mercury
- Dissolved Zinc
- Total Zinc
- Total Suspended Solids
- Total Dissolved Solids
- Total Kjeldalh Nitrogen
- Ammonia
- Cyanide
- Turbidity
- Diazinon
- Chlorpyrifos
- Dissolved Phosphorus
- Total Phosphorus
- Total Coliform
- Fecal Coliform
- Fecal Streptococcus
- Fecal Enterococcus
- Bis(2-ethylhexyl)phthalate
- Phenanthrene
- Pyrene
- Nitrate
- Nitrite

The above 30 constituents of concern were used in developing the percentile distribution (box and whisker) graphs, bacteria count trend analysis, and pollutant loading estimations.

There are no numerical effluent standards that apply to stormwater pollution. Current federal and state numeric effluent standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation or noncompliance with the plans. The 2000 California Toxics Rule is, strictly speaking, applicable to industrial and sewage treatment plant point-source discharges, but not to stormwater runoff discharges, which do not have any effluent limits. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the tables are detected values before dilution, a factor allowed by the Ocean Plan. At the same time, however, it should be noted that new stormwater permits are including the narrative guidelines and limitations prescribed in the local Basin Plans.

4.2.2 Mass Emission Element

The NPDES Municipal Stormwater Permit mandates that the County monitor the quality of its stormwater discharges and create various programs for managing and improving stormwater runoff quality. The permit specifically requires the County to assess the pollutant loading from all six of its Watershed Management Areas following the 2000-2001 storm season.

4.2.2.1 GIS Model

To assist in implementing this requirement, the Department developed a GIS application called the Pollutant Loading Model.

The Pollutant Loading application computes total pollutant loading for selected pollutants originating in user-defined watersheds or political boundaries. It draws upon many existing data sources, such as predetermined drainage subbasins, land use, historical and event rainfall data, water quality monitoring station results, and multiple underlying geographic data including political boundaries, natural boundaries, census tracts, forest boundaries, streets, and drains.

Assumptions and Limitations

- An imperviousness value used for the calculations is associated with 104 different land use categories.
- The 104 SCAG land use categories have been aggregated into 34 categories covering 100% of the County.
- Water quality data collected from 8 different land use monitoring stations yields Event Mean Concentration (EMC) values. The remaining land use categories (34-8 = 26) use assumed EMC values based on their association with the 8 monitored land use types.
- All polygons of the same land use type are assumed to have the same EMC value regardless of their spatial location within the county.
- Annual pollutant loadings use previously calculated seasonal EMCs for their calculation.
- Rainfall grid cell sizes are 500 feet by 500 feet. Rainfall depth does not vary within the grid cell.
- The model does not account for variation over time in soil permeability which influences surface runoff in undeveloped watersheds. In other words, a given coefficient of discharge for a particular land use type will not change regardless of previous soil conditions (saturated soil versus dry soil)

The model does not take into account possible degradation or adsorption of the pollutant as it is transported downstream. These results therefore should not be taken as absolute; rather, they should be used for unmonitored watersheds or smaller portions of monitored watersheds for comparative purposes only.

4.2.2.2 Mass Emission Water Quality

This section provides a description of wet-weather results generated during the 2000-2001 monitoring season (Figures 4-2a through 4-2u). The figures present several panels, one for each parameter, with a series of box and whisker plots, one for each constituent. This box and whisker presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available.

The criteria and conventions used in generation of these statistics are as follows:

- Only datasets that had at least 20% "detections" (positive result, with value above the method detection limit), and at least three "detections", were included;
- For data sets that met the selection criteria, if a parameter was a "non-detect", i.e., under the method detection limit, it was included in the dataset as half the method detection limit.

Thus, absence of a plot for a specific station for a given parameter may indicate that the dataset did not meet the selection criteria. However, in some situations it may indicate lack of data (due to logistical constraints related to sampling activities). The reader is referred to Table 4-3 for data inventory information.

All data for mass emission stations are presented in Appendix B.

- Malibu Creek had noticeably higher median concentrations of both total and dissolved phosphorus, while the San Gabriel River has the highest median concentration of nitrate.
- The median total dissolved solids concentration in Malibu Creek is more than twice that of any other mass emission sites.
- Both total and fecal coliforms exhibited higher medians in the Los Angeles River. Ballona Creek had the greatest range of results for both total and fecal coliforms as well as fecal enterococcus, while the Los Angeles River had the greatest variablilty for fecal streptococcus results. Please see Table 4-5 and Figures 4-3a through 4-3d for bacteria counts from 1994-2001.
- Concentrations were similar among stations for a given metal. In other words, no station appeared to be "cleaner" or "dirtier" than any other with respect to metals.
- There were several individual exceedances of water quality objectives, either of the California Toxics Rule or of the Ocean Plan (or of both), for metals; and in fact, total aluminum, total copper, dissolved copper, and total zinc each had at least one seasonal mean or median exceed an objective.

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station then that constituent may qualify for removal from the analytical suite for the associated station. Several mass emission stations meet this criterion and are summarized in Table 4-6. It is recommended that these constituents be removed from the analytical suite for the associated stations.

4.2.2.3 Loadings for Constituents of Concern for 2000-2001 Storm Season

Derivation of Event Mean Concentrations

Section B.4 of Attachment C of the Municipal Stormwater Permit (CAS614001) requires the County to "perform a loads assessment analysis for each of the six Watershed Management Areas to determine pollutant loads entering the ocean from receiving waters in the county . . . using the collected monitoring data from the land use and mass emission stations . . . and employing the USEPA simplified model". The work plan for this assessment, submitted to the Regional Board on November 6, 1997, was described in detail in *Monitoring Task Report No. 2* (Woodward-Clyde, December 9, 1996b). Loads from monitored mass emission watersheds have been calculated from observed mass emission mean concentrations and runoff volumes. Loads

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from unmonitored watersheds have been estimated using the GIS loading model with mean concentrations derived from the land use monitoring program. Following is a brief explanation of how event mean concentrations were calculated.

The event mean concentration is based on flow-weighted composited samples. Numerous data sets were created comprised of laboratory results from each monitoring station for a given season. Data were screened and analyzed to determine the quality and amount of data present. The following criteria were applied:

- at least 20% of the sample results were detected concentrations;
- there were at least 3 detected sample concentrations.

If the set of data did not meet these criteria, it was not used to calculate an event mean concentration. If sufficient data existed to conduct the statistical analysis, two methods were followed to address non-detects.

Initially, the Hazen robust method was used to calculate land use EMCs. The robust method uses a combination of regression and probability analysis to determine the "assumed" concentration to assign to samples with concentrations below the method detection limit. The "assumed" concentration is the point along a probability distribution regression line (derived from detected data) where true concentrations of non-detected data have the highest probability of residing. Each non-detect result was assigned the value of the detection limit and ranked along with the other detected results in the data set. The cumulative frequency data were plotted on a logarithmic plot and a straight line regression was fitted to the points. The mean, m, and variance, σ^2, of the natural logarithm of each point of the data set were used to calculate the event mean concentration. The event mean concentration, which the loading model multiplies by the volume of the event runoff to develop total loading, is defined as follows:

$$\text{Event Mean Concentration} = \exp(m + 0.5\sigma^2).$$

In order to reduce analysis time, another method, which has been successfully implemented by other agencies, was also used to calculate EMCs for the mass emission water quality data. That second method assigned a value of half the detection limit to each non-detect result. The resulting data set of concentrations was analyzed as described above to develop the mass emission EMCs. A comparison of the two methods showed that differences between EMCs developed from the same data set were insignificant in most cases; therefore, the second method assumed a valid approach.

The calculated EMCs are summarized in Table 4-7 for specific land uses. These EMCs were used to estimate loadings for several watersheds.

The loadings calculated for the monitored watersheds are summarized in Tables 4-8a through 4-8e and Figures 4-4a through 4-10.

The locations of unmonitored watersheds are shown in Figures 4-11 through 4-13. The loadings calculated for the unmonitored watersheds are summarized in Tables 4-9a through 4-9c and Figures 4-14 through 4-16.

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4.2.3 Land Use Element

The land use element monitoring results for the 2000-2001 season are summarized in Table 4-10. This table includes the number of samples analyzed and the percentage of samples that had detectable concentrations, as well as summary statistics (the mean, median, and coefficient of variation (CV)). Box and whisker plots for several constituents are included as Figures 4-17a through 4-17v for the 2000-2001 season. This "box-and whisker" presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available.

The criteria and conventions used in generation of these statistics are as follows:

- Only datasets that had at least 20% "detections" (positive result, with value above the method detection limit), and at least three "detections", were included;
- For data sets that met the selection criteria, if a parameter was a "non-detect", i.e., under the method detection limit, it was included in the dataset as half the method detection limit.

All data for land use monitoring stations are presented in Appendix B.

Thus, absence of a plot for a specific station for a given parameter may indicate that the dataset did not meet the selection criteria. However, in some situations it may indicate lack of data (due to logistical constraints related to sampling activities). The reader is referred to Table 4-3 and to the summary tables for data inventory information.

The median pH values were visibly different between catchment types, and this trend is also reflected in the median concentrations of bicarbonate. Runoff from the vacant catchment had high pH (8.0) and high alkalinity (median of 180 mg/l), while runoff from the light industrial, transportation, mixed residential, and high density residential stations had lower median pH values (6.9, 6.8, 6.8, and 6.8 respectively) and lower median alkalinity concentrations (26, 21, 26, and 23 mg/l respectively). The educational and multiple family residential stations fell in between these two extremes with median pH values of 7.1 and 7.3 respectively, and median alkalinities of 31 and 48 mg/l respectively.

Hardness is also an important variable of water quality because it diminishes the potential of dissolved metals to cause toxicity to aquatic life. Median hardness concentrations are similar to the alkalinity pattern: high (200 mg/l) at the vacant station; low in the transportation (30 mg/l), mixed residential (40 mg/l), and high density residential stations (20 mg/l); and in between (55, 60, and 75 mg/l) at the educational, light industrial, and multiple family residential stations.

Total suspended solids (TSS) measurements reflect the amount of sediment in the water. Sediment is a constituent of concern because of the potential to adversely affect the aquatic habitat and also cause sediment accumulation that ultimately may require dredging. Sediment also may be a carrier of other chemicals that have a tendency to adsorb to particulate matter. TSS results overlapped substantially among the different land uses; however, the light industrial station had the highest median for TSS (199 mg/l) being more than twice as high as the next highest median (84 mg/l for transportation).

Metals in stormwater runoff can be of concern because some metals are toxic to aquatic organisms and some can bio-accumulate in the tissues of aquatic organisms (e.g., fish and clams) and be a human health concern. Total and dissolved copper concentrations overlapped among

the different land uses, however, the dissolved copper median for the transportation station (31.6 μg/l) was more than twice as high as the next highest median (9.0 μg/l for mixed residential). Dissolved copper generally exceeds the 3.1 μg/l California Toxics Rule guideline while both mean and median concentrations of total copper exceed the Ocean Plan guideline in the transportation, light industrial, educational high density single family residential, and mixed residential stations. Total lead results are fairly consistent among land uses. Dissolved and total zinc exhibit similar patterns; there is substantial overlap among the different land uses although the mean and median for the light industrial station is highest in each case. All data for land use monitoring stations are presented in Appendix B.

The Permit states that if a given constituent is not detected in at least 25% of the samples taken in ten consecutive storm events at a given station then that constituent may qualify for removal from the analytical suite for the associated station. Several land use stations meet this criterion and are summarized in Table 4-11. It is recommended that these constituents be removed from the analytical suite for the associated stations.

The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived at the 25% error rate. We used the mean standard error as a substitute for error rate as mutually agreed upon with the RWQCB (Swamikannu, 1999).

The constituents evaluated include:

- PAHs
- Copper
- Chromium
- Selenium
- Total Phosphorus
- Chlorpyrifos
- Total DDTs
- Chlordane
- Nickel
- Silver
- Mercury
- TSS
- Malathion
- Total PCBs
- Cadmium
- Lead
- Zinc
- Total Nitrogen
- Diazinon
- Simazine

We first identified 114 station-constituent combinations which had at least 10 detected samples and no more than 20% non-detected samples. Non-detects were replaced with half of the corresponding detection limit. Then, we performed the Shapiro-Wilk Normality Test at 5% significance level on each station-constituent to determine whether the concentrations were normally or lognormally distributed (Gibbons 1994, USEPA 1995). If the p-value of the normality test in raw scale of the constituent's concentration was greater than 0.05, such station-constituent was concluded to be normally distributed. Similarly, if the p-value of the normality test in log-transformed scale was greater than 0.05, it was concluded to be lognormally distributed. If a station-constituent was determined to be both normally and lognormally distributed (the p-values for both tests for normality were greater than 0.05), we assigned such station-constituent with a normal distribution. Similarly, if a station-constituent was neither normally nor lognormally distributed based on the normality tests (both p-values less than 0.05), we assumed that it had a normal distribution.

Based on the probability distribution determined above, we calculated the mean standard error as follows:

$$\text{Mean Standard Error} = \frac{\text{Standard Error}}{\text{Mean}} = \frac{\text{Standard Deviation}/\sqrt{\text{Sample Size}}}{\text{Mean}}$$

For those station-constituents with a normal distribution, the sample mean and standard deviation were used in the above formula. However, for station-constituents with a lognormal distribution, the mean and standard deviation were estimated as follows (Gilbert 1987):

$$\text{Mean, } \hat{\mu} = e^{\left(\bar{y} + \frac{s_y^2}{2}\right)}$$

$$\text{Standard Error, } s(\hat{\mu}) = \sqrt{e^{\left(2\bar{y} + \frac{s_y^2}{n}\right)}\left[\left(1 - \frac{2s_y^2}{n}\right)^{-\frac{(n-1)}{2}} \cdot e^{\left(\frac{s_y^2}{n}\right)} - \left(1 - \frac{s_y^2}{n}\right)^{-(n-1)}\right]}$$

where $\bar{y}$ and s_y^2 are the arithmetic mean and variance of the log-transformed values

n is the sample size

All results of this analysis are summarized in Table 4-12. Of 114 station-constituents under investigation, 25 of them had an EMC with a mean standard error higher than 25%. In other words, there were 25 station-constituents which had a standard error (standard deviation of the mean) larger than 25% of their corresponding mean concentrations. These station-constituents must continue to be monitored under the current Permit. The remaining 89 station-constituent combinations met the criteria and it is recommended that monitoring be discontinued for these constituents at the associated stations.

4.2.4 Critical Source Element

The following is a discussion of the results of the 2000-2001 critical source study results summarized in Table 4-13. This table includes the number of samples analyzed and the percentage of samples that had detectable concentrations, as well as summary statistics (the mean, median, and coefficient of variation (CV)). Box and whisker plots for several constituents are included as Figures 4-18a through 4-18q for the 2000-2001 season. This "box and whisker" presentation of the data provides information on the distribution and variability of each data set. It shows the median, mean, 25 and 75 percentiles, 10 and 90 percentiles, as well as the 5 and 95 percentiles. Common water quality objectives for each parameter are also provided where available. This was the second year BMPs were installed under the Critical Source Monitoring Program.

Note there are no numerical effluent standards that apply to stormwater pollution. Current federal and state standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean and other water bodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate

violation or noncompliance with the plans. The Toxic Rule is, strictly speaking, applicable to industrial and sewage treatment plant point-source discharges, but not to stormwater runoff discharges, which do not have any effluent limits. The Ocean Plan objectives apply to "instantaneous" grab samples. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards is not directly applicable since the results presented in the tables are detected values before dilution, a factor allowed by the Ocean Plan. At the same time, however, it should be noted that new stormwater permits are including the narrative guidelines and limitations prescribed in the local Basin Plans.

The chemical constituents whose means were above the objectives of the Ocean Plan, Basin Plan, or California Toxics Rule are discussed below and are as follows:

- Bis(2-ethylhexyl)phthalate (a semi-volatile organic)
- Dissolved copper
- Total copper
- Total lead
- Dissolved nickel
- Dissolved zinc
- Total zinc

The testing methods for the critical source program are outlined in Section 3.

A comparison of control to test sites for the motor freight companies reveals the following.

- Median oil and grease concentrations were higher at the test sites (5.50 mg/l) than the control sites (1.80 mg/l).
- Median bacterial counts for all bacterial types examined were lower at the test sites than the control sites.

Sample sizes for the oil and grease samples as well as the bacterial samples were significantly higher (n=12 to n=21) than for the other analyses discussed (n=3). Therefore, caution must be used in applying the following observations.

- Median suspended solids concentrations were higher at the test sites (147 mg/l) than the control sites (73 mg/l).
- Median zinc concentrations, both total and dissolved, were higher at the test sites (245 and 178 mg/l ,respectively) than the control sites (157 and 110 mg/l, respectively).
- Median total aluminum concentrations were lower at the test sites (318 mg/l) than the control sites (635 mg/l).
- Median iron concentrations, both total and dissolved, were lower at the test sites (270 and 200 mg/l, respectively) than the control sites (920 and 320 mg/l, respectively).

A comparison of control to test sites for the auto dealers reveals the following.

- Median oil and grease concentrations were lower at the test sites (1.45 mg/l) than the control sites (3.7 mg/l).

- Median bacterial counts for all bacterial types examined were higher at the test sites than the control sites.

Sample sizes for the oil and grease samples as well as the bacterial samples were significantly higher (n=8 to n=16) than for the other analyses discussed (n=2 to n=3). Therefore, caution must be used in applying the following observations.

- Median suspended solids concentrations were lower at the test sites (46.5 mg/l) than the control sites (125 mg/l).
- Median zinc concentrations, both total and dissolved, were lower at the test sites (85.7 and 54.7 mg/l, respectively) than the control sites (150 and 133 mg/l, respectively).
- Median iron concentrations, both total and dissolved, were higher at the test sites (240 and 110 mg/l, respectively) than the control sites (110 and 50 mg/l, respectively).

The 2000-2001 season was the first year for which BMPs were implemented at the test sites for the motor freight and automobile dealership industries. Motor freight and automobile dealership industries had both active test and control sites this season for the first time. A list of initial BMPs purchased is included as Table 4-14. Individual business owners were encouraged throughout the storm season to use the BMPs at all times, although LACDPW had no control over this action on the part of the owners.

This report describes the results of the 2000-2001 Monitoring Program that was conducted in compliance with the Program's NPDES Municipal Stormwater Permit No. CAS614004. Elements of the Monitoring Program consisted of land use station monitoring, mass emission station monitoring, and the Critical Source/BMP Monitoring Study. The following are the principal conclusions and recommendations from this work.

5.1 OBJECTIVES ACHIEVED IN 2000-2001

The land use monitoring was conducted at seven stations and included flow composite sample data collected during 71 station events through April 7, 2001. The mass emission monitoring was conducted at 5 stations and consisted of 37 station events. Some grab sample data were also obtained at the mass emission stations. Generally, sampling activities were conducted according to plan, and attempts were made to capture as many storms as possible.

Monitoring at the land use stations and mass emission stations included a broad constituent suite including bacteria, metals, organics, major ions, and nutrients. The laboratory analytical efforts achieved detection limits (DL) as required by the Permit for all constituents, and achieved DLs that were lower than Permit requirements for many analytes, particularly for constituents of concern. Lower DLs are beneficial for two reasons: 1) to increase the probability of detection of potentially harmful substances at the concentrations of concern, and 2) to enhance the information value of the data by improving the quality of the data sets and allowing for more rigorous statistical analyses and data interpretation techniques. Thus, the major objective of runoff characterization at mass emission and land use catchments was achieved.

5.2 MASS EMISSION PROGRAM CONCLUSIONS

- Malibu Creek had noticeably higher median concentrations of both total and dissolved phosphorus, while the San Gabriel River has the highest median concentration of nitrate.
- The median total dissolved solids concentration in Malibu Creek is more than twice that of any other mass emission sites.
- Both total and fecal coliforms exhibited higher medians in the Los Angeles River. Ballona Creek had the greatest range of results for both total and fecal coliforms as well as fecal enterococcus. While the Los Angeles River had the greatest variability for fecal streptococcus results
- Concentrations were similar among stations for a given metal. In other words, no station appeared to be "cleaner" or "dirtier" than any other with respect to metals.
- There were several individual exceedances of water quality objectives, either of the California Toxics Rule or of the Ocean Plan (or of both), for metals; and in fact, total aluminum, total copper, dissolved copper, and total zinc each had at least one seasonal mean or median exceed an objective.

5.3 LAND USE PROGRAM CONCLUSIONS

- Runoff from the vacant catchment had high pH (8.0) and high alkalinity (median of 180 mg/l), while runoff from the light industrial, transportation, mixed residential, and high

density residential stations had lower median pH values (6.9, 6.8, 6.8, and 6.8 respectively) and lower median alkalinity concentrations (26, 21, 26, and 23 mg/l respectively). The educational and multiple family residential stations fell in between these two extremes with median pH values of 7.1 and 7.3 respectively, and median alkalinities of 31 and 48 mg/l respectively.

- Median hardness concentrations are similar to the alkalinity pattern: high (200 mg/l) at the vacant station; low in the transportation (30 mg/l), mixed residential (40 mg/l), and high density residential stations (20 mg/l); and in between (55, 60, and 75 mg/l) at the educational, light industrial, and multiple family residential stations.
- TSS results overlapped substantially among the different land uses; however, the light industrial station had the highest median for TSS (199 mg/l) being more than twice as high as the next highest median (84 mg/l for transportation).
- Total and dissolved copper concentrations overlapped among the different land uses, however, the dissolved copper median for the transportation station (31.6 μg/l) was more than twice as high as the next highest median (9.0 μg/l for mixed residential). Dissolved copper generally exceeds the 3.1 μg/l California Toxics Rule guideline while both mean and median concentrations of total copper exceed the Ocean Plan guideline in the transportation, light industrial, educational high density single family residential, and mixed residential stations.
- Total lead results are fairly consistent among land uses.
- Dissolved and total zinc exhibit similar patterns; there is substantial overlap among the different land uses although the mean and median for the light industrial station is highest in each case.

5.4 CRITICAL SOURCE PROGRAM CONCLUSIONS

A comparison of control to test sites for the motor freight companies reveals the following.

- Median oil and grease concentrations were higher at the test sites (5.50 mg/l) than the control sites (1.80 mg/l).
- Median bacterial counts for all bacterial types examined were lower at the test sites than the control sites.

A comparison of control to test sites for the auto dealers reveals the following.

- Median oil and grease concentrations were lower at the test sites (1.45 mg/l) than the control sites (3.7 mg/l).
- Median bacterial counts for all bacterial types examined were higher at the test sites than the control sites.

5.5 RECOMMENDATIONS

The Permit allows the discontinuation of monitoring at a land use station for specific constituents once the event mean concentration (EMC) is derived at the 25% error rate. We used the mean

standard error as a substitute for error rate as mutually agreed upon with the RWQCB (Swamikannu, 1999).

Of 114 station-constituents under investigation, 25 of them had an EMC with a mean standard error higher than 25%. In other words, there were 25 station-constituents which had a standard error (standard deviation of the mean) larger than 25% of their corresponding mean concentrations. These station-constituents must continue to be monitored under the current Permit. The remaining 89 station-constituent combinations met the criterion and it is recommended that monitoring be discontinued for these constituents at the associated stations.

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Table 2-1
Land Use Distribution of Monitored Catchments for the Monitoring Program

Station Name	Station No.	Drainage Area (sq. mi.)	HDSFR [1] (%)	Light Industrial (%)	Vacant (%)	Retail/ Commercial (%)	Multi-Fam. Residential (%)	Transportation (%)	Educational Facilities (%)	Mixed Residential (%)	Other (%)
LAND USE STATIONS											
Santa Monica Pier Drain [2] @ Appian Way, Santa Monica	S08	0.13	--	--	--	53.6	5.1	4.6	--	--	36.7
Sawpit Creek @ Monrovia Cr. Monrovia	S11	5.18	--	--	98.0	--	--	--	--	--	2.0
Project 620 @ Glenwood Rd. Glendale	S18	0.19	100.0	--	--	--	--	--	--	--	--
Dominguez Channel @ 116th St. Unincorporated L.A. County	S23	1.41	0.6	17.0	--	0.1	--	75.2	--	--	7.1
Project 1202 @ Wilmington Ave Carson	S24	1.07	--	67.1	1.0	0.3	--	4.7	--	--	26.9
Project 474 @ Nordoff St. Los Angeles	S25	0.41	7.6	--	--	--	2.2	--	89.5	--	0.7
Project 404 @ La Cadena Ave. Arcadia	S26	0.34	6.3	--	--	13.1	74.3	1.7	--	--	4.6
Project 156 @ Concord St. Glendale	S27	0.20	3.8	--	--	4.5	4.0	--	5.1	77.2	5.4
MASS EMISSION STATIONS											
Ballona Creek @ Sawtelle Blvd. Los Angeles	S01	88.8	40.0	3.5	11.1	9.9	12.3	1.5	2.7	6.7	12.3
Malibu Creek @ Piuma Rd. Unincorporated L.A. County	S02	105.0	5.7	0.3	79.3	0.5	1.3	0.5	0.5	--	11.9
L.A. River @ Wardlow Long Beach	S10	822.5	28.8	5.1	40.4	3.6	3.5	2.4	1.9	1.8	12.5
San Gabriel River @ SGR Pkwy Pico Riveria	S14	450.6	15.2	2.3	66.7	1.5	1.4	1.0	1.6	0.1	10.2
Coyote Creek @ Spring St. [3] Long Beach	S13	148.6	38.3	8.4	14.3	5.6	6.1	1.8	4.3	0.2	21.0

Notes:

All land use percentages are rounded to the nearest tenth of a percent.
Land use percentages less than 0.1% are represented with a dash (--).
(1) HDSFR = High density single-family residential.
(2) The Retail/Commercial sampling site on Pier Drain in Santa Monica (S08) was dismantled and not in use in the 2000-2001 season, with prior approval from the RWQCB, to accommodate construction by city of Santa Monica of its stormwater treatment plant.
(3) Coyote Creek is not required under the Municipal Stormwater Permit, but is included in the Monitoring Plan.

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Table 3-1. Analytical Methods for Constituents for Land Use and Mass Emission Monitoring

Class	Constituent	Sample Type	Method	DL	PQL	Units	Preservation	Holding Time	ME	LU
Conventional										
	Cyanide	Grab	A335.2	0.01	0.01	mg/l	NaOH, ascorbic acid	14 days	x	
	TPH	Grab	A418.1	1.0	1.0	mg/l	-	28 days	x	
	Oil and Grease	Grab	A413.1	1.0	1.0	mg/l	-	28 days	x	
	Total Phenols	Grab	A420.1	0.1	0.1	mg/l	$Na_2S_2O_3$	7 days	x	
Indicator Bacteria										
	Total Coliform	Grab		20	20	MPN/100ml	-	6 hours	x	x
	Fecal Coliform	Grab		20	20	MPN/100ml	-	6 hours	x	x
	Fecal Streptococcus	Grab		20	20	MPN/100ml	-	6 hours	x	x
General										
	Ammonia	Comp	A350.3	0.1	0.1	mg/l	H_2SO_4	28 days	x	x
	Calcium	Comp	A215.2	1.0	1.0	mg/l	HNO_3	6 months	x	x
	Magnesium	Comp	C3500MgD	1.0	1.0	mg/l	HNO_3	6 months	x	x
	Potassium	Comp	A258.1	1.0	1.0	mg/l	HNO_3	6 months	x	x
	Sodium	Comp	A273.1	1.0	1.0	mg/l	HNO_3	6 months	x	x
	Bicarbonate	Comp	A310.1	2.0	2.0	mg/l	-	14 days	x	x
	Carbonate	Comp	A310.1	2.0	2.0	mg/l	-	14 days	x	x
	Chloride	Comp	B429	2.0	2.0	mg/l	-	28 days	x	x
	Fluoride	Comp	B429	0.1	0.1	mg/l	-	28 days	x	x
	Nitrate	Comp	B429	0.1	0.1	mg/l	-	48 hours	x	x
	Sulfate	Comp	B429	0.1	0.1	mg/l	-	48 hours	x	x
	Alkalinity	Comp	A310.1	4.0	4.0	mg/l	-	14 days	x	x
	Hardness	Comp	A130.2	2.0	2.0	mg/l	HNO_3 or H_2SO_4	6 months	x	x
	Dissolved Phosphorus	Comp	A365.2	0.05	0.05	mg/l	-	48 hours	x	x
	Total Phosphorus	Comp	A365.2	0.05	0.05	mg/l	H_2SO_4	28 days	x	x
	COD	Comp	A410.4	5	5	mg/l	H_2SO_4	28 days	x	x
	pH	Comp	A150.1	na	na		-	immed.	x	x
	NH3-N	Comp	A350.3	0.1	0.1	mg/l	H_2SO_4	28 days	x	x
	Nitrate-N	Comp	C4110B	0.1	0.1	mg/l	-	48 hours	x	x
	Nitrite-N	Comp	C4110B	0.1	0.1	mg/l	-	48 hours	x	x
	TKN	Comp	A351.4	0.1	0.1	mg/l	H_2SO_4	28 days	x	x
	Specific Conductance	Comp	A120.1	1	1	umhos/cm	-	immed.	x	x
	Total Dissolved Solids	Comp	A160.1	2.0	2.0	mg/l	-	7 days	x	x
	Turbidity	Comp	A180.1	0.1	0.1	NTU	-	48 hours	x	x
	Suspended Solids	Comp	A160.2	2.0	2.0	mg/l	-	7 days	x	x
	Volatile Suspended Solids	Comp	160.4	1.0	1.0	mg/l	-	7 days	x	x
	MBAS	Comp	A425.1	0.05	0.05	mg/l	-	48 hours	x	x
	Total Organic Carbon	Comp	A415.1	1.0	1.0	mg/l	HCl, H_2SO_4, or H_3PO_4	28 days	x	x
	BOD_5	Comp	A405.1	2.0	2.0	mg/l	-	48 hours	x	x
Metals										
	Dissolved Aluminum	Comp	A202.2	1000	1000	µg/l	HNO_3	6 months	x	x
	Total Aluminum	Comp	A202.2	1000	1000	µg/l	HNO_3	6 months	x	x
	Dissolved Antimony	Comp	A204.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Antimony	Comp	A204.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Arsenic	Comp	A206.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Arsenic	Comp	A206.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Barium	Comp	A208.2	10	10	µg/l	HNO_3	6 months	x	x
	Total Barium	Comp	A208.2	10	10	µg/l	HNO_3	6 months	x	x

DL = Detection limit
PQL = Practical quantitation limit
ME = Constituents marked analyzed for mass emission stations
LU = Constituents marked analyzed for land use stations.
"-" = No preservation required other than cooling the sample to 4° C.
na = not applicable

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Table 3-1. Analytical Methods for Constituents for Land Use and Mass Emission Monitoring

Class	Constituent	Sample Type	Method	DL	PQL	Units	Preservation	Holding Time	ME	LU
Metals (cont.)										
	Dissolved Beryllium	Comp	A210.2	1	1	µg/l	HNO_3	6 months	x	x
	Total Beryllium	Comp	A210.2	1	1	µg/l	HNO_3	6 months	x	x
	Dissolved Boron	Comp	A212.3	100	100	µg/l	HNO_3	6 months	x	x
	Total Boron	Comp	A212.3	100	100	µg/l	HNO_3	6 months	x	x
	Dissolved Cadmium	Comp	A213.2	1	1	µg/l	HNO_3	6 months	x	x
	Total Cadmium	Comp	A213.2	1	1	µg/l	HNO_3	6 months	x	x
	Dissolved Chromium	Comp	A218.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Chromium	Comp	A218.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Chromium +6	Comp		10	10	µg/l	-	24 hours	x	x
	Total Chromium +6	Comp		10	10	µg/l	-	24 hours	x	x
	Dissolved Copper	Comp	A220.1	5	5	µg/l	HNO_3	6 months	x	x
	Total Copper	Comp	A220.1	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Iron	Comp	A236.1	100	100	µg/l	HNO_3	6 months	x	x
	Total Iron	Comp	A236.1	100	100	µg/l	HNO_3	6 months	x	x
	Dissolved Lead	Comp	A239.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Lead	Comp	A239.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Manganese	Comp	A243.1	100	100	µg/l	HNO_3	6 months	x	x
	Total Manganese	Comp	A243.1	100	100	µg/l	HNO_3	6 months	x	x
	Dissolved Mercury	Comp	A245.1	1	1	µg/l	HNO_3	28 days	x	x
	Total Mercury	Comp	A245.1	1	1	µg/l	HNO_3	28 days	x	x
	Dissolved Nickel	Comp	A249.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Nickel	Comp	A249.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Selenium	Comp	A270.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Selenium	Comp	A270.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Silver	Comp	A272.2	1	1	µg/l	HNO_3	6 months	x	x
	Total Silver	Comp	A272.2	1	1	µg/l	HNO_3	6 months	x	x
	Dissolved Thallium	Comp	A279.2	5	5	µg/l	HNO_3	6 months	x	x
	Total Thallium	Comp	A279.2	5	5	µg/l	HNO_3	6 months	x	x
	Dissolved Zinc	Comp	A289.1	50	50	µg/l	HNO_3	6 months	x	x
	Total Zinc	Comp	A289.1	50	50	µg/l	HNO_3	6 months	x	x
Semi-Volatile Organics										
	Bis(2-ethylhexyl)phthalate	Comp	625M	3.0	1.0	µg/l	-	7 days	x	x
	All other SVOCs	Comp	625M	0.5 - 5.0	0.05 - 5.0	µg/l	-	7 days	x	x
Pesticides										
	Organochlorine Pesticides & PCBs	Comp	D608	0.05 - 1.0	0.05 - 1.1	µg/l	-	7 days	x	x
	Diazinon	Comp	8141SOP	0.01	0.01	µg/l	-	7 days	x	x
	Chlorpyrifos	Comp	8141SOP	0.05	0.1	µg/l	-	7 days	x	x
	Other N- and P-Containing Pesticides	Comp	507	1.0 - 2.0	1.0 - 2.0	µg/l	-	7 days	x	x
	Carbofuran	Comp	531.1	5.0	5.0	µg/l	-	7 days	x	x
	Chlorinated Herbicides & Bentazon									
	2,4-D	Comp	515.1	10.0	10.0	µg/l	-	7 days	x	x
	2,4,5-TP	Comp	515.1	1.0	1.0	µg/l	-	7 days	x	x
	Bentazon	Comp	515.1	2.0	2.0	µg/l	-	7 days	x	x
	Glyphosate	Comp	547	25	25	µg/l	$Na_2S_2O_3$	14 days	x	x

DL = Detection limit
PQL = Practical quantitation limit
ME = Constituents marked analyzed for mass emission stations
LU = Constituents marked analyzed for land use stations.
"-" = No preservation required other than cooling the sample to 4° C.
na = not applicable

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Table 3-2. Analytical Methods for Constituents for Critical Source Monitoring

Class	Constituent	Sample Type	Method	DL	PQL	Units	Preservation	Holding Time	CS
Conventional									
	TPH	Grab	A418.1	1.0	1.0	mg/l	-	28 days	x
	Oil and Grease	Grab	A413.1	1.0	1.0	mg/l	-	28 days	x
Indicator Bacteria									
	Total Coliform	Grab		20	20	MPN/100ml	-	6 hours	x
	Fecal Coliform	Grab		20	20	MPN/100ml	-	6 hours	x
	Fecal Streptococcus	Grab		20	20	MPN/100ml	-	6 hours	x
General									
	COD	Comp	A410.4	5	5	mg/l	H_2SO_4	28 days	x
	pH	Comp	A150.1	na	na		-	immed.	x
	Specific Conductance	Comp	A120.1	1	1	umhos/cm	-	immed.	x
	Total Dissolved Solids	Comp	A160.1	2.0	2.0	mg/l	-	7 days	x
	Suspended Solids	Comp	A160.2	2.0	2.0	mg/l	-	7 days	x
	MBAS	Comp	A425.1	0.05	0.05	mg/l	-	48 hours	x
	Total Organic Carbon	Comp	A415.1	1.0	1.0	mg/l	HCl, H_2SO_4, or H_3PO_4	28 days	x
Metals									
	Dissolved Aluminum	Comp	A202.2	100	100	µg/l	HNO_3	6 months	x
	Total Aluminum	Comp	A202.2	100	100	µg/l	HNO_3	6 months	x
	Dissolved Cadmium	Comp	A213.2	1	1	µg/l	HNO_3	6 months	x
	Total Cadmium	Comp	A213.2	1	1	µg/l	HNO_3	6 months	x
	Dissolved Chromium	Comp	A218.2	5	5	µg/l	HNO_3	6 months	x
	Total Chromium	Comp	A218.2	5	5	µg/l	HNO_3	6 months	x
	Dissolved Copper	Comp	A220.1	5	5	µg/l	HNO_3	6 months	x
	Total Copper	Comp	A220.1	5	5	µg/l	HNO_3	6 months	x
	Dissolved Iron	Comp	A236.1	100	100	µg/l	HNO_3	6 months	x
	Total Iron	Comp	A236.1	100	100	µg/l	HNO_3	6 months	x
	Dissolved Lead	Comp	A239.2	5	5	µg/l	HNO_3	6 months	x
	Total Lead	Comp	A239.2	5	5	µg/l	HNO_3	6 months	x
	Dissolved Nickel	Comp	A249.2	5	5	µg/l	HNO_3	6 months	x
	Total Nickel	Comp	A249.2	5	5	µg/l	HNO_3	6 months	x
	Dissolved Zinc	Comp	A289.1	50	50	µg/l	HNO_3	6 months	x
	Total Zinc	Comp	A289.1	50	50	µg/l	HNO_3	6 months	x
Semi-Volatile Organics									
	Bis(2-ethylhexyl)phthalate	Comp	625	3.0	3.0	µg/l	-	7 days	x
	All other SVOCs	Comp	625	0.5 - 5.0	0.5 - 5.0	µg/l	-	7 days	x

DL = Detection limit
PQL = Practical quantitation limit
CS = Constituents marked analyzed for critical source sites.
"-" = No preservation required other than cooling the sample to 4° C.
na = not applicable

Table 4-1. Summary of Hydrologic Data for Monitored Stations

DATE	STATION	LAND USE	ANTECEDENT DRY PERIOD (days)	TOTAL PRECIPITATION (in.)	RAINFALL DURATION (hrs)	AVG. RAINFALL INTENSITY (in./hr)	TOTAL RUNOFF VOLUME (acre-ft)
10 12 00	Ballona Creek (S01)	ME	177	0 08	0 75	0 11	647 43
10.12/00	Malibu Creek (S02)	ME	177	0 00	0 00	NA	4 24
10'12/00	Santa Monica Pier (S08)	COMM	177	0 08	0 75	0 11	NA
10/12/00	L A River @ Wardlow (S10)	ME	177	0 12	0 50	0 24	394 96
10/12/00	Sawpit Creek (S11)	VAC	19	0 04	0 25	0.16	NA
10/12/00	Coyote Creek (S13)	ME	86	0 20	4 00	0.05	165 55
10/12/00	San Gabriel River (S14)	ME	19	0 04	0 25	0 16	8 42
10/12/00	Project 620 (S18)	HDSFR	177	0 00	0.00	NA	NA
10/12/00	Dominguez Channel (S23)	TRAN	177	0 08	0 75	0 11	0 14
10/12/00	Project 1202 (S24)	LT IND	177	0 12	0 50	0 24	NA
10/12/00	Project 474 (S25)	EDU	177	0 16	2 75	0 06	0 30
10/12/00	Project 404 (S26)	MFR	19	0 04	0 25	0 16	0 55
10/12/00	Project 156 (S27)	MIX RES	177	0 00	0 00	NA	0 45
10/26/00	Ballona Creek (S01)	ME	15	0 68	8 75	0 08	NA
10/26/00	Malibu Creek (S02)	ME	14	1 48	20 25	0.07	NA
10/26/00	Santa Monica Pier (S08)	COMM	15	0 68	8 75	0 08	NA
10/26/00	L A River @ Wardlow (S10)	ME	15	0 40	43.75	0 01	171,536 41
10/26/00	Sawpit Creek (S11)	VAC	15	0 88	40 50	0 02	NA
10/26/00	Coyote Creek (S13)	ME	13	2 16	7.25	0 30	1,688 41
10/26/00	San Gabriel River (S14)	ME	15	0 88	40 50	0 02	623 25
10/26/00	Project 620 (S18)	HDSFR	14	0 48	23 50	0 02	0 26
10/26/00	Dominguez Channel (S23)	TRAN	15	0 68	8 75	0 08	2 44
10/26/00	Project 1202 (S24)	LT IND	15	0 40	43 75	0 01	45 74
10/26/00	Project 474 (S25)	EDU	14	0 32	7 25	0 04	6 20
10/26/00	Project 404 (S26)	MFR	380	0.84	23 50	0 04	3 34
10/26/00	Project 156 (S27)	MIX RES	14	0 48	23 50	0 02	1.57
10/29/00	Ballona Creek (S01)	ME	2	0 40	5 50	0.07	351 17
10/29/00	Malibu Creek (S02)	ME	2	0 92	7 50	0 12	NA
10/29/00	Santa Monica Pier (S08)	COMM	2	0 40	5 50	0 07	NA
10/29/00	L A River @ Wardlow (S10)	ME	1	0 87	11 00	0.08	2,303 96
10/29/00	Sawpit Creek (S11)	VAC	2	0 72	7.75	0 09	No Data
10/29/00	Coyote Creek (S13)	ME	2	0 36	4 25	0.08	388 04
10/29/00	San Gabriel River (S14)	ME	2	0 72	7 75	0 09	372 20
10/29/00	Project 620 (S18)	HDSFR	2	0.56	5 25	0 11	0.78
10/29/00	Dominguez Channel (S23)	TRAN	2	0 40	5 50	0.07	19 13
10/29/00	Project 1202 (S24)	LT IND	1	0 87	11 00	0.08	14 09
10/29/00	Project 474 (S25)	EDU	1	0.40	6 25	0 06	1 83
10/29/00	Project 404 (S26)	MFR	2	0 68	6 25	0 11	3 38
10/29/00	Project 156 (S27)	MIX RES	2	0 56	5 25	0 11	2 95
01/08/01	Ballona Creek (S01)	ME	71	0 16	2 50	0 06	450 63
01/08/01	Malibu Creek (S02)	ME	67	0 20	6 75	0 03	NA
01/08/01	Santa Monica Pier (S08)	COMM	71	0 16	2 50	0 06	NA
01/08/01	L A River @ Wardlow (S10)	ME	71	0 16	3.25	0.05	NA
01/08/01	Sawpit Creek (S11)	VAC	60	0.00	0 00	NA	NA
01/08/01	Coyote Creek (S13)	ME	15	0.40	4.50	0.09	357 95
01/08/01	San Gabriel River (S14)	ME	60	0 00	0.00	NA	62 87
01/08/01	Project 620 (S18)	HDSFR	71	0 08	2 00	0 04	1 40
01/08/01	Dominguez Channel (S23)	TRAN	71	0.16	2.50	0 06	5 67
01/08/01	Project 1202 (S24)	LT IND.	71	0 16	3.25	0 05	5 89
01/08/01	Project 474 (S25)	EDU	71	0.12	2.50	0.05	0 53
01/06/01	Project 404 (S26)	MFR	71	0 04	0.25	0 16	0 13
01/08/01	Project 156 (S27)	MIX RES.	71	0 08	2 00	0.04	0 44
01/10/01	Ballona Creek (S01)	ME	2	3 88	18.00	0.22	7,221 60
01/10/01	Malibu Creek (S02)	ME	2	5 62	16.75	0.34	NA
01/10/01	Santa Monica Pier (S08)	COMM	2	3 88	18.00	0.22	NA
01/10/01	L A River @ Wardlow (S10)	ME	2	1 16	7.25	0.16	25,152 72
01/10/01	Sawpit Creek (S11)	VAC	60	3 72	19 00	0 20	17.29
01/10/01	Coyote Creek (S13)	ME	2	2 24	18 50	0 12	2,018 24
01/10/01	San Gabriel River (S14)	ME	60	3 72	19 00	0 20	2,660 80
01/10/01	Project 620 (S18)	HDSFR	2	3 52	18.00	0.20	5 80
01/10/01	Dominguez Channel (S23)	TRAN	2	3 88	18 00	0.22	119 13
01/10/01	Project 1202 (S24)	LT IND	2	1 16	7.25	0 16	70 40
01/10/01	Project 474 (S25)	EDU	2	2.88	17.50	0 16	NA
01/10/01	Project 404 (S26)	MFR	2	3 04	19.50	0 16	23 19
01/10/01	Project 156 (S27)	MIX RES	2	3.52	18 00	0 20	20 04
01/24/01	Ballona Creek (S01)	ME	10	0 28	5 75	0 05	680 07

All flows include base flow
Hydrologic_Data xls

Table 4-1. Summary of Hydrologic Data for Monitored Stations

DATE	STATION	LAND USE	ANTECEDENT DRY PERIOD (days)	TOTAL PRECIPITATION (In.)	RAINFALL DURATION (hrs)	AVG. RAINFALL INTENSITY (in/hr)	TOTAL RUNOFF VOLUME (acre-ft)
01/24/01	Malibu Creek (S02)	ME	12	0 52	4 25	0 12	83.02
01/24/01	Santa Monica Pier (S08)	COMM	10	0 28	5 75	0 05	NA
01/24/01	L A River @ Wardlow (S10)	ME	14	0 32	6 25	0 05	1,349 86
01/24/01	Sawpit Creek (S11)	VAC	13	0.52	10 00	0 05	10 28
01/24/01	Coyote Creek (S13)	ME	9	0 24	10 50	0 02	803.55
01/24/01	San Gabriel River (S14)	ME	13	0 52	10 00	0 05	421.27
01/24/01	Project 620 (S18)	HDSFR	12	0 28	3 75	0 07	1.87
01/24/01	Dominguez Channel (S23)	TRAN	10	0 28	5 75	0 05	9.09
01/24/01	Project 1202 (S24)	LT IND	14	0 32	6 25	0 05	No Data
01/24/01	Project 474 (S25)	EDU	12	0 44	8 50	0 05	1.67
01/24/01	Project 404 (S26)	MFR	12	0 44	6 50	0 07	0.19
01/24/01	Project 156 (S27)	MIX RES	12	0 28	3 75	0 07	1.75
01/26/01	Ballona Creek (S01)	ME	2	0 04	0.75	0 05	1,197.60
01/26/01	Malibu Creek (S02)	ME	2	0 08	0.25	0 32	174 82
01/26/01	Santa Monica Pier (S08)	COMM	2	0 04	0 75	0 05	NA
01/26/01	L A River @ Wardlow (S10)	ME	2	0 04	0.25	0 16	1,437.31
01/26/01	Sawpit Creek (S11)	VAC	2	0 24	4 75	0.05	12.19
01/26/01	Coyote Creek (S13)	ME	2	0 20	16 75	0.01	1,252.84
01/26/01	San Gabriel River (S14)	ME	2	0 24	4 75	0 05	503 10
01/26/01	Project 620 (S18)	HDSFR	2	0 04	0 25	0 16	0 79
01/26/01	Dominguez Channel (S23)	TRAN	2	0 04	0 75	0 05	22 60
01/26/01	Project 1202 (S24)	LT IND	2	0 04	0 25	0 16	9 85
01/26/01	Project 474 (S25)	EDU	2	0 16	1.75	0 09	3.64
01/26/01	Project 404 (S26)	MFR	2	0 32	9 75	0 03	NA
01/26/01	Project 156 (S27)	MIX RES	2	0 04	0.25	0 16	1 84
02/10/01	Ballona Creek (S01)	ME	15	4 12	90 00	0 05	802.90
02/10/01	Malibu Creek (S02)	ME	15	4.68	82.50	0 06	2,443.08
02/10/01	Santa Monica Pier (S08)	COMM	15	4 12	90 00	0 05	NA
02/10/01	L A River @ Wardlow (S10)	ME	15	2 74	88 00	0 03	NA
02/10/01	Sawpit Creek (S11)	VAC	3	3 76	81 50	0 05	4.23
02/10/01	Coyote Creek (S13)	ME	9	2 52	75 50	0 03	341.96
02/10/01	San Gabriel River (S14)	ME	3	3 76	81.50	0.05	203.02
02/10/01	Project 620 (S18)	HDSFR	15	3 48	86.75	0 04	0.77
02/10/01	Dominguez Channel (S23)	TRAN	15	4 12	90.00	0 05	8 76
02/10/01	Project 1202 (S24)	LT IND	15	2 74	88 00	0 03	5.26
02/10/01	Project 474 (S25)	EDU	15	3 16	93 75	0 03	2.20
02/10/01	Project 404 (S26)	MFR	3	1 12	85 25	0 01	36.46
02/10/01	Project 156 (S27)	MIX RES	15	3 48	86.75	0 04	10.49
02/19/01	Ballona Creek (S01)	ME	6	0 40	3 25	0 12	1,145 72
02/19/01	Malibu Creek (S02)	ME	2	0 80	6 25	0 13	NA
02/19/01	Santa Monica Pier (S08)	COMM	6	0 40	3 25	0 12	NA
02/19/01	L A River @ Wardlow (S10)	ME	1	0 12	2 00	0 06	762.96
02/19/01	Sawpit Creek (S11)	VAC	5	0 20	5 75	0 03	6.81
02/19/01	Coyote Creek (S13)	ME	5	0 12	12 00	0 01	597.40
02/19/01	San Gabriel River (S14)	ME	5	0 20	5.75	0 03	429.76
02/19/01	Project 620 (S18)	HDSFR	6	0 20	4 00	0 05	NA
02/19/01	Dominguez Channel (S23)	TRAN	6	0 40	3 25	0 12	NA
02/19/01	Project 1202 (S24)	LT IND	1	0.12	2 00	0.06	6.07
02/19/01	Project 474 (S25)	EDU	1	0 24	9.00	0 03	0.49
02/19/01	Project 404 (S26)	MFR	1	0 04	0 25	0.16	0.67
02/19/01	Project 156 (S27)	MIX RES	6	0 20	4 00	0.05	1.25
02/24/01	Ballona Creek (S01)	ME	1	2 28	57 00	0.04	6,541.33
02/24/01	Malibu Creek (S02)	ME	1	2 63	57 75	0.05	1,877.89
02/24/01	Santa Monica Pier (S08)	COMM	1	2 28	57 00	0.04	NA
02/24/01	L A River @ Wardlow (S10)	ME	1	0 87	36 50	0 02	24,881.34
02/24/01	Sawpit Creek (S11)	VAC	1	0 96	39 25	0 02	34.90
02/24/01	Coyote Creek (S13)	ME	1	0 08	1 00	0 08	6,240.30
02/24/01	San Gabriel River (S14)	ME	1	0 96	39 25	0 02	2,132.16
02/24/01	Project 620 (S18)	HDSFR	1	2 20	59 75	0 04	1.90
02/24/01	Dominguez Channel (S23)	TRAN	1	2 28	57 00	0 04	122.46
02/24/01	Project 1202 (S24)	LT IND	1	0 87	36 50	0.02	NA
02/24/01	Project 474 (S25)	EDU	1	3 24	45 25	0 07	17.40
02/24/01	Project 404 (S26)	MFR	1	0 12	53 50	0 00	21.44
02/24/01	Project 156 (S27)	MIX RES	1	2 20	59.75	0 04	13 72
03/04/01	Ballona Creek (S01)	ME	4	1.28	37 00	0 03	2,766 45
03/04/01	Malibu Creek (S02)	ME	4	4 80	43 00	0 11	6,573.24
03/04/01	Santa Monica Pier (S08)	COMM	4	1 28	37 00	0 03	NA

All flows include base flow
Hydrologic_Data xls

Table 4-1. Summary of Hydrologic Data for Monitored Stations

DATE	STATION	LAND USE	ANTECEDENT DRY PERIOD (days)	TOTAL PRECIPITATION (In.)	RAINFALL DURATION (hrs)	AVG. RAINFALL INTENSITY (In./hr)	TOTAL RUNOFF VOLUME (acre-ft)
03/04/01	L A River @ Wardlow (S10)	ME	8	0 75	23 75	0 03	10,093 36
03/04/01	Sawpit Creek (S11)	VAC	6	1 00	48 75	0 02	No Data
03/04/01	Coyote Creek (S13)	ME	1	0 16	16 50	0 01	40 96
03/04/01	San Gabriel River (S14)	ME	6	1 00	48 75	0 02	341 57
03/04/01	Project 620 (S18)	HDSFR	4	0 76	37 25	0 02	0 61
03/04/01	Dominguez Channel (S23)	TRAN	4	1.28	37.00	0 03	26 25
03/04/01	Project 1202 (S24)	LT IND	8	0 75	23.75	0.03	6 28
03/04/01	Project 474 (S25)	EDU	4	0 48	12 50	0 04	7 18
03/04/01	Project 404 (S26)	MFR	1	0 64	53 75	0 01	0 80
03/04/01	Project 156 (S27)	MIX RES	4	0 76	37 25	0 02	2 49
04/07/01	Ballona Creek (S01)	ME	32	0 48	7 50	0 06	1,918 03
04/07/01	Malibu Creek (S02)	ME	31	1 28	11.00	0 12	111 28
04/07/01	Santa Monica Pier (S08)	COMM	32	0 48	7 50	0 06	NA
04/07/01	L A River @ Wardlow (S10)	ME	32	0 24	1 50	0 16	NA
04/07/01	Sawpit Creek (S11)	VAC	5	1.20	10 50	0.11	NA
04/07/01	Coyote Creek (S13)	ME	1	0 20	5 50	0 04	720 84
04/07/01	San Gabriel River (S14)	ME	5	1 20	10.50	0 11	645 45
04/07/01	Project 620 (S18)	HDSFR	29	1 20	10 25	0 12	NA
04/07/01	Dominguez Channel (S23)	TRAN	32	0 48	7 50	0 06	14 08
04/07/01	Project 1202 (S24)	LT IND	32	0 24	1 50	0 16	3 87
04/07/01	Project 474 (S25)	EDU	33	0 52	8 50	0 06	3 50
04/07/01	Project 404 (S26)	MFR	11	0 68	11 25	0 06	8 92
04/07/01	Project 156 (S27)	MIX RES	29	1 20	10 25	0 12	5 66

NA - No Flow Data Recorded At This Station
LAND USE CODES

ME - Mass Emission
COMM - Retail/Commercial
VAC - Vacant
HDSFR - High Density Single Family Residential
TRAN - Transportation
LT IND - Light Industrial
EDU - Educational
MFR - Multi-Family Residential
MIX RES - Mixed Residential

All flows include base flow
Hydrologic_Data xls

Table 4-2 Seasonal Summary of Hydrologic Data for Monitored Stations

SEASON	STATION	LAND USE	TOTAL PRECIPITATION (in.)	TOTAL RUNOFF VOLUME* (acre-ft)
94-95	BALLONA CREEK (S01)	ME	14 76	47,900
	MALIBU CREEK (S02)	ME	35 41	37,700
	KENTER CANYON (S04)	ME	19 39	6,840
	TRANCAS CANYON (S03)	VAC	29 73	3,590
	PROJECT 1105 (S05)	HDSFR	17 17	1,920
	PROJECT 558 (S06)	LDSFR	17 17	161
	PROJECT 5401 (S07)	HDSFR	17 17	197
	SANTA MONICA PIER (S08)	COMM	19.39	272
	L.A. DRAIN 2361 (S09)	COMM	16 61	125
96-97	BALLONA CREEK (S01)	ME	11.18	22,200
	MALIBU CREEK (S02)	ME	9 22	NA
	KENTER CANYON (S04)	ME	7 42	675
	L A RIVER AT WARDLOW (S10)	ME	6 17	66,700
	COYOTE CREEK (S13)	ME	6 06	NA
	SAN GABRIEL RIVER (S14)	ME	8 00	NA
	SANTA MONICA PIER (S08)	COMM	13.82	211
	SAWPIT CREEK (S11)	VAC	15 15	189
	PROJECT 620 (S18)	HDSFR	2.68	22
	DOMINGUEZ CHANNEL (S23)	TRAN	13.82	446
	PROJECT 1202 (S24)	LT IND	12.64	463
97-98	BALLONA CREEK (S01)	ME	28 28	18,300
	MALIBU CREEK (S02)	ME	37 51	39,700
	L A RIVER AT WARDLOW (S10)	ME	17 80	297,000
	COYOTE CREEK (S13)	ME	23 03	60,500
	SAN GABRIEL RIVER (S14)	ME	28 80	32,800
	SANTA MONICA PIER (S08)	COMM	28 28	215
	SAWPIT CREEK (S11)	VAC	24 56	303
	PROJECT 620 (S18)	HDSFR	24 44	66
	DOMINGUEZ CHANNEL (S23)	TRAN	28 28	1,250
	PROJECT 1202 (S24)	LT IND	30 06	906
	PROJECT 474 (S25)	EDU	33 72	161
	PROJECT 404 (S26)	MFR	24 76	176
	PROJECT 156 (S27)	MIX RES	24 44	144
98-99	BALLONA CREEK (S01)	ME	9 48	10,700
	MALIBU CREEK (S02)	ME	8 48	419
	L A RIVER AT WARDLOW (S10)	ME	6 34	NA
	COYOTE CREEK (S13)	ME	6.64	11,500
	SAN GABRIEL RIVER (S14)	ME	6.20	12,700
	SANTA MONICA PIER (S08)	COMM	9 48	91
	SAWPIT CREEK (S11)	VAC	10 00	47
	PROJECT 620 (S18)	HDSFR	6 11	6
	DOMINGUEZ CHANNEL (S23)	TRAN	10 28	334
	PROJECT 1202 (S24)	LT IND	4.83	218
	PROJECT 474 (S25)	EDU	8.16	3
	PROJECT 404 (S26)	MFR	10 60	1,280
	PROJECT 156 (S27)	MIX RES	7 08	475
99-2000	BALLONA CREEK (S01)	ME	6 76	20,086
	MALIBU CREEK (S02)	ME	10 95	4,286
	L A RIVER AT WARDLOW (S10)	ME	5 00	18,515
	COYOTE CREEK (S13)	ME	2.96	22,937
	SAN GABRIEL RIVER (S14)	ME	11 96	3,777
	SANTA MONICA PIER (S08)	COMM	6 76	NA
	SAWPIT CREEK (S11)	VAC	11 96	61
	PROJECT 620 (S18)	HDSFR	9.36	33
	DOMINGUEZ CHANNEL (S23)	TRAN.	6 76	239
	PROJECT 1202 (S24)	LT IND	2.96	1,671
	PROJECT 474 (S25)	EDU	8 36	51
	PROJECT 404 (S26)	MFR	8.16	101
	PROJECT 156 (S27)	MIX RES	9 04	56
2000-01	BALLONA CREEK (S01)**	ME	14 52	23,723
	MALIBU CREEK (S02)**	ME	24 01	11,268
	SANTA MONICA PIER (S08)	COMM.	9 00	NA
	L A RIVER AT WARDLOW (S10)**	ME	14 52	237,913
	SAWPIT CREEK (S11)**	VAC	14.00	86
	COYOTE CREEK (S13)	ME	8.07	14,616
	SAN GABRIEL RIVER (S14)	ME	14 00	8,404
	PROJECT 620 (S18)**	HDSFR	13 40	14
	DOMINGUEZ CHANNEL (S23)**	TRAN.	14 52	350
	PROJECT 1202 (S24)**	LT IND	8.07	167
	PROJECT 474 (S25)**	EDU	12.60	45
	PROJECT 404 (S26)**	MFR	8.24	99
	PROJECT 156 (S27)	MIX RES	13.40	63

*ALL FLOWS INCLUDE BASE FLOW
**RUNOFF VOLUME OF SOME EVENTS IS NOT INCLUDED.
Hydrologic Data_Int xls

Table 4-3. 2000-2001 Los Angeles County Stormwater Monitoring Analytical Data Inventory

Station No.	Station Type	No. of Events Sampled	Sample Type	Analytes: General Minerals	Heavy Metals	Miscellaneous Bacteria	Semi-Volatiles	Pesticides
S11-Sawpit Creek	LU	6	Grab			X		
	Vacant	7	Comp	X	X	X	X	X
S18-Project 620	LU	3	Grab			X		
	HDSFR	10	Comp	X	X	X	7/10	X
S23-Dominguez Channel	LU	4	Grab			X		
	Trans	12	Comp	X	X	X		X
S24-Project 1202	LU	3	Grab			X		
	Lt. Ind.	10	Comp	X	X	X		X
S25-Project 474	LU	4	Grab			X		
	Edu.	12	Comp	X	X	X		X
S26-Project 404	LU	2	Grab			X		
	Multi-Fam	9	Comp	X	X	X	5/9	X
S27-Project 156	LU	3	Grab			X		
	Mix. Res.	11	Comp	X	X	X	10/11	X
S01-Ballona Creek	ME	8	Grab			X		
		10	Comp	X	X	X		X
S02-Malibu Creek	ME	8	Grab			X		
		10	Comp	X	X	X	6/10	X
S10-L.A. River	ME	7	Grab			X		
		11	Comp	X	X	X		X

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Table 4-3. 2000-2001 Los Angeles County Stormwater Monitoring Analytical Data Inventory

Station No.	Station Type	No. of Events Sampled	Sample Type	Analytes: General Minerals	Heavy Metals	Miscellaneous Bacteria	Semi-Volatiles	Pesticides
S13-Coyote Creek	ME	4	Grab			X		
		10	Comp	X	X	X		X
S14-San Gabriel River	ME	6	Grab			X		
		9	Comp	X	X	X		X

Notes:

Comp= flow composite sample
X= denotes analytes reported for all events
1/6 = denotes analytes reported for 1 out of 6 events
Blank= no analytes reported
LU= Land Use Station
- Comm= commercial
- HDSFR= High Density Single Family Residential
- Trans= Transportation
- Lt. Ind.= Light Industrial
- Edu.= Educational
- Multi-Fam.= Multi-Family Residential
- Mix. Res.= Mixed Residential

ME= Mass Emission Station

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Table 4-4a. Comparison of 2000-2001 Mass Emissions Results with Standards

Class Constituent	Data Included Since[a]	DL	Units	Guidelines and Standards					Mass Emission					
				Ocean Plan[b]	Basin Plan[b]	AB 411	California Toxics Rule (freshwater)[c]	California Toxics Rule (saltwater)[c]	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Dissolved Antimony	97	5	µg/l						50	50	0	S I D	0 00	S I D
Total Antimony	97	5	µg/l	1200[e]	6				50	50	0	S I D	S I D	S I D
Dissolved Arsenic	97	5	µg/l				150	36	50	50	0	S I D	S I D	S I D
Total Arsenic	97	5	µg/l	32[d]	50				50	50	0	S I D	S I D	S I D
Dissolved Barium	97	10	µg/l						50	0	100	S I D	S I D	0 29
Total Barium	97	10	µg/l		1000				50	0	100	36 54	S I D	0 48
Dissolved Beryllium	97	1	µg/l						50	50	0	0 00	0 00	S I D
Total Beryllium	97	1	µg/l	0.033[e]	4				50	50	0	S I D	0 000	S I D
Dissolved Boron	97	100	µg/l						50	12	76	S I D	S I D	0 81
Total Boron	97	100	µg/l		1000				50	6	88	204 38	S I D	0 64
Dissolved Cadmium	97	1	µg/l				2 2	9 3	50	49	2	0 03	0 00	S I D
Total Cadmium	97	1	µg/l	4[d]	5				50	48	4	S I D	0 00	S I D
Dissolved Chromium	97	5	µg/l				180		50	47	6	S I D	S I D	S I D
Total Chromium	97	5	µg/l	190[e]	50				50	47	6	S I D	S I D	S I D
Dissolved Chromium +6	94	10	µg/l				11	50	50	50	0	S I D	S I D	S I D
Total Chromium +6	94	10	µg/l	8[d]					50	50	0	S I D	S I D	S I D
Dissolved Copper	97	5	µg/l				9	3 1	50	26	48	S I D	S I D	1 14
Total Copper	97	5	µg/l	12[d]					50	1	98	11 13	S I D	0 80
Dissolved Iron	94	100	µg/l						50	25	50	116 20	50 00	1 25
Total Iron	94	100	µg/l						50	6	88	577.08	335 00	1 87
Dissolved Lead	97	5	µg/l				2 5	8 1	50	50	0	0 00	0 00	S I D
Total Lead	97	5	µg/l	8[d]					50	41	18	S I D	0 00	S I D
Dissolved Manganese	98	100	µg/l						50	49	2	S I D	S I D	S I D
Total Manganese	98	100	µg/l						50	43	14	S I D	S I D	S I D
Dissolved Mercury	94	1	µg/l						49	49	0	S I D	S I D	S I D
Total Mercury	94	1	µg/l	0 16[d]	2				49	49	0	S I D	S I D	S I D
Dissolved Nickel	97	5	µg/l				52	8 2	50	23	54	S I D	S I D	1 0
Nickel	97	5	µg/l	20[d]	100				50	16	68	5 87	S I D	0 94
Dissolved Selenium	94	5	µg/l				5[f]	71	50	49	2	0 14	0 00	S I D
Total Selenium	94	5	µg/l	60[d]	50				50	49	2	S I D	0 00	S I D
Dissolved Silver	97	1	µg/l				3 4[g]	1 9[g]	50	50	0	S I D	S I D	S I D
Total Silver	97	1	µg/l	2 8[d]					50	50	0	S I D	S I D	S I D
Dissolved Thallium	97	5	µg/l						50	50	0	S I D	S I D	S I D
Total Thallium	97	5	µg/l	14[e]	2				50	50	0	S I D	S I D	S I D
Dissolved Zinc	94	50	µg/l				120	81	50	39	22	S I D	S I D	2 44
Total Zinc	94	50	µg/l	80[d]					50	32	36	35 04	S I D	1 95
SVOCs														
Bis(2-ethylhexyl)phthalate	99	1	µg/l	3 5[e]					6	2	67	3.75	3 55	0 99
PAHs				0 0088[h]										
Acenaphthene	99	0 05	µg/l						6	6	0	S I D	S I D	S I D
Acenaphthylene	99	0.05	µg/l						6	6	0	S I D	S I D	S I D
Anthracene	99	0 05	µg/l						6	6	0	S I D	S I D	S I D
Benzo(a)anthracene	99	0 1	µg/l		2				6	6	0	S I D	S I D	S I D
Benzo(a)pyrene	99	0.1	µg/l						6	6	0	S I D	S I D	S I D
Benzo(b)fluoranthene	99	0.1	µg/l						6	6	0	S I D	S I D	S I D
Benzo(k)fluoranthene	99	0.1	µg/l						6	6	0	S I D	S I D	S I D
Chrysene	99	0 1	µg/l						6	6	0	S I D	S I D	S I D
Dibenz(a,h)anthracene	99	0 1	µg/l						6	6	0	S I D	S I D	S I D
Fluoranthene	99	0 1	µg/l	15[e]					6	6	0	S I D	S I D	S I D
Fluorene	99	0.1	µg/l						6	6	0	S I D	S I D	S I D
Indeno (1,2,3-cd)pyrene	99	0 1	µg/l						6	6	0	S I D	S I D	S I D
Naphthalene	99	0 05	µg/l						6	6	0	S I D	S I D	S I D
Phenanthrene	99	0 05	µg/l						6	6	0	S I D	S I D	S I D

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Table 4-4a. Comparison of 2000-2001 Mass Emissions Results with Standards

Class Constituent	Data Included Since[a]	DL	Units	Guidelines and Standards: Ocean Plan[b]	Basin Plan[b]	AB 411	California Toxics Rule (freshwater)[c]	California Toxics Rule (saltwater)[c]	Mass Emission: No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents														
Cyanide	96	0 01	mg/l	0 004[d]	0 2		0 0052	0.001	30	0	100	0 013	0 005	1 51
TPH	94	1	mg/l						30	0	100	2	1	1 13
Oil and Grease	94	1	mg/l	25[e]					30	0	100	2	1	1 10
Total Phenols	94	0.1	mg/l						30	0	100	0	0	0 00
Indicator Bacteria														
Total Coliform	94	20	MPN/100ml	1000[e]	70	10,000 (Instantaneous)			34	0	100	1,674,426	500,000	2 02
Fecal Coliform	94	20	MPN/100ml	200[e]	200	400 (Instantaneous)			34	0	100	938,381	140,000	2 95
Ratio Fecal Coliform/Total Coliform	94					10% (Instantaneous) if Total Coliform is between 1000 & 10,000			5	0	100	66.88%	63 64%	0 55
Fecal Streptococcus	94	20	MPN/100ml						34	0	100	968,317	160,000	3 00
Fecal Enterococcus	94	20	MPN/100ml	24[e]		104			34	0	100	291,022	50,000	2 01
General Minerals														
Ammonia	94	0 1	mg/l	2.4[d]	6 8				47	1	98	0 65	0 15	2 06
Calcium	96	1 0	mg/l						50	0	100	49 94	40 08	0 75
Magnesium	96	1 0	mg/l						50	0	100	25 34	12 86	1 37
Potassium	94	1 0	mg/l						50	0	100	5 40	4 46	0 61
Sodium	96	1 0	mg/l						50	0	100	50 24	35 10	0 85
Bicarbonate	94	2 0	mg/l						50	0	100	117 53	104 10	0 64
Carbonate	94	2 0	mg/l						50	1	98	0 61	0 05	7 07
Chloride	94	2 0	mg/l						50	0	100	54 64	43 05	0 84
Fluoride	94	0 1	mg/l		2.4				50	0	100	0 21	0 18	0 58
Nitrate	94	0 1	mg/l						50	0	100	7.76	4 87	1 09
Sulfate	94	0.1	mg/l						50	0	100	138 05	63 30	1 34
Alkalinity	94	4 0	mg/l						50	0	100	96 85	85 50	0 65
Hardness	96	2.0	mg/l						50	0	100	228.83	150 00	0 92
COD	97	5	mg/l						50	0	100	74.02	64 25	0 69
pH	94	0-14			6 5< x <8 5				50	0	100	7 38	7 28	0 07
Specific Conductance	94	1.0	umhos/cm						50	0	100	2.51	484 00	0 90
Total Dissolved Solids	96	2 0	mg/l		250				50	0	100	419.44	305 00	0 90
Turbidity	94	0 1	NTU	75[e]					50	0	100	90.46	44 20	1 72
Total Suspended Solids	96	2.0	mg/l						50	0	100	237 66	123 50	1 39
Volatile Suspended Solids	94	1.0	mg/l/hr						50	0	100	45 80	33 00	0 98
MBAS	97	0.05	mg/l		0 5				50	0	100	0.09	0 08	0 84
Total Organic Carbon	94	1.0	mg/l						50	0	100	11 23	7 77	1 02
BOD	94	2.0	mg/l						50	0	100	7.80	5 80	1 13
Nutrients														
Dissolved Phosphorus	94	0.05	mg/l						50	0	100	2.50	0 23	6 10
Total Phosphorus	94	0.05	mg/l						50	0	100	3.73	0 30	6 32
NH3-N	94	0.1	mg/l	2.4[d]	2.7				48	1	98	0 52	0 12	2 14
Nitrate-N	96	0.1	mg/l		10 and also must not exceed 5 when added to Nitrite-N				50	0	100	1.77	1 10	1 08
Nitrite-N	94	0 1	mg/l		1 and also must not exceed 5 when added to Nitrate-N				50	0	100	0 22	0 08	1 63
TKN	96	0.1	mg/l						49	0	100	2.51	1 72	0 80
Metals														
Dissolved Aluminum	96	100	µg/l						50	43	14	SID	SID	SID
Total Aluminum	96	100	µg/l		1000				50	12	76	333 89	SID	1.74

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Table 4-4a. Comparison of 2000-2001 Mass Emissions Results with Standards

Class Constituent	Data Included Since[a]	DL	Units	Guidelines and Standards					Mass Emission					
				Ocean Plan[b]	Basin Plan[b]	AB 411	California Toxics Rule (freshwater)[c]	California Toxics Rule (saltwater)[c]	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Pyrene	99	0 05	µg/l						6	6	0	S I D	S I D	S I D
All other SVOCs	94	0 05-5 0	µg/l						438	438	0	S I D	S I D	S I D
Pesticides														
Organochlorine Pesticides & PCBs	94	0 05-1 0	µg/l	0 000019[e]	0 00007		0 014	0 03	10	10	0	S I D	S I D	S I D
Carbofuran	96	5	µg/l		18				50	50	0	S I D	S I D	S I D
Glyphosate	98	25	µg/l		700				50	50	0	S I D	S I D	S I D
Organo-Phosphate Pesticides														
Diazinon	96	0 01	µg/l						50	50	0	S I D	S I D	S I D
Chlorpyrifos	96	0 05	µg/l						50	50	0	S I D	S I D	S I D
N- and P-Containing Pesticides														
Thiobencarb	96	1	µg/l						50	50	0	S I D	S I D	S I D
All other N- and P- Pesticides	94	1 0-2 0	µg/l						400	400	0	S I D	S I D	S I D
Phenoxyacetic Acid Herbicides														
2,4-D	96	10	µg/l		70				10	10	0	S I D	S I D	S I D
2,4,5-TP	96	1	µg/l		50				10	10	0	S I D	S I D	S I D
Bentazon	96	2	µg/l		18				9	9	0	S I D	S I D	S I D

CV = Coefficient of variation

DL = Detection Limit

S I D = Statistically Invalid Data not enough data above detection limit collected

a) Detection limits have changed throughout the monitoring process Only data matching the current detection limit is displayed in this table The *Data Included Since* field indicates the first year of the storm season with the current detection limit

b) Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation or noncompliance with the plans Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan

c) Criterion represents the highest concentration of pollutant to which aquatic life can be exposed for an extended period time (4 days) without deleterious effects.

d) Criterion based on daily maximum

e) Criterion based on 30-day average

f) Criterion expressed in the total recoverable form.

g) Criterion represents the highest concentration of pollutant to which aquatic life can be exposed for a short period time without deleterious effects.

h) Criterion for the sum of acenaphthylene, anthracene, 1,2-benzanthracene, 3,4-benzofluoranthene, benzo(k)fluoranthene, 1,1,2-benzoperylene, benzo(a)pyrene, chrysene, dibenzo(ah)anthracene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene and pyrene.

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Mass Emission Site 01 Ballona Creek						Mass Emission Site 02 Malibu Creek					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents															
Cyanide	96	0 01	mg/l	8	6	25	0 009	0 005	0 83	8	8	0	SID	SID	SID
TPH	94	1	mg/l	8	8	0	SID	SID	SID	8	8	0	SID	SID	SID
Oil and Grease	94	1	mg/l	8	3	63	3	2	1 03	8	5	38	1 250	0 500	1 16
Total Phenols	94	0 1	mg/l	8	1	88	3	2	0 85	8	7	13	SID	SID	SID
Indicator Bactena															
Total Coliform	94	20	MPN/100ml	8	0	100	3,506,375	500,000	1 68	8	0	100	124,563	15,500	2 52
Fecal Coliform	94	20	MPN/100ml	8	0	100	2,538,375	370,000	2 16	8	0	100	27,743	11,500	1 68
Ratio Fecal Coliform/Total Coliform	94			0	0	SID	SID	SID	SID	4	0	100	68 60%	81 82%	0 62
Fecal Streptococcus	94	20	MPN/100ml	8	0	100	1,000,000	240,000	1 69	8	0	100	119,948	4,550	2 01
Fecal Enterococcus	94	20	MPN/100ml	8	0	100	615,000	205,000	1 62	8	0	100	33,305	3,550	2 28
General Minerals															
Ammonia	94	0 1	mg/l	9	3	67	0 56	0 45	0 88	9	2	78	0 18	0 15	0 71
Calcium	96	1 0	mg/l	10	0	100	27 09	19 02	0 70	10	0	100	107 78	105 45	0 29
Magnesium	96	1 0	mg/l	10	0	100	11 76	9 57	0 73	10	0	100	77 86	61 95	0 62
Potassium	94	1 0	mg/l	10	0	100	3 77	2 71	0 73	10	0	100	5 98	5 64	0 43
Sodium	96	1 0	mg/l	10	0	100	24 47	17 95	0 64	10	0	100	99 12	96 50	0 46
Bicarbonate	94	2 0	mg/l	10	0	100	82 89	56 91	0 69	10	0	100	99 12	96 50	0 46
Carbonate	94	2 0	mg/l	10	10	0	SID	SID	SID	10	9	10	SID	SID	SID
Chlonde	94	2 0	mg/l	10	0	100	25 12	14 00	0 90	10	0	100	104 31	96 90	0 41
Fluonde	94	0 1	mg/l	10	1	90	0 20	0 12	0 80	10	0	100	0 20	0 20	0 14
Nitrate	94	0 1	mg/l	10	0	100	3 04	2 20	0 74	10	0	100	9 23	7 98	0 53
Sulfate	94	0 1	mg/l	10	0	100	41 23	22 05	0 98	10	0	100	449 40	368 50	0 44
Alkalinity	94	4 0	mg/l	10	0	100	68 10	46 65	0 69	10	0	100	188 10	189 40	0 20
Hardness	96	2 0	mg/l	10	0	100	126 07	81 25	0 63	10	0	100	589 30	565 00	0 30
COD	97	5	mg/l	10	0	100	53 10	59 35	0 48	10	0	100	83 10	79 45	0 55
pH	94	0-14		10	0	100	7 25	7 24	0 06	10	0	100	8 10	8 10	0 02
Specific Conductance	94	1 0	umhos/cm	10	0	100	322 01	198 50	0 74	10	0	100	1615 20	1459 50	0 38
Total Dissolved Solids	96	2 0	mg/l	10	0	100	194 52	122 00	0 76	10	0	100	1026 80	967 00	0 31
Turbidity	94	0 1	NTU	10	0	100	47 03	40 00	0 78	10	0	100	171 37	41 00	1 81
Total Suspended Solids	96	2 0	mg/l	10	0	100	164 90	142 50	0 73	10	0	100	353 10	95 50	1 67
Volatile Suspended Solids	94	1 0	mg/l/hr	10	0	100	46 60	35 00	0 63	10	0	100	39 80	23 00	1 54
MBAS	97	0 05	mg/l	10	1	90	0 11	0 09	0 72	10	8	20	0 07	0 05	0 97
Total Organic Carbon	94	1 0	mg/l	10	0	100	9 53	6 92	0 52	10	0	100	6 71	6 35	0 16
BOD	94	2 0	mg/l	10	1	90	9 35	7 75	0 58	10	1	90	5 40	4 90	0 71
Nutrients															
Dissolved Phosphorus	94	0 05	mg/l	10	0	100	0 20	0 17	0 51	10	0	100	0 55	0 56	0 60
Total Phosphorus	94	0 05	mg/l	10	0	100	0 24	0 21	0 41	10	0	100	0 61	0 61	0 55
NH3-N	94	0 1	mg/l	9	0	100	0 47	0 37	0 87	9	4	56	0 14	0 12	0 78
Nitrate-N	96	0 1	mg/l	10	3	70	0 68	0 50	0 75	10	0	100	2 15	2 00	0 50
Nitrite-N	94	0 1	mg/l	10	1	90	0 21	0 11	1 34	10	9	10	SID	SID	SID
TKN	96	0 1	mg/l	9	1	89	2 20	2 30	0 52	10	0	100	2 48	1 27	1 13
Metals															
Dissolved Aluminum	96	100	µg/l	10	8	20	71 20	50 00	0 71	10	10	0	2 50	2 50	0 00
Total Aluminum	96	100	µg/l	10	1	90	400 81	205 50	1.24	10	10	0	2 50	2 50	0 00
Dissolved Antimony	97	5	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Antimony	97	5	µg/l	10	10	0	SID	SID	SID	10	0	100	SID	SID	SID
Dissolved Arsenic	97	5	µg/l	10	10	0	SID	SID	SID	10	0	100	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since*	DL	Units	Mass Emission Site 01 Ballona Creek						Mass Emission Site 02 Malibu Creek					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Total Arsenic	97	5	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Barium	97	10	µg/l	10	0	100	29 47	25 80	0 41	10	10	0	0 50	0 50	0 00
Total Barium	97	10	µg/l	10	0	100	36 80	27 70	0 61	10	4	60	133 10	116 50	0 76
Dissolved Beryllium	97	1	µg/l	10	10	0	SID	SID	SID	10	3	70	SID	SID	SID
Total Beryllium	97	1	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Boron	97	100	µg/l	10	4	60	133 10	116 50	0 76	10	10	0	0 50	0 50	0 00
Total Boron	97	100	µg/l	10	3	70	157 00	137 00	0 69	10	9	10	2 96	2 50	0 49
Dissolved Cadmium	97	1	µg/l	10	10	0	SID	SID	SID	10	9	10	SID	SID	SID
Total Cadmium	97	1	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Chromium	97	5	µg/l	10	9	10	SID	SID	SID	10	10	0	SID	SID	SID
Total Chromium	97	5	µg/l	10	9	10	SID	SID	SID	10	2	80	SID	SID	SID
Dissolved Chromium +6	94	10	µg/l	10	10	0	SID	SID	SID	10	0	100	SID	SID	SID
Total Chromium +6	94	10	µg/l	10	10	0	SID	SID	SID	10	5	50	SID	SID	SID
Dissolved Copper	97	5	µg/l	10	2	80	6 91	6 87	0 44	10	1	90	797 00	330 00	1 50
Total Copper	97	5	µg/l	10	0	100	14 76	10 25	0 87	10	10	0	2 50	2 50	0 00
Dissolved Iron	94	100	µg/l	10	5	50	129 00	75 00	0 96	10	8	20	6 10	2 50	1 65
Total Iron	94	100	µg/l	10	1	90	797 00	330 00	1 50	10	10	0	50 00	50 00	0 00
Dissolved Lead	97	5	µg/l	11	10	9	SID	SID	SID	11	9	18	SID	SID	SID
Total Lead	97	5	µg/l	10	8	20	6 10	2 50	1 65	10	10	0	0 50	0 50	0 00
Dissolved Manganese	98	100	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Manganese	98	100	µg/l	10	9	10	SID	SID	SID	10	7	30	SID	SID	SID
Dissolved Mercury	94	1	µg/l	10	10	0	SID	SID	SID	10	6	40	SID	SID	SID
Total Mercury	94	1	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Nickel	97	5	µg/l	10	7	30	3 63	2 50	0 56	10	10	0	2 50	2 50	0 00
Nickel	97	5	µg/l	10	6	40	4 37	2 50	0 65	10	10	0	0 50	0 50	0 00
Dissolved Selenium	94	5	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Selenium	94	5	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Silver	97	1	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Silver	97	1	µg/l	10	10	0	SID	SID	SID	10	6	40	SID	SID	SID
Dissolved Thallium	97	5	µg/l	10	10	0	SID	SID	SID	10	5	50	SID	SID	SID
Total Thallium	97	5	µg/l	10	10	0	SID	SID	SID	0	0	SID	SID	SID	SID
Dissolved Zinc	94	50	µg/l	10	6	40	56 99	25 00	1 27	0	0	SID	SID	SID	SID
Total Zinc	94	50	µg/l	10	5	50	86 96	39 60	1 31	0	0	SID	SID	SID	SID
SVOCs															
Bis(2-ethylhexyl)phthalate	99	1	µg/l	0	0	SID	SID	SID	SID	6	2	67	4 33	3 63	0 71
PAHs															
Acenaphthene	99	0 05	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Acenaphthylene	99	0 05	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Anthracene	99	0 05	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Benzo(a)anthracene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Benzo(a)pyrene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Benzo(b)fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Benzo(k)fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Chrysene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Dibenz(a,h)anthracene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Fluorene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Indeno (1,2,3-cd)pyrene	99	0 1	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Naphthalene	99	0 05	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Mass Emission Site 01 Ballona Creek						Mass Emission Site 02 Malibu Creek					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Phenanthrene	99	0 05	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
Pyrene	99	0 05	µg/l	0	0	SID	SID	SID	SID	6	6	0	SID	SID	SID
All other SVOCs	94	0 05-5 0	µg/l	0	0	SID	SID	SID	SID	438	438	0	SID	SID	SID
Pesticides															
Organochlorine Pesticides & PCBs	94	0 05-1 0	µg/l	0	0	0	SID	SID	SID	210	210	0	SID	SID	SID
Carbofuran	96	5	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Glyphosate	98	25	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Organo-Phosphate Pesticides															
Diazinon	96	0 01	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
Chlorpyrifos	96	0 05	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
N- and P-Containing Pesticides															
Thiobencarb	96	1	µg/l	10	10	0	SID	SID	SID	10	10	0	SID	SID	SID
All other N- and P- Pesticides	94	1 0-2 0	µg/l	70	70	0	SID	SID	SID	70	70	0	SID	SID	SID
Phenoxyacetic Acid Herbicides															
2,4-D	96	10	µg/l	0	0	0	SID	SID	SID	9	9	0	SID	SID	SID
2,4,5-TP	96	1	µg/l	0	0	0	SID	SID	SID	9	9	0	SID	SID	SID
Bentazon	96	2	µg/l	0	0	0	SID	SID	SID	9	9	0	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Mass Emission Site 10 L.A. River						Mass Emission Site 13 Coyote Creek					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents															
Cyanide	96	0 01	mg/l	7	4	43	0 027	0 005	1 35	0	0	SID	SID	SID	SID
TPH	94	1	mg/l	7	7	0	SID	SID	SID	0	0	SID	SID	SID	SID
Oil and Grease	94	1	mg/l	7	1	86	2 571	2 000	0 84	0	0	SID	SID	SID	SID
Total Phenols	94	0 1	mg/l	7	2	71	2 229	2 400	0 66	0	0	SID	SID	SID	SID
Indicator Bacteria															
Total Coliform	94	20	MPN/100ml	7	0	100	2,057,143	2,200,000	0 80	4	0	100	432,000	400,000	0 85
Fecal Coliform	94	20	MPN/100ml	7	0	100	1,365,714	1,600,000	0 77	4	0	100	157,725	165,000	0 83
Ratio Fecal Coliform/Total Coliform	94			0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Fecal Streptococcus	94	20	MPN/100ml	7	0	100	3,260,286	500,000	1 80	4	0	100	38,950	22,500	1 25
Fecal Enterococcus	94	20	MPN/100ml	7	0	100	558,857	SID	1 00	4	0	100	22,950	20,500	0 92
General Minerals															
Ammonia	94	0 1	mg/l	11	4	64	1 15	0 15	1 78	10	3	70	0 72	0 16	2 17
Calcium	96	1 0	mg/l	11	0	100	27 50	28 00	0 44	10	0	100	30 91	23 07	0 62
Magnesium	96	1 0	mg/l	11	3	73	9 32	6 08	1 18	10	0	100	8 69	5 17	0 92
Potassium	94	1 0	mg/l	11	3	73	9 41	6 08	1 18	10	0	100	4 31	2 71	0 99
Sodium	96	1 0	mg/l	11	0	100	28 16	25 10	0 66	10	0	100	38 10	19 95	1 23
Bicarbonate	94	2 0	mg/l	11	0	100	68 65	51 72	0 58	10	0	100	88 37	52 36	0 74
Carbonate	94	2 0	mg/l	11	3	73	9 24	6 08	1 21	10	10	0	SID	SID	SID
Chloride	94	2 0	mg/l	11	0	100	30 77	19 00	0 93	10	0	100	34 56	21 65	1 00
Fluoride	94	0 1	mg/l	11	0	100	0 21	0 14	0 58	10	0	100	0 20	0 12	0 84
Nitrate	94	0 1	mg/l	11	1	91	3 86	3 23	0 61	10	2	80	3 47	2 85	1 04
Sulfate	94	0 1	mg/l	11	0	100	38 18	26 50	0 76	10	0	100	53 85	26 50	1 19
Alkalinity	94	4 0	mg/l	11	0	100	56 27	42 40	0 58	10	0	100	72 46	42 95	0 74
Hardness	96	2 0	mg/l	11	0	100	97 55	100 00	0 45	10	0	100	112 87	76 25	0 70
COD	97	5	mg/l	11	0	100	69 83	64 10	0 71	10	1	90	80 87	54 95	0 95
pH	94	0-14		11	0	100	6 93	6 92	0 04	10	0	100	7 11	7 09	0 06
Specific Conductance	94	1 0	umhos/cm	11	0	100	330 08	334 00	0 61	10	0	100	387 79	249 50	0 86
Total Dissolved Solids	96	2 0	mg/l	11	0	100	197 64	198 00	0 64	10	0	100	237 70	148 00	0 92
Turbidity	94	0 1	NTU	11	0	100	97 49	59 50	0 93	10	0	100	87 33	60 25	1 04
Total Suspended Solids	96	2 0	mg/l	11	0	100	244 09	161 00	0 90	10	0	100	306 70	187 00	1 34
Volatile Suspended Solids	94	1 0	mg/l/hr	11	0	100	53 82	41 00	0 65	10	0	100	61 30	50 50	0 83
MBAS	97	0 05	mg/l	11	1	91	0 11	0 09	0 52	10	0	100	0 10	0 09	0 31
Total Organic Carbon	94	1 0	mg/l	11	0	100	16 02	10 20	0 95	10	0	100	15 58	9 46	1 19
BOD	94	2 0	mg/l	11	3	73	7 12	5 50	1 15	10	1	90	9 49	7 30	0 83
Nutrients															
Dissolved Phosphorus	94	0 05	mg/l	11	0	100	0 43	0 36	0 60	10	0	100	0 24	0 19	0 71
Total Phosphorus	94	0 05	mg/l	11	0	100	0 49	0 42	0 55	10	0	100	0 31	0 22	0 67
NH3-N	94	0 1	mg/l	11	5	55	0 95	0 12	1 78	10	5	50	0 59	0 11	2 20
Nitrate-N	96	0 1	mg/l	11	1	91	0 88	0 73	0 60	10	2	80	0 79	0 64	1 01
Nitrite-N	94	0 1	mg/l	11	2	82	0 29	0 19	1 00	10	2	80	0 13	0 09	0 83
TKN	96	0 1	mg/l	11	0	100	3 02	2 08	0 70	10	0	100	2 45	2 04	0 71
Metals															
Dissolved Aluminum	96	100	µg/l	11	9	18	SID	SID	SID	10	9	10	SID	SID	SID
Total Aluminum	96	100	µg/l	11	2	82	575 08	278 00	1 72	10	2	80	174 46	157 50	0 60
Dissolved Antimony	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Antimony	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Arsenic	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Mass Emission Site 10 L.A. River						Mass Emission Site 13 Coyote Creek					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Total Arsenic	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Barium	97	10	µg/l	11	0	100	30 13	26 60	0 42	10	0	100	28 21	23 45	0 54
Total Barium	97	10	µg/l	11	0	100	40 08	31 40	0 60	10	0	100	32 45	26 70	0 52
Dissolved Beryllium	97	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Beryllium	97	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Boron	97	100	µg/l	11	1	91	154 36	172 00	0 38	10	5	50	114 10	81 00	0 78
Total Boron	97	100	µg/l	11	0	100	181 00	174 00	0 38	10	2	80	160 00	125 50	0 63
Dissolved Cadmium	97	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Cadmium	97	1	µg/l	11	10	9	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Chromium	97	5	µg/l	11	9	18	SID	SID	SID	10	10	0	SID	SID	SID
Total Chromium	97	5	µg/l	11	9	18	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Chromium +6	94	10	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Chromium +6	94	10	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Copper	97	5	µg/l	11	1	91	8 24	7 57	0 41	10	5	50	4 52	3 79	0 50
Total Copper	97	5	µg/l	11	0	100	16 36	11 50	0 73	10	0	100	9 15	8 69	0 25
Dissolved Iron	94	100	µg/l	11	3	73	235 45	200 00	0 71	10	0	100	95 00	50 00	0 81
Total Iron	94	100	µg/l	11	0	100	1038 55	420 00	1 87	10	1	90	306 00	285 00	0 57
Dissolved Lead	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Lead	97	5	µg/l	11	5	55	10 20	5 10	1 58	10	10	0	SID	SID	SID
Dissolved Manganese	98	100	µg/l	11	11	0	SID	SID	SID	10	9	10	SID	SID	SID
Total Manganese	98	100	µg/l	11	8	27	79 36	50 00	0 70	10	8	20	82 60	50 00	0 98
Dissolved Mercury	94	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Mercury	94	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Nickel	97	5	µg/l	11	5	55	6 30	5 82	0 80	10	8	20	3 92	2 50	0 90
Nickel	97	5	µg/l	11	2	82	8 13	6 75	0 68	10	7	30	4 30	2 50	0 83
Dissolved Selenium	94	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Selenium	94	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Silver	97	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Silver	97	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Thallium	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Total Thallium	97	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Dissolved Zinc	94	50	µg/l	11	6	45	46 55	25 00	0 61	10	9	10	SID	SID	SID
Total Zinc	94	50	µg/l	11	0	100	65 54	54 90	0 87	10	7	30	35.90	25 00	0 54
SVOCs															
Bis(2-ethylhexyl)phthalate	99	1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
PAHs															
Acenaphthene	99	0 05	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Acenaphthylene	99	0 05	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Anthracene	99	0 05	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Benzo(a)anthracene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Benzo(a)pyrene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Benzo(b)fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Benzo(k)fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Chrysene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Dibenz(a,h)anthracene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Fluorene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Indeno (1,2,3-cd)pyrene	99	0 1	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Naphthalene	99	0 05	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Mass Emission Site 10 L.A. River						Mass Emission Site 13 Coyote Creek					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV	No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Phenanthrene	99	0 05	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Pyrene	99	0 05	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
All other SVOCs	94	0 05-5 0	µg/l	0	0	SID	SID	SID	SID	0	0	SID	SID	SID	SID
Pesticides															
Organochlorine Pesticides & PCBs	94	0 05-1 0	µg/l	0	0	0	SID	SID	SID	0	0	0	SID	SID	SID
Carbofuran	96	5	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Glyphosate	98	25	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Organo-Phosphate Pesticides															
Diazinon	96	0 01	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
Chlorpyrifos	96	0 05	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
N- and P-Containing Pesticides															
Thiobencarb	96	1	µg/l	11	11	0	SID	SID	SID	10	10	0	SID	SID	SID
All other N- and P- Pesticides	94	1 0-2 0	µg/l	77	77	0	SID	SID	SID	70	70	0	SID	SID	SID
Phenoxyacetic Acid Herbicides															
2,4-D	96	10	µg/l	0	0	0	SID	SID	SID	1	1	0	SID	SID	SID
2,4,5-TP	96	1	µg/l	0	0	0	SID	SID	SID	1	1	0	SID	SID	SID
Bentazon	96	2	µg/l	0	0	0	SID	SID	SID	0	0	0	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since*	DL	Units	Mass Emission Site 14 San Gabriel River					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents									
Cyanide	96	0 01	mg/l	7	4	43	0 014	0 005	1 00
TPH	94	1	mg/l	7	7	0	S I D	S I D	S I D
Oil and Grease	94	1	mg/l	7	4	43	1 271	0 500	0 99
Total Phenols	94	0 1	mg/l	7	7	0	S I D	S I D	S I D
Indicator Bactena									
Total Coliform	94	20	MPN/100ml	7	0	100	1,679,286	500,000	1 94
Fecal Coliform	94	20	MPN/100ml	7	0	100	169,300	30,000	1 53
Ratio Fecal Coliform/Total Coliform	94			1	0	100	S I D	S I D	S I D
Fecal Streptococcus	94	20	MPN/100ml	7	0	100	140,771	50,000	1 30
Fecal Enterococcus	94	20	MPN/100ml	7	0	100	100,643	14,000	1 81
General Minerals									
Ammonia	94	0 1	mg/l	8	0	100	0 47	0 05	1 83
Calcium	96	1 0	mg/l	9	0	100	59 63	56 10	0 32
Magnesium	96	1 0	mg/l	9	0	100	20 15	17 01	0 40
Potassium	94	1 0	mg/l	8	0	100	19 44	17 01	0 42
Sodium	96	1 0	mg/l	9	0	100	65 03	60 00	0 43
Bicarbonate	94	2 0	mg/l	9	0	100	126 90	128 00	0 31
Carbonate	94	2 0	mg/l	8	1	88	25 90	17 01	1 21
Chlonde	94	2 0	mg/l	9	0	100	83 74	67 10	0 46
Fluonde	94	0 1	mg/l	9	0	100	0 23	0 21	0 26
Nitrate	94	0 1	mg/l	9	0	100	20 89	15 90	0 50
Sulfate	94	0 1	mg/l	9	0	100	115 29	104 00	0 36
Alkalinity	94	4 0	mg/l	9	0	100	104 08	105 00	0 31
Hardness	96	2.0	mg/l	9	0	100	231 78	220 00	0 30
COD	97	5	mg/l	9	0	100	84 71	74 50	0 57
pH	94	0-14		9	0	100	7 54	7 62	0 03
Specific Conductance	94	1 0	umhos/cm	9	0	100	766 56	671 00	0 32
Total Dissolved Solids	96	2 0	mg/l	9	0	100	467 56	412 00	0 31
Turbidity	94	0 1	NTU	9	0	100	43 71	19 90	1 72
Total Suspended Solids	96	2 0	mg/l	9	0	100	105 67	39 00	1 82
Volatile Suspended Solids	94	1 0	mg/l/hr	9	0	100	24 56	12 00	1 64
MBAS	97	0 05	mg/l	9	0	100	0 08	0 06	0 41
Total Organic Carbon	94	1 0	mg/l	9	0	100	7 48	7 50	0 26
BOD	94	2 0	mg/l	9	0	100	7 68	0 05	2 08
Nutrients									
Dissolved Phosphorus	94	0 05	mg/l	9	0	100	12 24	0 25	2 94
Total Phosphorus	94	0 05	mg/l	9	0	100	18 81	0 29	2 95
NH3-N	94	0 1	mg/l	9	0	100	0 36	0 05	1 89
Nitrate-N	96	0 1	mg/l	9	0	100	4 72	3 59	0 50
Nitnte-N	94	0 1	mg/l	9	0	100	0 40	0 05	1 35
TKN	96	0 1	mg/l	9	0	100	2 27	1 00	0 90
Metals									
Dissolved Aluminum	96	100	µg/l	9	8	11	S I D	S I D	S I D
Total Aluminum	96	100	µg/l	9	4	56	316 56	123 00	1 67
Dissolved Antimony	97	5	µg/l	9	9	0	S I D	S I D	S I D
Total Antimony	97	5	µg/l	9	9	0	S I D	S I D	S I D
Dissolved Arsenic	97	5	µg/l	9	9	0	S I D	S I D	S I D

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since*	DL	Units	Mass Emission Site 14 San Gabriel River					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Total Arsenic	97	5	µg/l	9	9	0	SID	SID	SID
Dissolved Barium	97	10	µg/l	9	0	100	40 42	2 50	0 19
Total Barium	97	10	µg/l	9	0	100	43 12	41 70	0 18
Dissolved Beryllium	97	1	µg/l	9	9	0	SID	SID	SID
Total Beryllium	97	1	µg/l	9	9	0	SID	SID	SID
Dissolved Boron	97	100	µg/l	9	1	89	202 44	205 00	0 52
Total Boron	97	100	µg/l	9	0	100	235 22	205 00	0 40
Dissolved Cadmium	97	1	µg/l	9	9	0	SID	SID	SID
Total Cadmium	97	1	µg/l	9	9	0	SID	SID	SID
Dissolved Chromium	97	5	µg/l	9	9	0	SID	SID	SID
Total Chromium	97	5	µg/l	9	9	0	SID	SID	SID
Dissolved Chromium +6	94	10	µg/l	9	9	0	SID	SID	SID
Total Chromium +6	94	10	µg/l	9	9	0	SID	SID	SID
Dissolved Copper	97	5	µg/l	9	8	11	SID	SID	SID
Total Copper	97	5	µg/l	9	0	100	8 56	7 69	0 28
Dissolved Iron	94	100	µg/l	9	4	56	133 33	110 00	0 76
Total Iron	94	100	µg/l	9	2	78	365 56	260 00	0 95
Dissolved Lead	97	5	µg/l	9	9	0	SID	SID	SID
Total Lead	97	5	µg/l	9	8	11	SID	SID	SID
Dissolved Manganese	98	100	µg/l	9	9	0	SID	SID	SID
Total Manganese	98	100	µg/l	9	9	0	SID	SID	SID
Dissolved Mercury	94	1	µg/l	9	9	0	SID	SID	SID
Total Mercury	94	1	µg/l	9	9	0	SID	SID	SID
Dissolved Nickel	97	5	µg/l	9	3	67	5 02	5 49	0 44
Nickel	97	5	µg/l	9	1	89	6 26	6 06	0 37
Dissolved Selenium	94	5	µg/l	9	9	0	SID	SID	SID
Total Selenium	94	5	µg/l	9	9	0	SID	SID	SID
Dissolved Silver	97	1	µg/l	9	9	0	SID	SID	SID
Total Silver	97	1	µg/l	9	9	0	SID	SID	SID
Dissolved Thallium	97	5	µg/l	9	9	0	SID	SID	SID
Total Thallium	97	5	µg/l	9	9	0	SID	SID	SID
Dissolved Zinc	94	50	µg/l	9	8	11	SID	SID	SID
Total Zinc	94	50	µg/l	9	5	44	39 17	25 00	0 44
SVOCs									
Bis(2-ethylhexyl)phthalate	99	1	µg/l	0	0	SID	SID	SID	SID
PAHs									
Acenaphthene	99	0 05	µg/l	0	0	SID	SID	SID	SID
Acenaphthylene	99	0 05	µg/l	0	0	SID	SID	SID	SID
Anthracene	99	0 05	µg/l	0	0	SID	SID	SID	SID
Benzo(a)anthracene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Benzo(a)pyrene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Benzo(b)fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Benzo(k)fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Chrysene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Dibenz(a,h)anthracene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Fluoranthene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Fluorene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Indeno (1,2,3-cd)pyrene	99	0 1	µg/l	0	0	SID	SID	SID	SID
Naphthalene	99	0 05	µg/l	0	0	SID	SID	SID	SID

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Table 4-4b. Summary of 2000-2001 Mass Emissions Results by Site

Class Constituent	Data Included Since[a]	DL	Units	Mass Emission Site 14 San Gabriel River					
				No of Samples	No of Non-detects	Percent Detects	Mean	Median	CV
Phenanthrene	99	0 05	µg/l	0	0	S I D	S I D	S I D	S I D
Pyrene	99	0 05	µg/l	0	0	S I D	S I D	S I D	S I D
All other SVOCs	94	0 05-5 0	µg/l	0	0	S I D	S I D	S I D	S I D
Pesticides									
Organochlorine Pesticides & PCBs	94	0 05-1 0	µg/l	0	0	0	S I D	S I D	S I D
Carbofuran	96	5	µg/l	9	9	0	S I D	S I D	S I D
Glyphosate	98	25	µg/l	9	9	0	S I D	S I D	S I D
Organo-Phosphate Pesticides									
Diazinon	96	0 01	µg/l	9	9	0	S I D	S I D	S I D
Chlorpyrifos	96	0 05	µg/l	9	9	0	S I D	S I D	S I D
N- and P-Containing Pesticides									
Thiobencarb	96	1	µg/l	9	9	0	S I D	S I D	S I D
All other N- and P Pesticides	94	1 0-2 0	µg/l	63	63	0	S I D	S I D	S I D
Phenoxyacetic Acid Herbicides									
2,4-D	96	10	µg/l	0	0	0	S I D	S I D	S I D
2,4,5-TP	96	1	µg/l	0	0	0	S I D	S I D	S I D
Bentazon	96	2	µg/l	0	0	0	S I D	S I D	S I D

CV = Coeffecient of variation

DL = Detection Limit

S I D = Statistically Invalid Data, not enough data above detection limit collected

a) Detection limits have changed throughout the monitoring process Only data matching the current detection limit is displayed in this table
The *Data Included Since* field indicates the first year of the storm season with the current detection limit

TW P:\EPPUB\WATER\MONITOR\REPORTS\MONITORING REPORTS\1999-00\WQ DATA\9400 ME\SEASON_9400_ME XLS

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Table 4-4c. 1994-2001 Comparison of Mass Emissions Annual Mean Concentrations to Objectives by Site

Class Constituent	Ballona Creek *								Malibu Creek *								Los Angeles River *						
	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Total	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Total	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Total
Total Rainfall (in.)	14.76	^	11.18	28.28	9.48	10.59			35.41	17.9	9.22	37.51	8.48	17.24			10.5	6.17	17.8	6.34	7.98		
Cyanide	-	-	-	-	-	-	X	1	-	-	-	X	-	-	X	2	-	-	-	X	-	X	2
Total Coliform	X	X	X	X	X	X	X	7	X	X	X	X	X	X	X	7	X	X	X	X	X	X	6
Fecal Coliform	X	X	X	X	X	X	X	7	X	X	X	X	X	X		6	X	X	X	X	X		5
**Fecal Streptococcus																							
Fecal Enterococcus	X	X	-	-	X	X	X	5	X	X	-	-	X	X	X	5	X	-	-	X	X	X	4
Total Dissolved Solids	-	-							-	-	-	X	X	X	X	4				X			1
Turbidity	-	-		X	X			2	-	-	-	X	X	X	X	4	X		X	X	X	X	5
**Total Suspended Solids	-	-							-	-	-												
**Dissolved Phosphorus	-	-							-	-	-												
**Total Phosphorus	-	-							-	-	-												
NH3-N	-	-							-	-	-												
Nitrate-N	-	-							-	-	-												
Nitrite-N	-	-							-	-	-	-	-	-	-								
**TKN	-	-							-	-	-												
Total Ammonia				X				1	-	-	-	X				1	-	X	X	X			3
Dissolved Cadmium				-	-	-	-		-	-	-		-	-	-		-	-	X	-	-	-	1
Dissolved Copper				X	X	X	X	4	-	-	-	X	-	X	-	2	X	X	X	X	X	X	6
Total Copper	-	-		X	X	X	X	4	-	-	-	X				1	X	X	X	X	X	X	6
Dissolved Lead	-	-	-	X	-	-	-	1	-	-	-	-	-	-	-		X	X	X	-	X	-	4
Total Lead	-	-	X	X			-	2	-	-	-	X	-	-	-	1	X	X	X	X	X	X	6
Total Mercury	-	-	X	-	-	-	-	1	-	-	-	-	-	-	-		-	-	-	-	-	-	
Dissolved Nickel	-	-		X	-	-		1	-	-	-	X				1			X				1
Nickel	-	-							-	-	-	X			-	1	X		X				2
Dissolved Zinc	-	-		X		-		1	-	-	-		-	-					X		-		1
Total Zinc	-	-	X	X	X			3	-	-	-	X	-	-	-	1	X	X	X	X			4
Bis(2-ethylhexyl)phthalate	-	-	X	X	X	-	NS	3	-	-	-	X	X	X	X	4	X	X	X	-	-	NS	3
Phenanthrene	-	-	-	-	-	-	NS		-	-	-	-	-	X	-	1	-	-	-	-	-	NS	
Pyrene	-	-	-	-	-	-	NS		-	-	-	-	-	X	-	1	-	-	-	-	-	NS	
**Diazinon	-	-					-		-	-	-				-		-	-	-		-	-	
**Chlorpyrifos	-	-					-		-	-	-				-		-	-	-	-	-	-	
Total	3	3	6	12	8	5	6		3	3	2	13	6	9	6		11	9	14	11	8	7	

X = Greater than objective Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean, and other waterbodies Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan

^ Rain gage not active

* Required by Permit

** Constituents have no objectives, but they are included due to their exceedence of AB411, or were identified as causing stormwater toxicity in independent studies, or were identified in the 303(d) list

- Statistically invalid data, not enough samples or data above detection limit collected

NS = Not Sampled

Blank = No Exceedence

R0012399

Table 4-4c. 1994-2001 Comparison of Mass Emissions Annual Mean Concentrations to Objectives by Site

Class Constituent	Coyote Creek							San Gabriel River *							Grand Total
	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Total	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	Total	
Total Rainfall (in.)	^	6.06	23.03	6.64	5.29			13.11	8	28.8	6.2	12.41			
Cyanide	-	-	-	-	-	NS		X	X	X	X	-	X	5	10
Total Coliform	X	NS	NS	NS	NS	X	2	X	X	X	X	X	X	6	28
Fecal Coliform	X	NS	NS	NS	NS		1	X	X	X	X	X		5	24
**Fecal Streptococcus		NS	NS	NS	NS										
Fecal Enterococcus	X	-	-	-	-	X	2	X	-	-	X	X	X	4	20
Total Dissolved Solids	X			X	X		3	X	X		X	X	X	5	13
Turbidity	X		X	X		X	4			X		X		2	17
**Total Suspended Solids															
**Dissolved Phosphorus															
**Total Phosphorus															
NH3-N												-			
Nitrate-N															
Nitrite-N															
**TKN															
Total Aluminum	-	X	X				2	-		X				1	8
Dissolved Cadmium	-	-		-	-	-		-	-	-	-				1
Dissolved Copper	X		X	X	X	X	5	-		X	-	-	-	1	18
Total Copper	X	X	X	X			4	X	X	X				3	18
Dissolved Lead	-		X	-	-	-	1	-	-	X	-	-	-	1	7
Total Lead	X	X	X	-	-	-	3	-	X	X	-	-	-	2	14
Total Mercury	-	-	-	-	-	-		-	-	-	-	-	-		1
Dissolved Nickel	-	-		-	-	-		-			-	-			3
Nickel						-					-		-		3
Dissolved Zinc		-	X		-		1	-	-	X		-		1	4
Total Zinc	X	X	X				3		X	X		-		2	13
Bis(2-ethylhexyl)phthalate	X	X	X	X	-	NS	4	X	X	X	-	-	NS	3	17
Phenanthrene	-	-	-	-	-	NS		-	-	-	-	-	NS		1
Pyrene	-	-	-	-	-	NS		-	-	-	-	-	NS		1
**Diazinon	-	-	-	-		-		-	-	-	-		-		
**Chlorpyrifos	-	-	-	-	-	-		-	-	-	-	-	-		
Total	10	5	9	5	2	4		7	8	12	5	5	4		221

X = Greater than objective. Except for indicator bacteria, there are no numerical water quality standards that apply to stormwater or "non-point source" pollution. Current federal and state numerical standards apply only to "point source pollution," such as sanitary sewage, industrial and commercial discharges to the ocean and other waterbodies. Water quality standards described in the 1995 Los Angeles Region Basin Plan or the 1997 California Ocean Plan do not apply to stormwater runoff, and any exceedance of values should not indicate violation nor noncompliance with the plans. Furthermore, a direct comparison of the sampling results with the Ocean Plan standards cannot be made since the results presented in the table are detected values before dilution, a factor allowed by the Ocean Plan.

^ Rain gage not active

* Required by Permit

** Constituents have no objectives, but they are included due to their exceedence of AB411, or were identified as causing stormwater toxicity in independent studies, or were identified in the 303(d) list

- Statistically invalid data, not enough samples or data above detection limit collected

NS = Not Sampled

Blank = No Exceedence

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Table 4-5. Stormwater Bacteria Counts

Parameters	Site Name	94-95 Log Mean (MPN/100ml)	95-96 Log Mean (MPN/100ml)	96-97 Log Mean (MPN/100ml)	97-98 Log Mean (MPN/100ml)	98-99 Log Mean (MPN/100ml)	99-00 Log Mean (MPN/100ml)	00-01 Log Mean (MPN/100ml)
Total Coliform	Ballona Ck (S01)	518,004	2,623,967	667,467	1,120,085	326,580	280,332	638.89
	Malibu Ck (S02)	160,000	120,240	58,285	239,022	35,502	34,594	12,211
	L.A. River (S10)		826,002	724,824	988,604	68,786	486,365	1,494,241
	S.G. River (S14)		2,774,828	131,521	1,050,695	84,375	207,753	323,221
Fecal Coliform	Ballona Ck (S01)	198,738	684,899	67,466	522,415	30,930	87,737	353,69
	Malibu Ck (S02)	22,000	13,221	8,794	53,312	3,866	10,792	6,409
	L.A. River (S10)		876,085	66,884	359,825	20,677	128,606	950,348
	S.G. River (S14)		900,265	11,817	168,789	2,350	22,780	31,679
Fecal Streptococcus	Ballona Ck (S01)	203,885	1,288,572	228,438	253,300	142,141	228,154	392,56
	Malibu Ck (S02)	3,000	15,745	80,332	189,244	6,243	26,247	5,108
	L.A. River (S10)		626,164	195,743	310,288	23,163	110,557	607,147
	S.G. River (S14)		503,179	68,399	217,081	4,900	47,068	43,053
Fecal Enterococcus	Ballona Ck (S01)	151,008	1,001,181	90,000		137,594	43,877	276,173
	Malibu Ck (S02)	2,400	6,996	30,000		4,538	5,386	2,293
	L.A. River (S10)		379,895	170,000		49,137	13,272	270,286
	S.G. River (S14)		185,922	2,200		8,846	9,912	18,835

R0012401

Table 4-6. Mass Emission Constituents Detected Less Than 25% of the Time

Analyte	Station				
	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Conventionals					
Cyanide	X	X	-	-	X
TPH	-	X	-	-	X
Total Phenols	X	X	X	X	X
MBAS	-	X	-	-	-
Metals					
Aluminum	d	d	d	d	d
Antimony	d and t	d and t	d and t	d and t	d and t
Arsenic	d and t	d and t	d and t	d and t	d and t
Beryllium	d and t	d and t	d and t	d and t	d and t
Cadmium	d and t	d and t	d and t	d and t	d and t
Chromium	d and t	d and t	d and t	d and t	d and t
Chromium 6+	d and t	d and t	d and t	d and t	d and t
Copper	-	d	-	-	d
Lead	d and t	d and t	d	d and t	d and t
Manganese	d and t	d and t	d	d and t	d and t
Mercury	d and t	d and t	d and t	d and t	d and t
Nickel	-	-	-	d	-
Selenium	d and t	d and t	d and t	d and t	d and t
Silver	d and t	d and t	d and t	d and t	d and t
Thallium	d and t	d and t	d and t	d and t	d and t
Pesticides					
All Pesticides					
Diazinon	X	X	X	X	X

Notes:

x = constituent which meets the criterion of less than 25% detection in ten consecutive samples

d and t = dissolved and total

d only = dissolved only

- = fails test

blank cell = not enough data to analyze

Table 4-7. Seasonal EMCs
2000-2001 Storm Season

GROUP	Constituent	Unit	High Density Residential	Light Industrial	Vacant	Retail/ Commercial	Multi-family Residential	Transportation	Education	Mixed Residential
GENERAL MINERALS	Dissolved Phosphorus	mg/l	0.45	0.24	0.05		0.37	4.81	0.24	0.33
	Kjeldahl-N	mg/l	4.14	2.49	1.04		1.60	2.21	2.13	3.32
	NH3-N	mg/l	0.69	0.60	n/m		0.70	0.67	0.45	0.79
	Nitrate-N	mg/l	0.36	0.74	1.11		1.69	0.80	0.73	0.54
	Nitrite-N	mg/l	0.11	0.14	n/m		0.25	0.12	0.18	0.21
	Suspended Solids	mg/l	194.92	213.53	135.91		28.71	93.97	92.80	105.30
	Total Phosphorus	mg/l	0.49	0.33	0.06		0.42	5.59	0.28	0.37
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	µg/l	n/m	n/m	n/m		n/m	0 88	0.71	n/m
	Dissolved Chromium +6	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Dissolved Copper	µg/l	11.18	8.92	n/m		8.87	42.00	10.66	11.27
	Dissolved Lead	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Dissolved Mercury	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Dissolved Nickel	µg/l	n/m	5.92	n/m		n/m	7.53	n/m	4.00
	Dissolved Selenium	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Dissolved Silver	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Dissolved Zinc	µg/l	n/m	406.82	n/m		76.73	359.76	94.85	166.20
HEAVY METALS (TOTAL)	Total Cadmium	µg/l	n/m	n/m	n/m		n/m	1.25	0.72	n/m
	Total Chromium +6	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Total Copper	µg/l	18.04	17.52	4.58		12.34	58.52	15.77	18.62
	Total Lead	µg/l	n/m	7.49	n/m		n/m	5.55	n/m	n/m
	Total Mercury	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Total Nickel	µg/l	n/m	7.75	n/m		5.10	9.61	n/m	4.28
	Total Selenium	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Total Silver	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Total Zinc	µg/l	n/m	447.47	n/m		92.23	391.04	106.15	179.82
MISCELLANEOUS	Cyanide	mg/l			n/m					
	Oil and Grease	mg/l			n/m					
	Total Petroleum Hydrocarbons	mg/l			n/m					
	Total Phenols	mg/l			n/m					

Notes:
n/m : Not meaningful, not enough data above detection limit
Blank cells: No data available

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Table 4-7. Seasonal EMCs
2000-2001 Storm Season (cont'd)

GROUP	Constituent	Unit	High Density Residential	Light Industrial	Vacant	Retail/ Commercial	Multi-family Residential	Transportation	Education	Mixed Residential
BACTERIA	Fecal Coliform	MPN/100m/	5,285,725	91,042	4,789		126,075	12,504	121,336	3,498,296
	Fecal Enterococcus	MPN/100m/	239,755	1,243,215	79,070		124,477	18,177	13,718	115,221
	Fecal Streptococcus	MPN/100m/	348,392	853,028	52,274		206,373	141,802	26,401	114.549
	Total Coliform	MPN/100m/	3,257,841	83,009	47,238		318,923	40,520	244,827	610,239
PESTICIDES	Chlordane	µg/l	n/m		n/m		n/m			n/m
	Chlorpyrifos	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Diazinon	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	Malathion	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
	p,p' DDT	µg/l	n/m		n/m		n/m			n/m
	PCB-1016	µg/l	n/m		n/m		n/m			n/m
	PCB-1221	µg/l	n/m		n/m		n/m			n/m
	PCB-1232	µg/l	n/m		n/m		n/m			n/m
	PCB-1242	µg/l	n/m		n/m		n/m			n/m
	PCB-1248	µg/l	n/m		n/m		n/m			n/m
	PCB-1254	µg/l	n/m		n/m		n/m			n/m
	PCB-1260	µg/l	n/m		n/m		n/m			n/m
	Simazine	µg/l	n/m	n/m	n/m		n/m	n/m	n/m	n/m
SEMIVOLATILES	Acenaphthene	µg/l	n/m		n/m		n/m			n/m
	Acenaphthylene	µg/l	n/m		n/m		n/m			n/m
	Anthracene	µg/l	n/m		n/m		n/m			n/m
	Benzo(a)anthracene	µg/l	n/m		n/m		n/m			n/m
	Benzo(a)pyrene	µg/l	n/m		n/m		n/m			n/m
	Benzo(b)fluoranthene	µg/l	n/m		n/m		n/m			n/m
	Benzo(k)fluoranthene	µg/l	n/m		n/m		n/m			n/m
	Chrysene	µg/l	n/m		n/m		n/m			n/m
	Dibenz(a,h)anthrecene	µg/l	n/m		n/m		n/m			n/m
	Fluoranthene	µg/l	n/m		n/m		n/m			n/m
	Fluorene	µg/l	n/m		n/m		n/m			n/m
	Indeno (1,2,3-cd) pyrene	µg/l	n/m		n/m		n/m			n/m
	Naphthalene	µg/l	n/m		n/m		n/m			n/m
	Phenanthrene	µg/l	n/m		n/m		n/m			n/m
	Pyrene	µg/l	n/m		n/m		n/m			n/m

Notes:
n/m : Not meaningful, not enough data above detection limit
Blank cells: No data available

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Table 4-8a. ESTIMATED MASS POLLUTANT LOADING
BALLONA CREEK
MONITORED WATERSHED

LANDUSE
HDSFR..... 40.0%
Light Ind..... 3.5%
Vacant..... 11.1%
Retail/Comm..... 9.9%
Multi-Fam.Res.... 12.3%
Transportation.... 1.5%
Education..... 2.7%
Mixed Residential. 6.7%
All Other..... 12.3%

Total Area: 88.8 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.)						
		1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01
GENERAL	Suspended Solids	n/a	n/a	6,550,000	13,200,000	5,840,000	9,290,000	10,637,906
MINERALS	Total Dissolved Solids	n/m	n/a	4,200,000	11,030,000	6,340,000	11,300,000	12,548,729
HEAVY	Dissolved Cadmium	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
METALS	Dissolved Copper	n/a	n/a	136	1,510	271	483	445,966
	Dissolved Lead	n/a	n/a	n/m	967	n/m	n/m	S.I.D
	Dissolved Nickel	n/m	n/a	174	562	n/m	n/m	234,305
	Dissolved Zinc	n/a	n/a	n/m	7,710	1,460	n/m	3,676,496
	Nickel	n/m	n/a	241	343	198	310	281,850
	Total Aluminum	n/m	n/a	n/m	115,000	13,000	18,600	25,856,756
	Total Copper	n/a	n/a	724	1,960	533	878	952,315
	Total Lead	n/a	n/a	528	1,750	189	269	393,648
	Total Mercury	n/a	n/a	n/m	25	n/m	n/m	S.I.D
	Total Zinc	n/a	n/a	4,840	19,000	2,790	3,990	5,609,899
PAHs	Phenanthrene	n/a	n/a	6,550,000	13,200,000	5,840,000	n/m	S.I.D
	Pyrene	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	136	1,510	271	14,700	12,922
	Total Phosphorus	n/a	n/a	n/m	967	n/m	19,500	15,573
	NH3-N	n/a	n/a	n/m	7,710	1,460	28,400	30,141
	Nitrate-N	n/a	n/a	724	1,960	533	70,000	44,055
	Nitrite-N	n/a	n/a	528	1,750	189	7,700	13,251
	TKN	n/a	n/a	n/m	25	n/m	154,000	142,140
PESTICIDES	Chlorpyrifos	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
	Diazinon	n/a	n/a	n/m	n/m	3	n/m	S.I.D
MISCELLANEOUS	Cyanide	n/m	n/a	n/m	n/m	n/m	n/m	574
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	460	774	679	n/m	S.I.D

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

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Table 4-8b. ESTIMATED MASS POLLUTANT LOADING
MALIBU CREEK
MONITORED WATERSHED

LANDUSE
HDSFR..... 5.7%
Light Ind..... 0.3%
Vacant..... 79.3%
Retail/Comm..... 0.5%
Multi-Fam.Res.... 1.3%
Transportation... 0.5%
Education..... 0.5%
Mixed Residential 0%
All Other..... 11.9%

Total Area: 105 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.)						
		1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01
GENERAL MINERALS	Suspended Solids	n/a	n/a	n/a	88,400,000	122,000	2,840,000	10,819,187
	Total Dissolved Solids	n/m	n/a	n/a	124	n/m	n/m	31,461,742
HEAVY METALS	Dissolved Cadmium	n/m	n/a	n/a	124	n/m	n/m	S.I.D
	Dissolved Copper	n/m	n/a	n/a	984	n/m	39.8608832	24,420,538
	Dissolved Lead	n/m	n/a	n/a	n/m	n/m	n/m	S.I.D
	Dissolved Nickel	n/m	n/a	n/a	1,190	3.82	38.72	S.I.D
	Dissolved Zinc	n/m	n/a	n/a	5,190	n/m	n/m	S.I.D
	Nickel	n/m	n/a	n/a	3,520	6.12	104.66	S.I.D
	Total Aluminum	n/m	n/a	n/a	948,000	332	1,930	S.I.D
	Total Copper	n/m	n/a	n/a	3950	9.59	82.60060796	S.I.D
	Total Lead	n/m	n/a	n/a	2550	n/m	n/m	S.I.D
	Total Mercury	n/m	n/a	n/a	n/m	n/m	n/m	S.I.D
	Total Zinc	n/m	n/a	n/a	12,300	n/m	n/m	S.I.D
PAHs	Phenanthrene	n/m	n/a	n/a	n/m	n/m	0	S.I.D
	Pyrene	n/m	n/a	n/a	n/m	n/m	2	S.I.D
NUTRIENTS	Dissolved Phosphorus	n/m	n/a	n/a	61,400	512	5,850	16,884
	Total Phosphorus	n/m	n/a	n/a	76,400	543	6,750	18,791
	NH3-N	n/m	n/a	n/a	26,200	165	927	4,365
	Nitrate-N	n/m	n/a	n/a	207,000	3,750	38,100	65,896
	Nitrite-N	n/m	n/a	n/a	n/m	n/m	n/m	S.I.D
	TKN	n/m	n/a	n/a	259,000	2,300	15,600	75,924
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
	Diazinon	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
MISCELLANEOUS	Cyanide	n/m	n/a	n/a	n/m	n/m	n/m	S.I.D
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	2,340	32.7	56.2	132,776

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

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Table 4-8c. ESTIMATED MASS POLLUTANT LOADING
LOS ANGELES RIVER
MONITORED WATERSHED

LANDUSE
HDSFR..... 28.8%
Light Ind..... 5.1%
Vacant..... 40.4%
Retail/Comm..... 3.6%
Multi-Fam.Res.... 3.5%
Transportation..... 2.4%
Education..... 1.9%
Mixed Residential. 1.8%
All Other..... 12.5%

Total Area: 825 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.)						
		1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01
GENERAL	Suspended Solids	n/a	n/a	53,500,000	444,000,000	34,400,000	16,800,000	157,919,785
MINERALS	Total Dissolved Solids	n/a	n/a	21,900,000	76,400,000	34,200,000	6,090,000	127,865,033
HEAVY	Dissolved Cadmium	n/a	n/a	n/m	2,670	n/m	n/m	S.I.D
METALS	Dissolved Copper	n/a	n/a	n/m	56,100	991	290	5,328,102
	Dissolved Lead	n/a	n/a	n/m	103,000	n/m	161	S.I.D
	Dissolved Nickel	n/a	n/a	385	13,400	373	226	4,077,683
	Dissolved Zinc	n/a	n/a	n/m	336,000	n/m	n/m	30,113,568
	Nickel	n/a	n/a	2,280	22,000	737	302	5,259,288
	Total Aluminum	n/a	n/a	361,000	8,890,000	183,000	25,300	372,061,366
	Total Copper	n/a	n/a	8,000	81,000	2,370	631	10,584,449
	Total Lead	n/a	n/a	8,290	208,000	n/m	457	6,599,694
	Total Mercury	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
	Total Zinc	n/a	n/a	36,800	463,000	13,400	2,230	42,400,139
PAHs	Phenanthrene	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
	Pyrene	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	54,200	530,000	46,400	15,100	277,839
	Total Phosphorus	n/a	n/a	180,000	683,000	58,800	20,800	318,851
	NH3-N	n/a	n/a	84,800	732,000	23,700	6,860	616,093
	Nitrate-N	n/a	n/a	224,000	533,000	67,300	39,300	566,600
	Nitrite-N	n/a	n/a	17,600	91,400	37,300	6,430	189,504
	TKN	n/a	n/a	747,000	3,540,000	399,000	119,000	1,951,912
PESTICIDES	Chlorpyrifos	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
	Diazinon	n/a	n/a	n/m	n/m	n/m	n/m	S.I.D
MISCELLANEOUS	Cyanide	n/a	n/a	n/m	n/m	n/m	n/m	17,653
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/m	20,600	n/a	n/m	S.I.D

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

R0012407

Table 4-8d. ESTIMATED MASS POLLUTANT LOADING
COYOTE CREEK
MONITORED WATERSHED

LANDUSE

HDSFR	38.3%
Light Ind	8.4%
Vacant	14.3%
Retail/Comm	5.6%
Multi-Fam.Res	6.1%
Transportation	1.8%
Education	4.3%
Mixed Residential	0.2%
All Other	21.0%

Total Area: 150 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb)						
		1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01
GENERAL	Suspended Solids	n/a	n/a	n/a	93,100,000	4,610,000	17,700,000	12,190,189
MINERALS	Total Dissolved Solids	n/a	n/a	n/a	38,300,000	12,100,000	16,700,000	9,447,694
HEAVY	Dissolved Cadmium	n/a	n/a	n/a	191	n/m	n/m	S.I.D
METALS	Dissolved Copper	n/a	n/a	n/a	5,180	162	364	179,614
	Dissolved Lead	n/a	n/a	n/a	3,230	n/m	n/m	S.I.D
	Dissolved Nickel	n/a	n/a	n/a	1,270	n/m	n/m	155,607
	Dissolved Zinc	n/a	n/a	n/a	38,500	1,060	n/m	S.I.D
	Nickel	n/a	n/a	n/a	2,220	178	284	170,750
	Total Aluminum	n/a	n/a	n/a	518,000	19,700	17,300	6,934,139
	Total Copper	n/a	n/a	n/a	7,110	445	645	363,679
	Total Lead	n/a	n/a	n/a	4,770	n/m	n/m	S.I.D
	Total Mercury	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
PAHs	Phenanthrene	n/a	n/a	n/a	n/m	n/m	n/m	1,426,892
	Pyrene	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	n/a	75,100	5,620	16,500	S.I.D
	Total Phosphorus	n/a	n/a	n/a	97,100	6,700	25,000	9,627
	NH3-N	n/a	n/a	n/a	141,000	19,500	52,500	12,234
	Nitrate-N	n/a	n/a	n/a	147,000	55,800	85,400	23,403
	Nitrite-N	n/a	n/a	n/a	29,300	5,540	19,800	31,400
	TKN	n/a	n/a	n/a	725,000	112,000	169,000	5,175
	Total Zinc	n/a	n/a	n/a	56,600	2,090	2,260	97,541
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
	Diazinon	n/a	n/a	n/a	n/m	n/m	1	S.I.D
MISCELLANEOUS	Cyanide	n/a	n/a	n/a		n/m	n/m	S.I.D
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	2,970	n/m	n/m	S.I.D

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

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Table 4-8e. ESTIMATED MASS POLLUTANT LOADING
SAN GABRIEL RIVER
MONITORED WATERSHED

LANDUSE
HDSFR..... 15.2%
Light Ind..... 2.3%
Vacant..... 66.7%
Retail/Comm..... 1.5%
Multi-Fam.Res.... 1.4%
Transportation..... 1.0%
Education..... 1.6%
Mixed Residential. 0.1%
All Other..... 10.2%

Total Area: 450 mi.^{2}

GROUP	CONSTITUENT	SEASONAL LOAD (lb.) 1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01
GENERAL MINERALS	Suspended Solids	n/a	n/a	n/a	28,700,000	2,810,000	1,380,000	2,414,824
	Total Dissolved Solids	n/a	n/a	n/a	22,200,000	15,500,000	2,740,000	10,685,150
HEAVY METALS	Dissolved Cadmium	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
	Dissolved Copper	n/a	n/a	n/a	1,120	n/m	n/m	S.I.D
	Dissolved Lead	n/a	n/a	n/a	901	n/m	n/m	S.I.D
	Dissolved Nickel	n/a	n/a	n/a	449	n/m	n/m	114,672
	Dissolved Zinc	n/a	n/a	n/a	8,840	1,090	n/m	S.I.D
	Nickel	n/a	n/a	n/a	791	n/m	48	142,985
	Total Aluminum	n/a	n/a	n/a	400,000	8,140	4,120	7,234,314
	Total Copper	n/a	n/a	n/a	2,180	252	76	195,598
	Total Lead	n/a	n/a	n/a	1,340	n/m	n/m	S.I.D
	Total Mercury	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
	Total Zinc	n/a	n/a	n/a	14,800	1,730	n/m	895,084
PAHs	Phenanthrene	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
	Pyrene	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
NUTRIENTS	Dissolved Phosphorus	n/a	n/a	n/a	42,500	15,500	2,310	279,612
	Total Phosphorus	n/a	n/a	n/a	52,100	17,700	2,710	429,907
	NH3-N	n/a	n/a	n/a	136,000	43,900	n/m	8,174
	Nitrate-N	n/a	n/a	n/a	135,000	72,200	16,700	107,791
	Nitrite-N	n/a	n/a	n/a	26,700	19,800	2,870	9,190
	TKN	n/a	n/a	n/a	310,000	134,000	15,000	51,981
PESTICIDES	Chlorpyrifos	n/a	n/a	n/a	n/m	n/m	n/m	S.I.D
	Diazinon	n/a	n/a	n/a	n/m	n/m	0	S.I.D
MISCELLANEOUS	Cyanide	n/a	n/a	n/a	2,230	1,240	n/m	330
SEMIVOLATILES	Bis(2-ethylhexyl)phthalate	n/a	n/a	n/a	1,390	n/m	n/m	S.I.D

Note: n/m = Not meaningful, not enough data above detection limit collected.
n/a = No data available.

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Table 4-9a. ESTIMATED MASS POLLUTANT LOADING UNMONITORED SMBRP BASINS 2000-2001 STORM SEASON

LANDUSE
HDSFR.....15.5%
Light Ind..... 0.6%
Vacant.....63.4%
Retail/Comm.....1.6%
Multi-Fam.Res..... 3.4%
Transportation..... 2.1%
Education..... 1.3%
Mixed Residential.... 0.9%
All Other.....11.2%

Total Area: 174 mi^2
Overall Imperviousness: 0.18

GROUP	CONSTITUENTS	SEASONAL LOAD (lb.)
GENERAL MINERALS	Total Dissolved Solids	17,700,000
	Suspended Solids	13,900,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	7.81
	Dissolved Copper	729
	Dissolved Lead	n/a
	Dissolved Zinc	5,640
	Dissolved Nickel	80.1
HEAVY METALS (TOTAL)	Total Copper	1,330
	Total Lead	76.6
	Total Mercury	n/a
	Total Aluminum	16,000
	Nickel	157
	Total Zinc	6,270
PESTICIDES	Chlorpyrifos	n/a
	Diazinon	n/a
PAHs	Phenantrene	n/a
	Pyrene	n/a
NUTRIENTS	Dissolved Phosphorus	50,000
	Total Phosphorus	57,500
	NH3-N	34,200
	Nitrate-N	91,400
	Nitrite-N	7,600
	TKN	208,000

Table 4-9b. ESTIMATED MASS POLLUTANT LOADING
SANTA CLARA RIVER
2000-2001 STORM SEASON

Total Area: 653 mi^2
Overall Imperviousness: 0.07

LANDUSE
HDSFR..... 1.8%
Light Ind..... 0.3%
Vacant.....88.2%
Retail/Comm..... 0.2%
Multi-Fam.Res..... 0.3%
Transportation..... 0.4%
Education..... 0.2%
Mixed Residential. 0%
All Other..... 8.6%

GROUP	CONSTITUENTS	SEASONAL LOAD (lb.)
GENERAL MINERALS	Total Dissolved Solids	29,800,000
	Suspended Solids	22,300,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	4.41
	Dissolved Copper	537
	Dissolved Lead	n/a
	Dissolved Zinc	11,400
	Dissolved Nickel	170
HEAVY METALS (TOTAL)	Total Copper	1,390
	Total Lead	200
	Total Mercury	n/a
	Total Aluminum	28,200
	Nickel	235
	Total Zinc	12,600
PESTICIDES	Chlorpyrifos	n/a
	Diazinon	n/a
PAHs	Phenantrene	n/a
	Pyrene	n/a
NUTRIENTS	Dissolved Phosphorus	36,100
	Total Phosphorus	43,000
	NH3-N	27,000
	Nitrate-N	148,000
	Nitrite-N	5,920
	TKN	232,000

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Table 4-9c. ESTIMATED MASS POLLUTANT LOADING
DOMINGUEZ CHANNEL / L.A. HARBOR
2000-2001 STORM SEASON

LANDUSE
HDSFR.....34.2%
Light Ind.....13.2%
Vacant..... 2.5%
Retail/Comm..... 6.2%
Multi-Fam.Res..... 5.8%
Transportation..... 4.7%
Education..... 3.7%
Mixed Residential... 4.3%
All Other.....25.4%

Total Area: 110 mi^2
Overall Imperviousness: 0.18

GROUP	CONSTITUENTS	SEASONAL LOAD (lb.)
GENERAL MINERALS	Total Dissolved Solids	7,260,000
	Suspended Solids	10,700,000
HEAVY METALS (DISSOLVED)	Dissolved Cadmium	7.66
	Dissolved Copper	783
	Dissolved Lead	n/a
	Dissolved Zinc	12,600
	Dissolved Nickel	186
HEAVY METALS (TOTAL)	Total Copper	1,280
	Total Lead	211
	Total Mercury	n/a
	Total Aluminum	32,500
	Nickel	272
	Total Zinc	13,900
PESTICIDES	Chlorpyrifos	n/a
	Diazinon	n/a
PAHs	Phenantrene	n/a
	Pyrene	n/a
NUTRIENTS	Dissolved Phosphorus	46,500
	Total Phosphorus	54,500
	NH3-N	38,500
	Nitrate-N	46,300
	Nitrite-N	8,490
	TKN	179,000
MISCELLANEOUS	Cyanide	n/a

Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Vacant						High Density Single Family Residential					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	Cyanide	0.01	mg/l	6	6	0%	SID	SID	SID	0	0				
	Oil and Grease	1	mg/l	6	4	33%	0.900	0.500	0.773	0	0				
	Total Phenols	0.1	mg/l	6	6	0%	SID	SID	SID	0	0				
Indicator Bacteria	Total Coliform	20	MPN/100ml	6	0	100%	41733.333	2900.000	2.328	3	0	100%	546000.000	30000.000	1.672
	Fecal Coliform	20	MPN/100ml	6	0	100%	3701.667	900.000	1.778	3	0	100%	540333.333	16000.000	1.698
	Fecal Streptococcus	20	MPN/100ml	6	0	100%	27261.667	800.000	2.385	3	0	100%	136333.333	160000.000	0.860
	Fecal Enterococcus	20	MPN/100ml	6	0	100%	27146.667	665.000	2.398	3	0	100%	113000.000	90000.000	1.037
General Minerals	Ammonia	0.1	mg/l	7	5	29%	0.085	0.050	0.743	10	1	90%	0.724	0.429	0.976
	Calcium	1	mg/l	7	0	100%	52.086	52.100	0.097	10	0	100%	13.386	8.915	0.912
	Magnesium	1	mg/l	7	0	100%	16.843	17.000	0.222	10	0	100%	2.929	1.880	1.322
	Potassium	1	mg/l	7	0	100%	2.734	2.620	0.214	10	0	100%	5.120	3.080	0.803
	Sodium	1	mg/l	7	0	100%	16.429	15.200	0.211	10	0	100%	9.640	5.900	0.910
	Bicarbonate	2	mg/l	7	0	100%	213.936	219.840	0.100	10	0	100%	42.990	27.700	0.979
	Carbonate	2	mg/l	7	7	0%	SID	SID	SID	9	9	0%	1.000	1.000	0.000
	Chloride	2	mg/l	7	0	100%	7.427	7.380	0.058	10	0	100%	8.198	4.605	1.301
	Fluoride	0.1	mg/l	7	0	100%	0.383	0.380	0.039	10	7	30%	0.074	0.050	0.591
	Nitrate	0.1	mg/l	7	0	100%	4.841	4.360	0.581	10	1	90%	1.462	1.095	1.105
	Sulfate	0.1	mg/l	7	0	100%	18.629	19.400	0.120	10	0	100%	8.843	5.995	1.037
	Alkalinity	4	mg/l	7	0	100%	175.371	180.000	0.102	10	0	100%	35.230	22.700	0.979
	Hardness	2	mg/l	7	0	100%	199.286	200.000	0.093	10	0	100%	45.520	30.000	1.017
	COD	5	mg/l	7	2	71%	32.243	34.000	0.705	10	2	80%	71.580	67.900	0.638
	pH	14		7	0	100%	8.071	8.030	0.031	10	0	100%	6.899	6.840	0.056
	Specific Conductance	1	umhos/cm	7	0	100%	406.571	416.000	0.071	10	0	100%	135.160	88.100	0.938
	Total Dissolved Solids	2	mg/l	7	0	100%	239.714	250.000	0.097	10	0	100%	83.000	53.000	1.007
	Turbidity	0.1	NTU	7	0	100%	52.936	12.000	2.022	10	0	100%	43.376	27.900	1.016
	Suspended Solids	2	mg/l	7	0	100%	153.714	22.000	2.077	10	0	100%	190.700	74.000	1.176
	Volatile Suspended Solids	1	mg/l	7	0	100%	35.143	16.000	1.675	10	0	100%	87.900	46.000	1.049
	MBAS	0.05	mg/l	7	7	0%	SID	SID	SID	10	3	70%	0.080	0.066	0.787
	Total Organic Carbon	1	mg/l	7	0	100%	4.001	3.600	0.470	10	0	100%	12.170	8.885	0.744
	BOD	2	mg/l	7	0	100%	5.771	6.000	0.433	10	1	90%	10.984	6.500	0.824
Nutrients	Dissolved Phosphorus	0.05	mg/l	7	4	43%	0.046	0.025	0.586	10	0	100%	0.407	0.316	0.673
	Total Phosphorus	0.05	mg/l	7	3	57%	0.058	0.050	0.667	10	0	100%	0.456	0.353	0.618
	NH3-N	0.1	mg/l	7	5	29%	0.076	0.050	0.631	10	1	90%	0.599	0.354	0.972
	Nitrate-N	0.1	mg/l	7	0	100%	1.093	0.985	0.582	10	2	80%	0.335	0.247	1.075
	Nitrite-N	0.1	mg/l	7	5	29%	0.048	0.050	0.089	10	3	70%	0.116	0.051	1.273
	Kjeldahl-N	0.1	mg/l	7	0	100%	1.209	0.430	1.694	9	0	100%	3.986	3.100	0.894
Metals	Dissolved Aluminum	100	ug/l	7	7	0%	SID	SID	SID	10	10	0%	50.000	50.000	0.000
	Total Aluminum	100	ug/l	7	5	29%	509.714	50.000	2.294	10	3	70%	189.340	110.700	1.338
	Dissolved Antimony	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	2.500	2.500	0.000
	Total Antimony	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Arsenic	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Arsenic	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Barium	10	ug/l	7	0	100%	44.200	43.700	0.116	10	3	70%	15.150	12.450	0.782
	Total Barium	10	ug/l	7	0	100%	48.729	44.700	0.209	10	2	80%	18.760	15.750	0.653
	Dissolved Beryllium	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Beryllium	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Boron	100	ug/l	7	4	43%	85.571	50.000	0.519	10	7	30%	73.100	50.000	0.515
	Total Boron	100	ug/l	7	2	71%	104.857	107.000	0.405	10	7	30%	93.400	50.000	0.810
	Dissolved Cadmium	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Cadmium	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID

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Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Vacant						High Density Single Family Residential					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
	Total Chromium	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Chromium +6	10	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Chromium +6	10	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	7	7	0%	SID	SID	SID	10	2	80%	10.926	7.510	0.927
	Total Copper	5	ug/l	7	3	57%	4.489	5.180	0.429	10	0	100%	17.721	12.050	0.625
	Dissolved Iron	100	ug/l	7	4	43%	165.714	50.000	0.890	10	6	40%	101.900	50.000	0.703
	Total Iron	100	ug/l	7	2	71%	330.000	260.000	0.925	10	1	90%	266.900	265.000	0.550
	Dissolved Lead	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Lead	5	ug/l	7	6	14%	2.864	2.500	0.336	10	9	10%	SID	SID	SID
	Dissolved Manganese	100	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Manganese	100	ug/l	7	6	14%	77.286	50.000	0.934	10	10	0%	SID	SID	SID
	Dissolved Mercury	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Mercury	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Nickel	5	ug/l	7	7	0%	SID	SID	SID	10	9	10%	SID	SID	SID
	Nickel	5	ug/l	7	7	0%	SID	SID	SID	10	9	10%	SID	SID	SID
	Dissolved Selenium	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Selenium	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Silver	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Silver	1	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Thallium	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Thallium	5	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Zinc	50	ug/l	7	7	0%	SID	SID	SID	10	9	10%	SID	SID	SID
	Total Zinc	50	ug/l	7	7	0%	SID	SID	SID	10	8	20%	33.120	25.000	0.521
SVOCs	Bis(2-ethylhexyl)phthalate	1	ug/l	7	1	86%	4.686	3.300	1.019	7	0	100%	5.800	4.600	0.747
	All other SVOCs	0.05-5.0	ug/l	7	7	0%				7	7	0%			
Pesticides	Glyphosate	25	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	All other Pesticides	0.01-25	ug/l	7	7	0%				10	10	0%			

Note:
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

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Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Transportation						Light Industrial					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	Cyanide	0.01	mg/l	0	0					0	0				
	Oil and Grease	1	mg/l	0	0					0	0				
	Total Phenols	0.1	mg/l	0	0					0	0				
Indicator Bacteria	Total Coliform	20	MPN/100ml	4	0	100%	36500.000	42500.000	0.504	3	0	100%	66333.333	22000.000	1.223
	Fecal Coliform	20	MPN/100ml	4	0	100%	8475.000	8000.000	0.784	3	0	100%	62000.000	17000.000	1.370
	Fecal Streptococcus	20	MPN/100ml	4	0	100%	82900.000	14500.000	1.747	3	0	100%	39433.333	28000.000	1.165
	Fecal Enterococcus	20	MPN/100ml	4	0	100%	13425.000	11000.000	0.894	3	0	100%	39410.000	28000.000	1.166
General Minerals	Ammonia	0.1	mg/l	12	4	67%	0.928	0.397	1.373	10	4	60%	0.606	0.276	1.290
	Calcium	1	mg/l	12	0	100%	12.779	9.015	0.984	10	0	100%	14.325	12.700	0.510
	Magnesium	1	mg/l	12	0	100%	4.489	1.985	1.168	10	1	90%	4.237	3.650	0.865
	Potassium	1	mg/l	12	0	100%	4.538	2.225	1.514	10	0	100%	3.181	2.985	0.597
	Sodium	1	mg/l	12	0	100%	15.792	10.600	1.131	10	0	100%	14.410	12.400	0.767
	Bicarbonate	2	mg/l	12	0	100%	35.720	25.880	0.762	10	0	100%	36.126	32.150	0.586
	Carbonate	2	mg/l	12	12	0%	1.000	1.000	0.000	10	10	0%	1.000	1.000	0.000
	Chloride	2	mg/l	12	1	92%	13.673	7.040	1.740	10	0	100%	12.003	9.390	0.643
	Fluoride	0.1	mg/l	12	4	67%	0.171	0.120	1.105	10	2	80%	0.133	0.130	0.451
	Nitrate	0.1	mg/l	12	0	100%	3.782	2.455	1.156	10	0	100%	2.770	2.880	0.514
	Sulfate	0.1	mg/l	12	0	100%	19.905	10.500	1.537	10	0	100%	12.852	12.040	0.604
	Alkalinity	4	mg/l	12	0	100%	29.308	21.200	0.764	10	0	100%	29.630	26.350	0.586
	Hardness	2	mg/l	12	0	100%	50.208	30.400	1.036	10	0	100%	54.530	60.000	0.447
	[illegible]COD	5	mg/l	12	1	92%	84.717	68.000	1.174	10	0	100%	60.610	59.850	0.546
	pH	14		12	0	100%	6.783	6.790	0.039	10	0	100%	6.877	6.920	0.043
	[illegible]	1	umhos/cm	12	0	100%	175.833	108.550	1.302	10	0	100%	148.000	127.500	0.491
	[illegible]Dissolved Solids	2	mg/l	12	0	100%	110.667	64.000	1.365	10	0	100%	89.600	75.000	0.520
	Turbidity	0.1	NTU	12	0	100%	46.550	35.400	0.724	10	0	100%	101.971	108.250	0.532
	Suspended Solids	2	mg/l	12	0	100%	88.083	83.500	0.630	10	0	100%	210.800	199.000	0.467
	Volatile Suspended Solids	1	mg/l	12	0	100%	35.500	39.500	0.459	10	0	100%	47.500	48.000	0.542
	MBAS	0.05	mg/l	12	0	100%	0.153	0.120	0.591	10	0	100%	0.175	0.151	0.456
	Total Organic Carbon	1	mg/l	12	0	100%	22.262	10.090	1.602	10	0	100%	14.696	12.165	0.636
	BOD	2	mg/l	12	3	75%	6.558	6.300	0.749	10	1	90%	7.760	7.350	0.473
Nutrients	Dissolved Phosphorus	0.05	mg/l	12	0	100%	15.836	0.625	3.324	10	1	90%	0.218	0.206	0.543
	Total Phosphorus	0.05	mg/l	12	0	100%	21.893	0.750	3.353	10	1	90%	0.280	0.270	0.559
	NH3-N	0.1	mg/l	12	4	67%	0.615	0.259	1.589	10	4	60%	0.504	0.228	1.275
	Nitrate-N	0.1	mg/l	12	0	100%	0.854	0.555	1.157	10	1	90%	0.622	0.650	0.525
	Nitrite-N	0.1	mg/l	12	0	100%	0.118	0.117	0.529	10	0	100%	0.134	0.102	0.684
	Kjeldahl-N	0.1	mg/l	12	0	100%	2.294	1.605	1.053	10	0	100%	2.426	1.930	0.644
Metals	Dissolved Aluminum	100	ug/l	12	9	25%	80.092	50.000	0.840	10	8	20%	86.200	50.000	1.080
	Total Aluminum	100	ug/l	12	0	100%	529.842	204.450	1.569	10	1	90%	1097.050	327.000	2.010
	Dissolved Antimony	5	ug/l	12	9	25%	5.584	2.500	1.485	10	10	0%	SID	SID	SID
	Total Antimony	5	ug/l	12	9	25%	5.820	2.500	1.447	10	10	0%	SID	SID	SID
	Dissolved Arsenic	5	ug/l	12	11	8%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Arsenic	5	ug/l	12	11	8%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Barium	10	ug/l	12	1	92%	17.625	16.300	0.400	10	1	90%	20.880	22.300	0.323
	Total Barium	10	ug/l	12	0	100%	28.342	20.100	0.800	10	0	100%	38.280	27.100	1.072
	Dissolved Beryllium	1	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Beryllium	1	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Boron	100	ug/l	12	7	42%	115.250	50.000	0.951	10	6	40%	86.500	50.000	0.629
	Total Boron	100	ug/l	12	6	50%	129.833	75.000	0.874	10	5	50%	99.400	77.000	0.613
	Dissolved Cadmium	1	ug/l	12	7	42%	0.874	0.500	0.584	10	10	0%	SID	SID	SID
	Total Cadmium	1	ug/l	12	6	50%	1.273	0.780	0.964	10	9	10%	SID	SID	SID
	Dissolved Chromium	5	ug/l	12	11	8%	SID	SID	SID	10	10	0%	SID	SID	SID

R0012415

Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Transportation						Light Industrial					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
	Total Chromium	5	ug/l	12	10	17%	SID	SID	SID	10	8	20%	4 119	2 500	1 007
	Dissolved Chromium +6	10	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Chromium +6	10	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	12	0	100%	41 558	31 450	0 606	10	0	100%	8 859	8 590	0 311
	Total Copper	5	ug/l	12	0	100%	59 017	42 950	0 824	10	0	100%	18 178	13 800	0 881
	Dissolved Iron	100	ug/l	12	4	67%	160 583	115 000	0 752	10	4	60%	233 000	175 000	0 931
	Total Iron	100	ug/l	12	1	92%	870 500	285 000	2 066	10	1	90%	1934 000	395 000	2 264
	Dissolved Lead	5	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Lead	5	ug/l	12	9	25%	6 488	2.500	1 596	10	6	40%	8.983	2.500	1 787
	Dissolved Manganese	100	ug/l	12	11	8%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Manganese	100	ug/l	12	9	25%	69 258	50 000	0 530	10	9	10%	SID	SID	SID
	Dissolved Mercury	1	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Mercury	1	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Nickel	5	ug/l	12	6	50%	8 116	3 845	1 353	10	4	60%	5 847	5 060	0 711
	Nickel	5	ug/l	12	4	67%	9 748	6 175	1 138	10	3	70%	7.527	6 010	0 732
	Dissolved Selenium	5	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Selenium	5	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Silver	1	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Silver	1	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Thallium	5	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Total Thallium	5	ug/l	12	12	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dissolved Zinc	50	ug/l	12	0	100%	369.092	232.000	1.034	10	1	90%	340 600	313 500	0 634
	Total Zinc	50	ug/l	12	0	100%	407 342	237.000	1.100	10	0	100%	447 650	323.500	1 018
SVOCs	Bis(2-ethylhexyl)phthalate	1	ug/l	0	0					0	0				
	All other SVOCs	0 05-5 0	ug/l	0	0					0	0				
Pesticides	Glyphosate	25	ug/l	12	11	8%	SID	SID	SID	10	10	0%	SID	SID	SID
	All other Pesticides	0.01-25	ug/l	12	12	0%				10	10	0			

Note:
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012416

Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Educational						Multifamily Residential					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	Cyanide	0.01	mg/l	0	0					0	0				
	Oil and Grease	1	mg/l	0	0					0	0				
	Total Phenols	0.1	mg/l	0	0					0	0				
Indicator Bacteria	Total Coliform	20	MPN/100ml	4	0	100%	171000.000	81000.000	1.323	3	0	100%	199333.333	220000.000	0.813
	Fecal Coliform	20	MPN/100ml	4	0	100%	45775.000	21000.000	1.404	3	0	100%	102666.667	140000.000	0.630
	Fecal Streptococcus	20	MPN/100ml	4	0	100%	24000.000	19500.000	0.768	3	0	100%	54066.667	70000.000	0.851
	Fecal Enterococcus	20	MPN/100ml	4	0	100%	12750.000	12000.000	0.635	3	0	100%	39233.333	26000.000	1.163
General Minerals	Ammonia	0.1	mg/l	12	6	50%	1.052	0.083	2.916	8	2	75%	0.639	0.590	0.887
	Calcium	1	mg/l	12	0	100%	21.715	15.000	0.788	9	0	100%	32.653	24.000	0.754
	Magnesium	1	mg/l	12	0	100%	6.153	3.485	0.980	9	1	89%	7.260	3.650	0.961
	Potassium	1	mg/l	12	0	100%	4.769	3.200	0.807	9	0	100%	4.444	2.660	0.791
	Sodium	1	mg/l	12	0	100%	20.867	13.400	1.051	9	0	100%	23.056	13.900	0.972
	Bicarbonate	2	mg/l	12	0	100%	52.428	38.165	0.748	9	0	100%	81.252	58.900	0.845
	Carbonate	2	mg/l	12	12	0%	1.000	1.000	0.000	9	9	0%	1.000	1.000	0.000
	Chloride	2	mg/l	12	0	100%	34.995	6.445	1.380	9	0	100%	64.248	11.900	1.731
	Fluoride	0.1	mg/l	12	5	58%	0.226	0.105	1.235	9	1	89%	0.216	0.160	0.793
	Nitrate	0.1	mg/l	12	0	100%	3.268	2.645	0.615	9	0	100%	7.362	6.220	0.532
	Sulfate	0.1	mg/l	12	0	100%	22.402	10.145	1.409	9	0	100%	20.647	14.600	0.971
	Alkalinity	4	mg/l	12	0	100%	42.950	31.250	0.747	9	0	100%	66.656	48.300	0.846
	Hardness	2	mg/l	12	0	100%	79.558	54.500	0.844	9	0	100%	111.111	75.000	0.802
	COD	5	mg/l	12	1	92%	68.058	71.000	0.590	9	0	100%	60.689	56.500	0.451
	pH	14		12	0	100%	7.149	7.090	0.046	9	0	100%	7.288	7.270	0.063
	Specific Conductance	1	umhos/cm	12	0	100%	237.225	123.700	0.971	9	0	100%	397.556	205.000	1.009
	Total Dissolved Solids	2	mg/l	12	0	100%	142.500	73.000	0.934	9	0	100%	237.556	132.000	1.009
	Turbidity	0.1	NTU	12	0	100%	54.633	46.350	0.537	9	0	100%	9.391	8.140	0.687
	Suspended Solids	2	mg/l	12	0	100%	91.833	74.000	0.534	9	0	100%	27.556	19.000	0.808
	Volatile Suspended Solids	1	mg/l	12	1	92%	24.125	24.500	0.482	9	0	100%	15.667	8.000	1.069
	MBAS	0.05	mg/l	12	5	58%	0.061	0.061	0.649	8	0	100%	0.104	0.097	0.370
	Total Organic Carbon	1	mg/l	12	0	100%	8.279	7.175	0.596	9	0	100%	9.230	7.830	0.426
	BOD	2	mg/l	12	1	92%	6.745	6.650	0.413	9	2	78%	7.878	6.500	0.892
Nutrients	Dissolved Phosphorus	0.05	mg/l	12	0	100%	0.233	0.160	0.757	8	0	100%	0.363	0.268	0.687
	Total Phosphorus	0.05	mg/l	12	0	100%	0.279	0.221	0.579	8	0	100%	0.410	0.314	0.697
	NH3-N	0.1	mg/l	12	7	42%	0.870	0.050	2.916	8	2	75%	0.530	0.487	0.878
	Nitrate-N	0.1	mg/l	12	0	100%	0.738	0.598	0.615	9	0	100%	1.662	1.400	0.532
	Nitrite-N	0.1	mg/l	12	2	83%	0.193	0.099	1.435	9	1	89%	0.246	0.088	1.285
	Kjeldahl-N	0.1	mg/l	12	0	100%	2.302	1.112	1.257	9	0	100%	1.575	1.530	0.443
Metals	Dissolved Aluminum	100	ug/l	12	6	50%	119.967	84.500	0.818	9	9	0%	SID	SID	SID
	Total Aluminum	100	ug/l	12	2	83%	460.800	458.500	0.727	9	6	33%	126.667	50.000	1.243
	Dissolved Antimony	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Antimony	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Arsenic	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Arsenic	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Barium	10	ug/l	12	0	100%	22.033	17.500	0.506	9	2	78%	24.867	14.200	0.861
	Total Barium	10	ug/l	12	0	100%	27.508	22.850	0.433	9	1	89%	28.500	16.900	0.767
	Dissolved Beryllium	1	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Beryllium	1	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Boron	100	ug/l	12	4	67%	154.333	131.000	0.766	9	2	78%	142.333	120.000	0.601
	Total Boron	100	ug/l	12	2	83%	185.083	140.500	0.628	9	2	78%	169.889	136.000	0.564
	Dissolved Cadmium	1	ug/l	12	9	25%	0.715	0.500	0.550	9	9	0%	SID	SID	SID
	Total Cadmium	1	ug/l	12	9	25%	0.722	0.500	0.565	9	9	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID

R0012417

Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Educational						Multifamily Residential					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
	Total Chromium	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Chromium +6	10	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Chromium +6	10	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	12	2	83%	10 548	8 250	0 898	9	0	100%	8 818	8 930	0 253
	Total Copper	5	ug/l	12	0	100%	15 839	12 600	0 568	9	0	100%	12 306	11 900	0 241
	Dissolved Iron	100	ug/l	12	3	75%	217 667	220 000	0 586	9	8	11%	SID	SID	SID
	Total Iron	100	ug/l	12	1	92%	639 833	560 000	0 752	9	2	78%	212 222	180 000	0 762
	Dissolved Lead	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Lead	5	ug/l	12	11	8%	SID	SID	SID	9	8	11%	SID	SID	SID
	Dissolved Manganese	100	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Manganese	100	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Mercury	1	ug/l	12	12	0%	SID	SID	SID	8	8	0%	SID	SID	SID
	Total Mercury	1	ug/l	12	12	0%	SID	SID	SID	8	8	0%	SID	SID	SID
	Dissolved Nickel	5	ug/l	12	11	8%	SID	SID	SID	9	7	22%	SID	SID	SID
	Nickel	5	ug/l	12	10	17%	SID	SID	SID	9	6	33%	SID	SID	SID
	Dissolved Selenium	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Selenium	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Silver	1	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Total Silver	1	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Dissolved Thallium	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	[illegible]	5	ug/l	12	12	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	[illegible]	50	ug/l	12	2	83%	91 467	79 750	0 618	9	1	89%	74 756	80 000	0 372
	[illegible]	50	ug/l	12	0	100%	105 625	94 300	0 457	9	0	100%	91 911	89 800	0 232
SVOCs	Bis(2-ethylhexyl)phthalate	1	ug/l	0	0					5	1	80%	7 860	1 700	1 818
	All other SVOCs	0 05-5 0	ug/l	0	0					5	5	0%			
Pesticides	Glyphosate	25	ug/l	12	11	8%	SID	SID	SID	9	9	0%	SID	SID	SID
	All other Pesticides	0 01-25	ug/l	12	12	0%				9	9	0%			

Note:
CV = Coeffiecient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012418

Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Mixed Residential					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	Cyanide	0.01	mg/l	0	0				
	Oil and Grease	1	mg/l	0	0				
	Total Phenols	0.1	mg/l	0	0				
Indicator Bacteria	Total Coliform	20	MPN/100ml	3	0	100%	390000.000	220000.000	1.153
	Fecal Coliform	20	MPN/100ml	3	0	100%	307733.333	21000.000	1.667
	Fecal Streptococcus	20	MPN/100ml	3	0	100%	96000.000	90000.000	0.742
	Fecal Enterococcus	20	MPN/100ml	3	0	100%	85666.667	70000.000	0.907
General Minerals	Ammonia	0.1	mg/l	11	2	82%	0.767	0.438	1.111
	Calcium	1	mg/l	11	0	100%	17.585	12.000	0.803
	Magnesium	1	mg/l	11	0	100%	6.180	3.640	0.964
	Potassium	1	mg/l	11	0	100%	3.507	2.550	0.543
	Sodium	1	mg/l	11	0	100%	17.809	13.500	0.928
	Bicarbonate	2	mg/l	11	0	100%	41.564	32.330	0.631
	Carbonate	2	mg/l	11	11	0%	SID	SID	SID
	Chloride	2	mg/l	11	0	100%	17.850	11.000	1.083
	Fluoride	0.1	mg/l	11	3	73%	0.135	0.100	0.806
	Nitrate	0.1	mg/l	11	0	100%	2.170	2.230	0.351
	Sulfate	0.1	mg/l	11	0	100%	26.330	16.000	1.124
	Alkalinity	4	mg/l	11	0	100%	34.073	26.500	0.631
	Hardness	2	mg/l	11	0	100%	69.336	40.000	0.774
	COD	5	mg/l	11	0	100%	72.036	60.700	0.597
	pH	14		11	0	100%	6.880	6.750	0.046
	Specific Conductance	1	umhos/cm	11	0	100%	208.736	147.000	0.790
	Total Dissolved Solids	2	mg/l	11	0	100%	128.727	92.000	0.811
	Turbidity	0.1	NTU	11	0	100%	26.457	15.800	1.089
	Suspended Solids	2	mg/l	11	0	100%	107.182	63.000	1.120
	Volatile Suspended Solids	1	mg/l	11	0	100%	50.636	29.000	1.167
	MBAS	0.05	mg/l	11	1	91%	0.124	0.105	0.535
	Total Organic Carbon	1	mg/l	11	0	100%	13.113	9.500	0.701
	BOD	2	mg/l	11	2	82%	7.145	5.790	0.692
Nutrients	Dissolved Phosphorus	0.05	mg/l	11	0	100%	0.325	0.250	0.722
	Total Phosphorus	0.05	mg/l	11	0	100%	0.372	0.284	0.645
	NH3-N	0.1	mg/l	11	4	64%	0.606	0.360	1.178
	Nitrate-N	0.1	mg/l	11	1	91%	0.477	0.504	0.417
	Nitrite-N	0.1	mg/l	11	0	100%	0.193	0.161	0.694
	Kjeldahl-N	0.1	mg/l	11	0	100%	3.223	2.660	0.562
Metals	Dissolved Aluminum	100	ug/l	11	11	0%	SID	SID	SID
	Total Aluminum	100	ug/l	11	4	64%	232.455	128.000	1.267
	Dissolved Antimony	5	ug/l	11	11	0%	SID	SID	SID
	Total Antimony	5	ug/l	11	11	0%	SID	SID	SID
	Dissolved Arsenic	5	ug/l	11	11	0%	SID	SID	SID
	Total Arsenic	5	ug/l	11	11	0%	SID	SID	SID
	Dissolved Barium	10	ug/l	11	0	100%	22.455	15.900	0.601
	Total Barium	10	ug/l	11	0	100%	27.055	19.700	0.623
	Dissolved Beryllium	1	ug/l	11	11	0%	SID	SID	SID
	Total Beryllium	1	ug/l	11	11	0%	SID	SID	SID
	Dissolved Boron	100	ug/l	11	8	27%	75.818	50.000	0.619
	Total Boron	100	ug/l	11	5	55%	96.909	101.000	0.594
	Dissolved Cadmium	1	ug/l	11	11	0%	SID	SID	SID
	Total Cadmium	1	ug/l	11	10	9%	0.580	0.500	0.457
	Dissolved Chromium	5	ug/l	11	11	0%	SID	SID	SID

R0012419

Table 4-10. Summary of Results for 2000-2001 Land Use Monitoring

				Mixed Residential					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
	Total Chromium	5	ug/l	11	11	0%	SID	SID	SID
	Dissolved Chromium +6	10	ug/l	11	11	0%	SID	SID	SID
	Total Chromium +6	10	ug/l	11	11	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	11	0	100%	11 209	9 020	0 483
	Total Copper	5	ug/l	11	0	100%	18 604	17 500	0 588
	Dissolved Iron	100	ug/l	11	7	36%	156 727	50.000	1 192
	Total Iron	100	ug/l	11	1	91%	412.091	240.000	1 257
	Dissolved Lead	5	ug/l	11	11	0%	SID	SID	SID
	Total Lead	5	ug/l	11	9	18%	SID	SID	SID
	Dissolved Manganese	100	ug/l	11	11	0%	SID	SID	SID
	Total Manganese	100	ug/l	11	11	0%	SID	SID	SID
	Dissolved Mercury	1	ug/l	11	11	0%	SID	SID	SID
	Total Mercury	1	ug/l	11	11	0%	SID	SID	SID
	Dissolved Nickel	5	ug/l	11	8	27%	4 033	2 500	0 677
	Nickel	5	ug/l	11	8	27%	4 320	2.500	0 726
	Dissolved Selenium	5	ug/l	11	11	0%	SID	SID	SID
	Total Selenium	5	ug/l	11	11	0%	SID	SID	SID
	Dissolved Silver	1	ug/l	11	11	0%	SID	SID	SID
	Total Silver	1	ug/l	11	11	0%	SID	SID	SID
	Dissolved Thallium	5	ug/l	11	11	0%	SID	SID	SID
	Total Thallium	5	ug/l	11	11	0%	SID	SID	SID
	Dissolved Zinc	50	ug/l	11	1	91%	157.027	118 100	0 629
	Total Zinc	50	ug/l	11	0	100%	179.209	120.000	0 575
SVOCs	Bis(2 ethylhexyl)phthalate	1	ug/l	10	1	90%	9 800	5 050	1.287
	All other SVOCs	0 05-5 0	ug/l	10	10	0%			
Pesticides	Glyphosate	25	ug/l	11	11	0%	SID	SID	SID
	All other Pesticides	0.01-25	ug/l	11	11	0%			

Note
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with ½ the detection limit to calculate Mean, Median, and CV

R0012420

Table 4-11. Land Use Constituents Detected Less Than 25% of the Time

Analyte	Station						
	Sawpit Creek	Project 620	Dominguez Channel	Project 1202	Project 474	Project 404	Project 156
Conventionals							
Total Phenols	X		X				
MBAS	X	-	-				
Metals							
Aluminum	d	d	-	d	-	d	d
Antimony	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Arsenic	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Beryllium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Cadmium	d and t	d and t	-	d and t	d and t	d and t	d and t
Chromium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Chromium 6+	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Copper	d	-	-	-	-	-	-
Iron	-	-	-	-	-	d	-
Lead	d and t	d and t	d	d	d and t	d and t	d and t
Manganese	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Mercury	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Nickel	d and t	d and t	-	-	d and t	d	d and t
Selenium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Silver	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Thallium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Zinc	d and t	d and t	-	-	-	-	-
Pesticides							
All Pesticides	X	X	X	X	X	X	X

Notes:
x = constituent which meets the criterion of less than 25% detection in ten consecutive samples
d and t = dissolved and total
d only = dissolved only
- = fails test
blank cell = not enough data to analyze

R0012421

Table 4-12. Summary of Mean Standard Error of Land Use Stations

Station	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
Dominguez	Ammonia	52	0.52	0.78	0.11	0.50	0.75	0.10	0	0.0268		20.7%	Y
Dominguez	Bis(2-ethylhexyl)phthalate	29	13.41	17.30	3.21	14.57	25.95	4.47	0.0001	0.8236	Lognormal	30.7%	N
Dominguez	Dissolved Copper	64	33.55	22.08	2.76	35.44	31.66	3.88	0.0001	0.0097		8.2%	Y
Dominguez	Dissolved Nickel	34	6.54	7.65	1.31	6.13	5.23	0.88	0.0001	0.0001		20.0%	Y
Dominguez	Dissolved Phosphorus	59	3.48	23.78	3.10	0.65	1.10	0.13	0	0.0001		89.0%	N
Dominguez	Dissolved Zinc	64	232.53	214.15	26.77	245.36	260.27	31.48	0.0001	0.0026		11.5%	Y
Dominguez	NH3-N	51	0.40	0.60	0.08	0.39	0.51	0.07	0	0.0128		20.9%	Y
Dominguez	Nitrate	62	3.68	4.09	0.52	3.53	3.20	0.40	0	0.4587	Lognormal	11.2%	Y
Dominguez	Nitrate-N	61	0.94	1.23	0.16	0.89	0.93	0.12	0	0.329	Lognormal	13.0%	Y
Dominguez	Nitrite-N	62	0.11	0.07	0.01	0.11	0.08	0.01	0.0001	0.2892	Lognormal	9.2%	Y
Dominguez	TKN	62	2.08	1.92	0.24	2.01	1.51	0.19	0	0.0504	Lognormal	9.4%	Y
Dominguez	Total Cadmium	38	1.36	1.21	0.20	1.33	1.11	0.18	0.0001	0.0001		14.4%	Y
Dominguez	Total Chromium	43	5.82	5.05	0.77	5.65	4.53	0.68	0.0001	0.0001		13.2%	Y
Dominguez	Total Copper	64	59.15	56.78	7.10	56.99	40.81	5.05	0	0.1021	Lognormal	8.9%	Y
Dominguez	Total Lead	49	12.94	17.91	2.56	12.11	17.49	2.34	0.0001	0.0001		19.8%	Y
Dominguez	Total Nickel	50	8.14	8.26	1.17	7.96	7.17	0.99	0.0001	0.0025		14.3%	Y
Dominguez	Total Phosphorus	59	4.80	33.14	4.31	0.81	1.30	0.16	0	0.0001		89.8%	N
Dominguez	Total Suspended Solids	62	90.24	99.62	12.65	87.29	80.81	10.03	0	0.342	Lognormal	11.5%	Y
Dominguez	Total Zinc	64	325.78	328.17	41.02	312.73	240.90	29.71	0	0.0293		12.6%	Y
Project 1202	Ammonia	55	0.60	0.80	0.11	0.64	1.19	0.14	0.0001	0.001		17.9%	Y
Project 1202	Bis(2-ethylhexyl)phthalate	21	9.71	9.68	2.11	10.78	17.06	3.56	0.0007	0.6052	Lognormal	33.1%	N
Project 1202	Dissolved Copper	49	13.05	9.24	1.32	13.42	11.49	1.61	0.0001	0.1571	Lognormal	12.0%	Y
Project 1202	Dissolved Nickel	33	5.53	4.12	0.72	5.61	4.56	0.78	0.0001	0.0391		13.0%	Y
Project 1202	Dissolved Phosphorus	54	0.21	0.15	0.02	0.22	0.22	0.03	0.0001	0.0247		9.8%	Y
Project 1202	Dissolved Zinc	57	357.14	349.50	46.29	421.24	636.02	78.26	0.0001	0.0001		13.0%	Y
Project 1202	NH3-N	56	0.49	0.66	0.09	0.50	0.86	0.10	0.0001	0.0006		17.7%	Y
Project 1202	Nitrate	56	4.14	4.21	0.56	4.11	4.29	0.56	0.0001	0.8574	Lognormal	13.5%	Y
Project 1202	Nitrate-N	55	0.96	1.12	0.15	0.95	1.08	0.14	0.0001	0.9402	Lognormal	14.8%	Y
Project 1202	Nitrite-N	56	0.10	0.07	0.01	0.10	0.07	0.01	0.0001	0.0797	Lognormal	9.4%	Y
Project 1202	TKN	55	2.63	1.89	0.25	2.67	2.14	0.28	0.0001	0.6165	Lognormal	10.6%	Y
Project 1202	Total Chromium	39	5.89	4.92	0.79	5.77	4.73	0.75	0.0001	0.0001		13.4%	Y
Project 1202	Total Copper	57	42.49	129.27	17.12	31.35	34.17	4.37	0	0.002		40.3%	N
Project 1202	Total Lead	43	13.92	15.74	2.40	13.84	18.71	2.71	0.0001	0.001		17.2%	Y
Project 1202	Total Nickel	43	9.44	12.19	1.86	8.90	7.81	1.17	0.0001	0.0058		19.7%	Y
Project 1202	Total Phosphorus	53	0.35	0.28	0.04	0.37	0.40	0.05	0.0001	0.119	Lognormal	14.5%	Y
Project 1202	Total Suspended Solids	52	181.35	177.94	24.68	188.49	196.54	26.45	0.0001	0.1717	Lognormal	14.0%	Y
Project 1202	Total Zinc	57	483.92	525.52	69.61	478.73	419.49	54.52	0	0.108	Lognormal	11.4%	Y
Project 156	Ammonia	39	0.81	0.86	0.14	0.97	2.00	0.29	0.0001	0.0139		17.0%	Y
Project 156	Dissolved Copper	38	15.11	18.05	2.93	15.10	17.53	2.75	0.0001	0.0362		19.4%	Y
Project 156	Dissolved Phosphorus	36	0.26	0.22	0.04	0.27	0.27	0.04	0.0001	0.4226	Lognormal	16.1%	Y
Project 156	Dissolved Zinc	38	172.38	188.94	30.65	170.56	172.68	27.33	0.0001	0.2628	Lognormal	16.0%	Y

R0012422

Table 4-12. Summary of Mean Standard Error of Land Use Stations

			Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test				
Station	Constituent	No. of Detections	Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution	Distribution*	Error Rate	Is Error Rate Less Than 25%?
Project 156	NH3-N	39	0.67	0.72	0.11	0.79	1.66	0.24	0.0001	0.0018		17.2%	Y
Project 156	Nitrate	35	7.48	26.25	4.44	5.08	8.09	1.28	0.0001	0.0001		59.3%	N
Project 156	Nitrate-N	35	0.67	0.42	0.07	0.73	0.69	0.11	0.0291	0.0017		10.5%	Y
Project 156	Nitrite-N	35	0.17	0.19	0.03	0.16	0.18	0.03	0.0001	0.7781	Lognormal	18.3%	Y
Project 156	TKN	40	3.09	2.44	0.39	3.46	4.11	0.63	0.0001	0.0012		12.5%	Y
Project 156	Total Copper	38	22.31	25.63	4.16	21.41	17.65	2.82	0.0001	0.3303	Lognormal	13.2%	Y
Project 156	Total Phosphorus	36	0.33	0.29	0.05	0.33	0.32	0.05	0.0001	0.6412	Lognormal	15.9%	Y
Project 156	Total Suspended Solids	34	90.24	99.00	16.98	87.00	87.89	14.73	0.0001	0.1781	Lognormal	16.9%	Y
Project 156	Total Zinc	38	233.74	294.10	47.71	217.51	194.13	30.95	0.0001	0.009		20.4%	Y
Project 404	Ammonia	34	0.57	0.75	0.13	0.65	1.49	0.22	0.0001	0.0018		22.5%	Y
Project 404	Bis(2-ethylhexyl)phthalate	22	25.00	48.66	10.38	25.38	81.58	15.24	0.0001	0.8252	Lognormal	60.1%	N
Project 404	Dissolved Copper	35	9.14	6.37	1.08	9.31	7.15	1.20	0.0001	0.0363		11.8%	Y
Project 404	Dissolved Zinc	35	107.25	138.23	23.37	101.47	92.85	15.42	0.0001	0.0219		21.8%	Y
Project 404	NH3-N	34	0.48	0.62	0.11	0.52	1.07	0.16	0.0001	0.0023		22.2%	Y
Project 404	Nitrate	33	7.28	4.36	0.76	7.59	6.22	1.07	0.0543	0.0934	Normal	10.4%	Y
Project 404	Nitrate-N	33	1.64	0.98	0.17	1.71	1.40	0.24	0.0553	0.0939	Normal	10.4%	Y
Project 404	Nitrite-N	33	0.16	0.24	0.04	0.14	0.16	0.03	0.0001	0.0023		25.8%	N
Project 404	TKN	37	2.20	2.23	0.37	2.10	1.46	0.24	0.0001	0.094	Lognormal	11.3%	Y
Project 404	Total Copper	40	13.19	5.99	0.95	13.33	6.52	1.03	0.001	0.1742	Lognormal	7.7%	Y
Project 404	Total Suspended Solids	32	51.50	68.00	12.02	48.66	62.54	10.61	0.0001	0.0958	Lognormal	21.8%	Y
Project 404	Total Zinc	40	155.46	209.50	33.12	144.22	137.98	21.35	0.0001	0.0045		21.3%	Y
Project 474	Ammonia	40	0.48	1.68	0.27	0.31	0.56	0.08	0	0.0001		55.6%	N
Project 474	Bis(2-ethylhexyl)phthalate	10	14.50	15.30	4.84	16.99	30.88	10.17	0.031	0.5983	Lognormal	59.9%	N
Project 474	Dissolved Copper	41	13.70	12.34	1.93	13.74	12.91	1.97	0.0001	0.1549	Lognormal	14.4%	Y
Project 474	Dissolved Phosphorus	37	0.27	0.24	0.04	0.27	0.24	0.04	0.0001	0.78	Lognormal	14.2%	Y
Project 474	Dissolved Zinc	36	82.88	61.42	10.24	84.08	68.59	11.28	0.0001	0.0052		12.4%	Y
Project 474	NH3-N	40	0.40	1.39	0.22	0.25	0.42	0.06	0	0.0001		55.0%	N
Project 474	Nitrate	38	3.12	1.88	0.31	3.17	2.13	0.34	0.0002	0.206	Lognormal	10.8%	Y
Project 474	Nitrate-N	37	0.68	0.38	0.06	0.67	0.37	0.06	0.0001	0.4868	Lognormal	9.0%	Y
Project 474	TKN	39	1.96	1.91	0.31	1.87	1.22	0.19	0.0001	0.0004		15.6%	Y
Project 474	Total Copper	41	25.07	36.33	5.67	22.47	17.18	2.65	0.0001	0.0001		22.6%	Y
Project 474	Total Phosphorus	37	0.31	0.20	0.03	0.31	0.18	0.03	0.0001	0.156	Lognormal	9.7%	Y
Project 474	Total Suspended Solids	39	111.64	95.99	15.37	122.92	150.17	23.10	0.0001	0.1693	Lognormal	18.8%	Y
Project 474	Total Zinc	41	141.18	242.41	37.86	127.05	114.27	17.52	0	0.0024		26.8%	N
Project 620	Ammonia	32	0.56	0.58	0.10	0.64	1.18	0.19	0.0001	0.0097		18.4%	Y
Project 620	Bis(2-ethylhexyl)phthalate	22	11.54	18.43	3.93	10.41	15.08	3.09	0.0001	0.0868	Lognormal	29.7%	N
Project 620	Dissolved Copper	30	11.35	9.08	1.66	11.75	11.89	2.12	0.0004	0.0275		14.6%	Y
Project 620	Dissolved Phosphorus	31	0.36	0.21	0.04	0.37	0.26	0.05	0.0164	0.1976	Lognormal	12.7%	Y
Project 620	NH3-N	32	0.49	0.48	0.08	0.55	0.91	0.15	0.0001	0.0095		17.3%	Y
Project 620	Nitrate	31	4.06	5.54	1.00	4.66	9.02	1.48	0.0001	0.2244	Lognormal	31.7%	N
Project 620	Nitrate-N	31	0.92	1.25	0.22	0.94	1.45	0.24	0.0001	0.826	Lognormal	26.1%	N

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Table 4-12. Summary of Mean Standard Error of Land Use Stations

Station	Constituent	No. of Detections	Normal Distribution			Lognormal Distribution			Shapiro-Wilk Normality Test		Distribution*	Error Rate	Is Error Rate Less Than 25%?
			Mean	Standard Deviation	Standard Error	Mean	Standard Deviation	Standard Error	p-value for Normal Distribution	p-value for Lognormal Distribution			
Project 620	TKN	34	3.41	3.34	0.57	3.36	3.18	0.53	0.0001	0.3445	Lognormal	15.9%	Y
Project 620	Total Copper	36	21.58	15.11	2.52	22.00	17.56	2.89	0.0003	0.4311	Lognormal	13.1%	Y
Project 620	Total Lead	29	14.85	20.80	3.86	14.35	26.36	4.52	0.0001	0.0001		26.0%	N
Project 620	Total Phosphorus	31	0.48	0.31	0.06	0.49	0.40	0.07	0.0097	0.314	Lognormal	14.4%	Y
Project 620	Total Suspended Solids	29	151.97	164.23	30.50	151.92	171.79	31.01	0.0001	0.9666	Lognormal	20.4%	Y
Project 620	Total Zinc	36	72.26	60.75	10.12	72.15	67.43	11.02	0.0001	0.0001		14.0%	Y
Santa Monica	Ammonia	30	6.54	6.46	1.18	8.32	18.85	3.06	0.0003	0.1426	Lognormal	36.8%	N
Santa Monica	Dissolved Chromium +6	26	12.28	9.03	1.77	12.57	10.57	2.05	0.0017	0.8565	Lognormal	16.3%	Y
Santa Monica	Dissolved Copper	26	247.83	590.58	115.82	414.86	3219.04	452.17	0.0001	0.0293		46.7%	N
Santa Monica	Dissolved Phosphorus	31	78.17	75.95	13.64	787.73	26264.38	2415.90	0.0001	0.0001		17.5%	Y
Santa Monica	Dissolved Zinc	22	68.15	69.89	14.90	92.22	259.13	49.32	0.0028	0.0207		21.9%	Y
Santa Monica	NH3-N	27	0.23	0.31	0.06	0.22	0.24	0.05	0.0001	0.17	Lognormal	20.5%	Y
Santa Monica	Nitrate	30	49.40	47.53	8.68	53.60	77.85	13.50	0.0001	0.1083	Lognormal	25.2%	N
Santa Monica	Nitrate-N	30	3.55	3.23	0.59	3.55	3.50	0.63	0.0001	0.1685	Lognormal	17.6%	Y
Santa Monica	Nitrite-N	27	386.03	371.19	71.44	1943.80	24569.04	3072.04	0.0007	0.0001		18.5%	Y
Santa Monica	TKN	32	196.34	216.73	38.31	1009.66	19221.47	1781.57	0.0001	0.0001		19.5%	Y
Santa Monica	Total Cadmium	12	5.59	3.62	1.05	5.73	4.24	1.22	0.0378	0.1708	Lognormal	21.4%	Y
Santa Monica	Total Chromium +6	26	29.77	19.61	3.85	30.33	23.07	4.49	0.0085	0.788	Lognormal	14.8%	Y
Santa Monica	Total Copper	37	714.73	1044.99	171.80	950.54	3720.60	466.62	0.0001	0.0626	Lognormal	49.1%	N
Santa Monica	Total Lead	13	42.46	42.08	11.67	42.70	45.55	12.59	0.0018	0.2252	Lognormal	29.5%	N
Santa Monica	Total Mercury	14	5.20	3.39	0.91	5.46	4.67	1.24	0.0713	0.1699	Normal	17.4%	Y
Santa Monica	Total Phosphorus	32	5.84	2.80	0.49	12.11	41.12	5.89	0.0001	0.0001		8.5%	Y
Santa Monica	Total Suspended Solids	29	11.30	25.91	4.81	10.07	311.76	33.05	0.0001	0.0001		42.6%	N
Santa Monica	Total Zinc	11	251.73	115.79	34.91	255.29	129.70	39.11	0.3026	0.6809	Normal	13.9%	Y
Sawpit	Bis(2-ethylhexyl)phthalate	27	16.74	33.12	6.37	16.03	38.85	6.64	0.0001	0.1434	Lognormal	41.4%	N
Sawpit	Nitrate	42	5.76	3.23	0.50	5.82	3.70	0.57	0.0004	0.0268		8.6%	Y
Sawpit	Nitrate-N	42	1.30	0.73	0.11	1.31	0.84	0.13	0.0004	0.0268		8.7%	Y
Sawpit	Nitrite-N	27	0.04	0.02	0.00	0.04	0.01	0.00	0.0001	0.0393		7.4%	Y
Sawpit	TKN	42	1.17	2.17	0.34	1.00	1.02	0.15	0	0.0114		28.6%	N
Sawpit	Total Copper	32	11.90	14.64	2.59	11.20	13.35	2.28	0.0001	0.0023		21.7%	Y
Sawpit	Total Phosphorus	31	0.11	0.14	0.02	0.11	0.10	0.02	0.0001	0.0077		21.6%	Y
Sawpit	Total Suspended Solids	40	150.13	241.16	38.13	170.40	690.14	81.44	0.0001	0.0098		25.4%	N
Sawpit	Total Zinc	27	42.33	44.79	8.62	39.86	29.42	5.62	0.0001	0.0001		20.4%	Y

* If a constituent is neither normal nor lognormal, we assume that it is normal.

R0012424

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Auto Dismantling Companies - Control						Auto Dismantling Companies - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0 5	mg/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	TPH as Gas	0 5	mg/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Oil and Grease	1	mg/l	3	0	100%	9.53	10.30	0 44	3	0	100%	11 37	11 80	0 11
Indicator Bacteria	Total Coliform	20	MPN/100ml	3	0	100%	3900 00	5000 00	0 49	3	0	100%	20466 67	9000 00	1 26
	Fecal Coliform	20	MPN/100ml	3	0	100%	3420.00	5000 00	0 80	3	0	100%	20466.67	9000 00	1 26
	Fecal Streptococcus	20	MPN/100ml	3	0	100%	16000 00	9000 00	0.76	3	0	100%	643333 33	220000 00	1 29
	Fecal Enterococcus	20	MPN/100ml	3	0	100%	16000 00	9000 00	0 76	3	0	100%	596666 67	140000 00	1 46
General Minerals	COD	5	mg/l	1	0	100%	110 00	110 00	0 00	1	0	100%	59.70	59 70	0 00
	pH	14		1	0	100%	6 46	6 46	0.00	1	0	100%	6 66	6 66	0 00
	Specific Conductance	1	umhos/cm	1	0	100%	136 00	136 00	0 00	1	0	100%	154 00	154 00	0 00
	Total Dissolved Solids	2	mg/l	1	0	100%	88 00	88 00	0 00	1	0	100%	88 00	88 00	0 00
	Suspended Solids	2	mg/l	1	0	100%	67 00	67 00	0.00	1	0	100%	125 00	125 00	0 00
	MBAS	0 05	mg/l	1	0	100%	0.14	0.14	0.00	1	0	100%	0 16	0 16	0 00
	Total Organic Carbon	1	mg/l	1	0	100%	24 42	24 42	0 00	1	0	100%	16 68	16 68	0 00
Metals	Dissolved Aluminum	100	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Aluminum	100	ug/l	1	0	100%	367.00	367.00	0 00	1	0	100%	791.00	791 00	0 00
	Dissolved Cadmium	1	ug/l	1	0	100%	3 36	3.36	0 00	1	0	100%	2.30	2 30	0 00
	Total Cadmium	1	ug/l	1	0	100%	3 36	3 36	0 00	1	0	100%	2 85	2 85	0 00
	Dissolved Chromium	5	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Chromium	5	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	1	0	100%	46 50	46 50	0 00	1	0	100%	31 80	31 80	0 00
	Total Copper	5	ug/l	1	0	100%	48 10	48 10	0 00	1	0	100%	42.50	42.50	0 00
	Dissolved Iron	100	ug/l	1	0	100%	250 00	250 00	0.00	1	0	100%	330 00	330 00	0 00
	Total Iron	100	ug/l	1	0	100%	1030 00	1030 00	0 00	1	0	100%	1840 00	1840 00	0 00
	Dissolved Lead	5	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Lead	5	ug/l	1	0	100%	17 50	17.50	0.00	1	0	100%	32.20	32 20	0 00
	Dissolved Nickel	5	ug/l	1	0	100%	39 50	39 50	0 00	1	1	0%	SID	SID	SID
	Nickel	5	ug/l	1	0	100%	39.50	39 50	0.00	1	0	100%	25.60	25 60	0 00
	Dissolved Zinc	50	ug/l	1	0	100%	325 00	325.00	0 00	1	0	100%	425.00	425 00	0 00
	Total Zinc	50	ug/l	1	0	100%	325.00	325.00	0 00	1	0	100%	425 00	425 00	0 00
SVOCs	Anthracene	0.5	ug/l												
	Benzo(a)anthracene	1	ug/l												
	Benzo(a)pyrene	1	ug/l												
	Benzo(b)fluoranthene	1	ug/l												
	Benzo(k)fluoranthene	1	ug/l												
	Benzyl butyl phthalate	3	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Bis(2-ethylhexyl)phthalate	3	ug/l	3	0	100%	24 73	27.00	0 42	3	0	100%	38 17	40 70	0 60
	Chrysene	1	ug/l												
	Di-n-octylphthalate	3	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l												
	Fluoranthene	1	ug/l												
	Indeno (1,2,3-cd) pyrene	1	ug/l												
	Phenanthrene	0.5	ug/l												
	Pyrene	0.5	ug/l												
	All other SVOCs	0.05-5 0	ug/l	3	3	0%				3	3	0%			

Note: Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012425

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Auto Repair Companies - Control						Auto Repair Companies - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0 5	mg/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	TPH as Gas	0 5	mg/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Oil and Grease	1	mg/l	3	0	100%	6 70	4 10	0 82	3	0	100%	3 73	2 80	0 29
Indicator Bacteria	Total Coliform	20	MPN/100ml	3	0	100%	11966 67	5000 00	1 32	3	0	100%	16333 33	16000 00	0 46
	Fecal Coliform	20	MPN/100ml	3	0	100%	10270 00	700 00	1 66	3	0	100%	15000 00	16000 00	0 61
	Fecal Streptococcus	20	MPN/100ml	3	0	100%	36333 33	50000 00	0 65	3	0	100%	33566 67	9000 00	1 46
	Fecal Enterococcus	20	MPN/100ml	3	0	100%	27000 00	22000 00	0 78	3	0	100%	7590 00	500 00	1 61
General Minerals	COD	5	mg/l	1	0	100%	106 00	106 00	0 00	1	0	100%	31 10	31 10	0 00
	pH	14		1	0	100%	5 83	5 83	0 00	1	0	100%	6 50	6 50	0 00
	Specific Conductance	1	umhos/cm	1	0	100%	146 00	146 00	0 00	1	0	100%	38 60	38 60	0 00
	Total Dissolved Solids	2	mg/l	1	0	100%	90 00	90 00	0 00	1	0	100%	24 00	24 00	0 00
	Suspended Solids	2	mg/l	1	0	100%	63 00	63 00	0 00	1	0	100%	52 00	52 00	0 00
	MBAS	0 05	mg/l	1	0	100%	0 40	0 40	0 00	1	0	100%	0 10	0 10	0 00
	Total Organic Carbon	1	mg/l	1	0	100%	24 75	24 75	0 00	1	0	100%	5 84	5 84	0 00
Metals	Dissolved Aluminum	100	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Aluminum	100	ug/l	1	0	100%	800 00	800 00	0 00	1	0	100%	340 00	340 00	0 00
	Dissolved Cadmium	1	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Cadmium	1	ug/l	1	0	100%	1 51	1 51	0 00	1	1	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Chromium	5	ug/l	1	0	100%	5 18	5.18	0 00	1	1	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	1	0	100%	45 40	45 40	0.00	1	0	100%	22 50	22 50	0 00
	Total Copper	5	ug/l	1	0	100%	69 20	69 20	0 00	1	0	100%	39 50	39 50	0 00
	Dissolved Iron	100	ug/l	1	1	0%	SID	SID	SID	1	1	0%	SID	SID	SID
	Total Iron	100	ug/l	1	0	100%	1970 00	1970 00	0 00	1	0	100%	790 00	790 00	0 00
	Dissolved Lead	5	ug/l	1	1	0%	SID	SID	SID	1	0	100%	36 20	36 20	0 00
	Total Lead	5	ug/l	1	0	100%	21 20	21 20	0 00	1	0	100%	172 00	172 00	0 00
	Dissolved Nickel	5	ug/l	1	0	100%	14 90	14 90	0 00	1	1	0%	SID	SID	SID
	Nickel	5	ug/l	1	0	100%	15 30	15 30	0 00	1	1	0%	SID	SID	SID
	Dissolved Zinc	50	ug/l	1	0	100%	299 00	299 00	0 00	1	0	100%	156 00	156 00	0 00
	Total Zinc	50	ug/l	1	0	100%	350 00	350 00	0 00	1	0	100%	156 00	156 00	0 00
SVOCs	Anthracene	0.5	ug/l												
	Benzo(a)anthracene	1	ug/l												
	Benzo(a)pyrene	1	ug/l												
	Benzo(b)fluoranthene	1	ug/l												
	Benzo(k)fluoranthene	1	ug/l												
	Benzyl butyl phthalate	3	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Bis(2-ethylhexyl)phthalate	3	ug/l	3	0	100%	13 43	6 30	1 06	3	0	100%	12 57	11 30	0 28
	Chrysene	1	ug/l												
	Di-n-octylphthalate	3	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l												
	Fluoranthene	1	ug/l												
	Indeno (1,2,3-cd) pyrene	1	ug/l												
	Phenanthrene	0.5	ug/l												
	Pyrene	0 5	ug/l												
	All other SVOCs	0 05-5 0	ug/l	3	3	0%				3	3	0%			

Note Control = No BMP implemented
Text = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012426

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

Class	Class Constituent	DL	Units	Fabricated Metals Companies - Control						Fabricated Metals Companies - Test					
				No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0.5	mg/l	9	9	0%	SID	SID	SID	5	5	0%	SID	SID	SID
	TPH as Gas	0.5	mg/l	9	9	0%	SID	SID	SID	6	6	0%	SID	SID	SID
	Oil and Grease	1	mg/l	9	1	89%	2.97	1.40	0.92	6	2	67%	2.48	1.55	1.10
Indicator Bacteria	Total Coliform	20	MPN/100ml	9	0	100%	259966.67	160000.00	1.70	6	1	83%	51058.33	8115.00	1.85
	Fecal Coliform	20	MPN/100ml	9	0	100%	130055.56	14000.00	1.77	6	1	83%	22693.33	8055.00	1.55
	Fecal Streptococcus	20	MPN/100ml	9	0	100%	69666.67	22000.00	1.39	6	1	83%	427258.33	1750.00	2.27
	Fecal Enterococcus	20	MPN/100ml	9	0	100%	66088.89	17000.00	1.50	6	1	83%	408613.33	815.00	2.39
General Minerals	COD	5	mg/l	3	0	100%	79.93	85.50	0.55	2	0	100%	144.15	144.15	1.07
	pH	14		3	0	100%	6.07	5.94	0.06	2	0	100%	6.24	6.24	0.04
	Specific Conductance	1	umhos/cm	3	0	100%	87.17	65.30	0.59	2	0	100%	213.35	213.35	1.20
	Total Dissolved Solids	2	mg/l	3	0	100%	50.00	36.00	0.59	2	0	100%	135.00	135.00	1.20
	Suspended Solids	2	mg/l	3	0	100%	77.33	79.00	0.76	2	0	100%	603.00	603.00	1.05
	MBAS	0.05	mg/l	3	0	100%	0.28	0.24	0.64	2	0	100%	0.31	0.31	0.81
	Total Organic Carbon	1	mg/l	3	0	100%	13.40	9.90	0.74	2	0	100%	45.81	45.81	1.28
Metals	Dissolved Aluminum	100	ug/l	3	2	33%	74.67	50.00	0.57	2	0	100%	238.50	238.50	0.80
	Total Aluminum	100	ug/l	3	0	100%	775.00	384.00	1.10	2	0	100%	4348.50	4348.50	1.37
	Dissolved Cadmium	1	ug/l	3	2	33%	0.76	0.50	0.60	2	1	50%	1.66	1.66	0.99
	Total Cadmium	1	ug/l	3	2	33%	0.87	0.50	0.74	2	1	50%	3.15	3.15	1.19
	Dissolved Chromium	5	ug/l	3	2	33%	3.63	2.50	0.54	2	1	50%	4.54	4.54	0.61
	Total Chromium	5	ug/l	3	1	67%	12.90	5.10	1.23	2	0	100%	16.61	16.61	0.80
	Dissolved Copper	5	ug/l	3	0	100%	128.93	164.00	0.52	2	0	100%	465.75	465.75	1.17
	Total Copper	5	ug/l	3	0	100%	221.10	271.00	0.64	2	0	100%	846.00	846.00	1.09
	Dissolved Iron	100	ug/l	3	0	100%	350.00	350.00	0.57	2	0	100%	485.00	485.00	0.95
	Total Iron	100	ug/l	3	0	100%	1596.67	790.00	0.99	2	0	100%	7355.00	7355.00	0.60
	Dissolved Lead	5	ug/l	3	0	100%	36.83	37.60	0.16	2	1	50%	14.80	14.80	1.18
	Total Lead	5	ug/l	3	0	100%	163.37	203.00	0.59	2	0	100%	206.05	206.05	0.84
	Dissolved Nickel	5	ug/l	3	0	100%	19.86	9.00	0.96	2	1	50%	15.00	15.00	1.18
	Nickel	5	ug/l	3	0	100%	21.63	10.30	0.97	2	0	100%	22.06	22.06	0.92
	Dissolved Zinc	50	ug/l	3	0	100%	246.67	190.00	0.64	2	0	100%	2296.00	2296.00	1.11
	Total Zinc	50	ug/l	3	0	100%	288.67	240.00	0.66	2	0	100%	2508.50	2508.50	1.12
SVOCs	Anthracene	0.5	ug/l												
	Benzo(a)anthracene	1	ug/l												
	Benzo(a)pyrene	1	ug/l												
	Benzo(b)fluoranthene	1	ug/l												
	Benzo(k)fluoranthene	1	ug/l												
	Benzyl butyl phthalate	3	ug/l	9	9	0%	SID	SID	SID	5	5	0%	SID	SID	SID
	Bis(2-ethylhexyl)phthalate	3	ug/l	9	0	100%	16.64	13.40	0.57	5	1	80%	22.30	10.10	1.35
	Chrysene	1	ug/l												
	Di-n-octylphthalate	3	ug/l	9	9	0%	SID	SID	SID	5	5	0%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l												
	Fluoranthene	1	ug/l												
	Indeno (1,2,3-cd) pyrene	1	ug/l												
	Phenanthrene	0.5	ug/l												
	Pyrene	0.5	ug/l												
	All other SVOCs	0.05-5.0	ug/l	9	9	0%				5	5	0%			

Note: Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012427

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Motor Freight Companies - Control						Motor Freight Companies - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0.5	mg/l	12	12	0%	SID	SID	SID	20	20	0%	SID	SID	SID
	TPH as Gas	0.5	mg/l	12	12	0%	SID	SID	SID	21	21	0%	SID	SID	SID
	Oil and Grease	1	mg/l	12	1	92%	2.10	1.80	0.56	20	3	85%	7.08	5.50	1.01
Indicator Bacteria	Total Coliform	20	MPN/100ml	12	0	100%	258375.00	125000.00	1.74	21	0	100%	54887.14	14000.00	1.47
	Fecal Coliform	20	MPN/100ml	12	0	100%	163275.00	19500.00	1.73	21	0	100%	28219.05	7000.00	1.76
	Fecal Streptococcus	20	MPN/100ml	12	0	100%	132708.33	70000.00	1.14	21	0	100%	63179.52	16000.00	2.02
	Fecal Enterococcus	20	MPN/100ml	12	0	100%	50851.67	24500.00	1.47	21	0	100%	26937.14	9000.00	1.98
General Minerals	COD	5	mg/l	3	0	100%	38.73	42.20	0.25	3	0	100%	39.73	40.70	0.57
	pH	14		3	0	100%	6.21	5.96	0.07	3	0	100%	6.07	5.90	0.07
	Specific Conductance	1	umhos/cm	3	0	100%	92.03	94.00	0.24	3	0	100%	78.50	81.70	0.17
	Total Dissolved Solids	2	mg/l	3	0	100%	53.33	56.00	0.23	3	0	100%	48.67	46.00	0.51
	Suspended Solids	2	mg/l	3	0	100%	72.67	73.00	0.39	3	0	100%	121.33	147.00	0.70
	MBAS	0.05	mg/l	3	0	100%	0.13	0.15	0.43	3	0	100%	0.15	0.13	0.54
	Total Organic Carbon	1	mg/l	3	0	100%	7.22	7.83	0.36	3	0	100%	8.33	6.41	0.65
Metals	Dissolved Aluminum	100	ug/l	3	3	0%	SID	SID	SID	3	2	33%	79.67	50.00	0.61
	Total Aluminum	100	ug/l	3	0	100%	686.33	635.00	0.51	3	1	67%	272.00	318.00	0.73
	Dissolved Cadmium	1	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Total Cadmium	1	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Total Chromium	5	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	[illegible]	5	ug/l	3	1	67%	7.61	8.83	0.61	3	0	100%	10.87	6.26	0.78
	[illegible]	5	ug/l	3	0	100%	14.23	13.30	0.30	3	0	100%	17.60	15.60	0.49
	[illegible]	100	ug/l	3	0	100%	403.33	320.00	0.40	3	1	67%	153.33	200.00	0.58
	Total Iron	100	ug/l	3	0	100%	873.33	920.00	0.54	3	1	67%	383.33	270.00	1.05
	Dissolved Lead	5	ug/l	3	3	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Total Lead	5	ug/l	3	1	67%	7.74	7.62	0.68	3	1	67%	9.33	12.60	0.63
	Dissolved Nickel	5	ug/l	3	3	0%	SID	SID	SID	3	2	33%	3.81	2.50	0.60
	Nickel	5	ug/l	3	3	0%	SID	SID	SID	3	2	33%	3.93	2.50	0.63
	Dissolved Zinc	50	ug/l	3	0	100%	104.63	110.00	0.22	3	0	100%	221.67	178.00	0.60
	Total Zinc	50	ug/l	3	0	100%	140.03	157.00	0.38	3	0	100%	261.33	245.00	0.51
SVOCs	Anthracene	0.5	ug/l												
	Benzo(a)anthracene	1	ug/l												
	Benzo(a)pyrene	1	ug/l												
	Benzo(b)fluoranthene	1	ug/l												
	Benzo(k)fluoranthene	1	ug/l												
	Benzyl butyl phthalate	3	ug/l	12	12	0%	SID	SID	SID	19	19	0%	SID	SID	SID
	Bis(2-ethylhexyl)phthalate	3	ug/l	12	1	92%	16.05	14.55	0.72	19	1	95%	17.28	11.50	0.94
	Chrysene	1	ug/l												
	Di-n-octylphthalate	3	ug/l	12	12	0%	SID	SID	SID	19	18	5%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l												
	Fluoranthene	1	ug/l												
	Indeno (1,2,3-cd) pyrene	1	ug/l												
	Phenanthrene	0.5	ug/l												
	Pyrene	0.5	ug/l												
	All other SVOCs	0.05-5.0	ug/l	12	12	0%				19	19	0%			

Note: Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012428

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Automobile Dealers - Control						Automobile Dealers - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0 5	mg/l	16	16	0%	SID	SID	SID	8	8	0%	SID	SID	SID
	TPH as Gas	0 5	mg/l	16	16	0%	SID	SID	SID	8	8	0%	SID	SID	SID
	Oil and Grease	1	mg/l	16	2	88%	5 51	3 70	1.07	8	3	63%	2 46	1 45	1 26
Indicator Bacteria	Total Coliform	20	MPN/100ml	16	1	94%	42433 75	6500.00	1.78	5	0	100%	400760 00	160000 00	1 69
	Fecal Coliform	20	MPN/100ml	16	1	94%	38740 00	2700 00	1 98	5	0	100%	328960 00	17000 00	2 16
	Fecal Streptococcus	20	MPN/100ml	16	0	100%	27286 88	900 00	2 79	5	0	100%	70940.00	24000 00	1 15
	Fecal Enterococcus	20	MPN/100ml	16	0	100%	14215 00	600 00	2.96	5	0	100%	70820 00	24000 00	1 16
General Minerals	COD	5	mg/l	3	0	100%	26 30	21.20	0 50	2	0	100%	39 85	39 85	0 51
	pH	14		3	0	100%	6 01	6 06	0 08	2	0	100%	5 94	5 94	0 03
	Specific Conductance	1	umhos/cm	3	0	100%	49.23	42 50	0 30	2	0	100%	36.20	36 20	0 42
	Total Dissolved Solids	2	mg/l	3	0	100%	30.67	26.00	0.38	2	0	100%	21 00	21 00	0 34
	Suspended Solids	2	mg/l	3	0	100%	117.33	125 00	0 33	2	0	100%	46.50	46 50	0 47
	MBAS	0.05	mg/l	3	0	100%	0 12	0 12	0.47	2	0	100%	0 18	0 18	0 57
	Total Organic Carbon	1	mg/l	3	0	100%	4.33	4 43	0 14	2	0	100%	6 31	6 31	0 40
Metals	Dissolved Aluminum	100	ug/l	3	3	0%	SID	SID	SID	2	2	0%	SID	SID	SID
	Total Aluminum	100	ug/l	3	0	100%	633 33	146 00	1 39	2	0	100%	153 00	153 00	0 15
	Dissolved Cadmium	1	ug/l	3	3	0%	SID	SID	SID	2	2	0%	SID	SID	SID
	Total Cadmium	1	ug/l	3	3	0%	SID	SID	SID	2	2	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	3	3	0%	SID	SID	SID	2	2	0%	SID	SID	SID
	Total Chromium	5	ug/l	3	2	33%	3.80	2.50	0 59	2	2	0%	SID	SID	SID
	Dissolved Copper	5	ug/l	3	0	100%	10 75	10 80	0 21	2	0	100%	9 03	9.03	0 34
	Total Copper	5	ug/l	3	0	100%	27.30	15 10	0 81	2	0	100%	11.79	11.79	0 24
	Dissolved Iron	100	ug/l	3	3	0%	SID	SID	SID	2	1	50%	110 00	110 00	0 77
	Total Iron	100	ug/l	3	1	67%	182 67	110 00	0 99	2	0	100%	240 00	240 00	0 00
	Dissolved Lead	5	ug/l	3	3	0%	SID	SID	SID	2	2	0%	SID	SID	SID
	Total Lead	5	ug/l	3	2	33%	11 80	2.50	1.37	2	0	100%	5 50	5 50	0 13
	Dissolved Nickel	5	ug/l	3	3	0%	SID	SID	SID	2	2	0%	SID	SID	SID
	Nickel	5	ug/l	3	2	33%	3.78	2.50	0 59	2	2	0%	SID	SID	SID
	Dissolved Zinc	50	ug/l	3	0	100%	127.33	133.00	0.20	2	1	50%	54 70	54 70	0 77
	Total Zinc	50	ug/l	3	0	100%	187 00	150.00	0 40	2	0	100%	85 70	85.70	0 02
SVOCs	Anthracene	0 5	ug/l												
	Benzo(a)anthracene	1	ug/l												
	Benzo(a)pyrene	1	ug/l												
	Benzo(b)fluoranthene	1	ug/l												
	Benzo(k)fluoranthene	1	ug/l												
	Benzyl butyl phthalate	3	ug/l	16	14	13%	SID	SID	SID	8	8	0%	SID	SID	SID
	Bis(2-ethylhexyl)phthalate	3	ug/l	16	0	100%	49.34	36.45	1.27	8	0	100%	19 08	15.70	0 66
	Chrysene	1	ug/l												
	Di-n-octylphthalate	3	ug/l	16	13	19%	SID	SID	SID	8	8	0%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l												
	Fluoranthene	1	ug/l												
	Indeno (1,2,3-cd) pyrene	1	ug/l												
	Phenanthrene	0.5	ug/l												
	Pyrene	0.5	ug/l												
	All other SVOCs	0.05-5.0	ug/l	16	16	0%				8	8	0%			

Note: Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012429

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Chemical Manufacturing Companies - Control						Chemical Manufacturing Companies - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0 5	mg/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	TPH as Gas	0 5	mg/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Oil and Grease	1	mg/l	7	2	71%	1 87	1 90	0 66	10	2	80%	4 41	3 20	1 01
Indicator Bacteria	Total Coliform	20	MPN/100ml	7	0	100%	142028 57	800 00	2 36	10	0	100%	130500 00	59000 00	1 23
	Fecal Coliform	20	MPN/100ml	7	0	100%	20651 43	270 00	2 55	10	0	100%	36320 00	17000 00	1 48
	Fecal Streptococcus	20	MPN/100ml	7	0	100%	26257 14	1300 00	2 26	10	0	100%	193570 00	115000 00	1 70
	Fecal Enterococcus	20	MPN/100ml	7	0	100%	26084 29	1300 00	2 28	10	0	100%	193570 00	115000 00	1 70
General Minerals	COD	5	mg/l	3	0	100%	55 40	44 80	0 65	4	0	100%	48 10	47 55	0 38
	pH	14		10	0	100%	6 37	6 58	0 07	14	0	100%	6 36	6 33	0 05
	Specific Conductance	1	umhos/cm	10	0	100%	114 33	78 60	0 95	14	0	100%	73 81	70 35	0 51
	Total Dissolved Solids	2	mg/l	3	0	100%	68 67	50 00	0 47	4	0	100%	40 75	39 00	0 40
	Suspended Solids	2	mg/l	3	0	100%	72 33	14 00	1 54	4	0	100%	167.25	114 00	0 92
	MBAS	0 05	mg/l	3	0	100%	0 13	0 12	0 09	4	0	100%	0 15	0 16	0 38
	Total Organic Carbon	1	mg/l	3	0	100%	9 17	8 27	0 30	4	0	100%	7 40	6 80	0 42
Metals	Dissolved Aluminum	100	ug/l	3	2	33%	155 00	50 00	1 17	4	4	0%	SID	SID	SID
	Total Aluminum	100	ug/l	3	1	67%	1255 67	397 00	1 43	4	1	75%	741 50	618 00	0 95
	Dissolved Cadmium	1	ug/l	3	3	0%	SID	SID	SID	4	4	0%	SID	SID	SID
	Total Cadmium	1	ug/l	3	3	0%	SID	SID	SID	4	4	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	3	3	0%	SID	SID	SID	4	4	0%	SID	SID	SID
	Total Chromium	5	ug/l	3	2	33%	4 45	2 50	0 76	4	3	25%	3 59	2 50	0 61
	Dissolved Copper	5	ug/l	3	0	100%	8 68	8 34	0 28	4	0	100%	12 55	12 85	0 34
	Total Copper	5	ug/l	3	0	100%	18 13	14 40	0 47	4	0	100%	22 83	21 75	0 40
	Dissolved Iron	100	ug/l	3	1	67%	210 00	120 00	1 04	4	1	75%	297 50	320 00	0 62
	Total Iron	100	ug/l	3	0	100%	2600 00	520 00	1 49	4	0	100%	1587 50	1020 00	1 15
	Dissolved Lead	5	ug/l	3	3	0%	SID	SID	SID	4	4	0%	SID	SID	SID
	Total Lead	5	ug/l	3	1	67%	10 17	5 00	1 10	4	2	50%	8 34	5 72	0 96
	Dissolved Nickel	5	ug/l	3	3	0%	SID	SID	SID	4	4	0%	SID	SID	SID
	Nickel	5	ug/l	3	2	33%	4 87	2.50	0 84	4	2	50%	4 76	4 38	0 56
	Dissolved Zinc	50	ug/l	3	0	100%	254 33	224 00	0 51	4	0	100%	124.25	120 00	0 52
	Total Zinc	50	ug/l	3	0	100%	323.00	369 00	0 38	4	0	100%	187.25	173 00	0 12
SVOCs	Anthracene	0.5	ug/l	7	7	0%	SID	SID	SID	10	9	10%	SID	SID	SID
	Benzo(a)anthracene	1	ug/l	7	7	0%	SID	SID	SID	10	8	20%	0 90	0 50	1 16
	Benzo(a)pyrene	1	ug/l	7	7	0%	SID	SID	SID	10	8	20%	1 12	0 50	1 46
	Benzo(b)fluoranthene	1	ug/l	7	7	0%	SID	SID	SID	10	9	10%	SID	SID	SID
	Benzo(k)fluoranthene	1	ug/l	7	7	0%	SID	SID	SID	10	8	20%	0.95	0 50	1 15
	Benzyl butyl phthalate	3	ug/l												
	Bis(2-ethylhexyl)phthalate	3	ug/l	7	0	100%	46.57	15.70	1 80	10	0	100%	10.23	7 00	0 57
	Chrysene	1	ug/l	7	7	0%	SID	SID	SID	10	8	20%	1 07	0 50	1 27
	Di-n-octylphthalate	3	ug/l	7	7	0%	SID	SID	SID	10	10	0%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l	7	7	0%	SID	SID	SID	10	9	10%	SID	SID	SID
	Fluoranthene	1	ug/l	7	7	0%	SID	SID	SID	10	8	20%	1 55	0 50	1 64
	Indeno (1,2,3-cd) pyrene	1	ug/l	7	7	0%	SID	SID	SID	10	8	20%	0 83	0.50	0 94
	Phenanthrene	0.5	ug/l	7	7	0%	SID	SID	SID	10	8	20%	0.64	0 25	1 48
	Pyrene	0.5	ug/l	7	7	0%	SID	SID	SID	10	8	20%	1.21	0 25	1 87
	All other SVOCs	0 05-5 0	ug/l	7	7	0%				10	10	0%			

Note. Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012430

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Machinery Manufacturing Companies - Control						Machinery Manufacturing Companies - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0 5	mg/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	TPH as Gas	0 5	mg/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Oil and Grease	1	mg/l	6	0	100%	4 88	4.20	0 62	7	3	57%	1.29	1 00	0 78
Indicator Bacteria	Total Coliform	20	MPN/100ml	6	0	100%	72371 67	15000 00	1 60	7	0	100%	1232 86	700 00	1 41
	Fecal Coliform	20	MPN/100ml	6	0	100%	71871 67	15000 00	1.62	7	0	100%	445.71	210 00	1 75
	Fecal Streptococcus	20	MPN/100ml	6	0	100%	2050.00	800 00	1 68	7	0	100%	2968.57	700 00	1 96
	Fecal Enterococcus	20	MPN/100ml	6	0	100%	2005 00	765 00	1.74	7	0	100%	1137.14	500 00	1 55
General Minerals	COD	5	mg/l	2	0	100%	107.35	107 35	0 94	3	0	100%	30 97	23 10	0 81
	pH	14		8	0	100%	6 40	6 37	0 06	10	0	100%	6 27	6 47	0 06
	Specific Conductance	1	umhos/cm	8	0	100%	63.93	57.75	0 41	10	0	100%	42 56	42 25	0 47
	Total Dissolved Solids	2	mg/l	2	0	100%	34.00	34.00	0 25	3	0	100%	33 00	36 00	0 18
	Suspended Solids	2	mg/l	2	0	100%	118 00	118.00	0.11	3	0	100%	112 00	108 00	0 20
	MBAS	0.05	mg/l	2	0	100%	0 14	0 14	0.39	3	0	100%	0 10	0 11	0 27
	Total Organic Carbon	1	mg/l	2	0	100%	6 63	6 63	0 03	2	0	100%	4.52	4 52	0 19
Metals	Dissolved Aluminum	100	ug/l	2	2	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Total Aluminum	100	ug/l	2	1	50%	102 00	102.00	0 72	3	2	33%	84.00	50 00	0 70
	Dissolved Cadmium	1	ug/l	2	0	100%	1.78	1.78	0.21	3	3	0%	SID	SID	SID
	Total Cadmium	1	ug/l	2	0	100%	1.97	1.97	0.16	3	3	0%	SID	SID	SID
	Dissolved Chromium	5	ug/l	2	2	0%	SID	SID	SID	3	0	100%	63 10	55.30	0 36
	Total Chromium	5	ug/l	2	2	0%	SID	SID	SID	3	0	100%	80 63	95 70	0 38
	Dissolved Copper	5	ug/l	2	0	100%	21 55	21.55	0 17	3	0	100%	10.01	10.20	0 33
	Total Copper	5	ug/l	2	0	100%	27.40	27 40	0.11	3	0	100%	14.30	13 90	0 07
	Dissolved Iron	100	ug/l	2	2	0%	SID	SID	SID	3	1	67%	96.67	110 00	0 43
	Total Iron	100	ug/l	2	0	100%	225 00	225 00	0.09	3	1	67%	136 67	170.00	0 55
	Dissolved Lead	5	ug/l	2	2	0%	SID	SID	SID	3	2	33%	4.81	2 50	0 83
	Total Lead	5	ug/l	2	1	50%	4.15	4.15	0 56	3	1	67%	6 25	5 56	0 66
	Dissolved Nickel	5	ug/l	2	2	0%	SID	SID	SID	3	0	100%	8.79	8 43	0 22
	Nickel	5	ug/l	2	2	0%	SID	SID	SID	3	0	100%	9 07	8 45	0 24
	Dissolved Zinc	50	ug/l	2	0	100%	112.00	112.00	0 23	3	1	67%	65 33	73 00	0 57
	Total Zinc	50	ug/l	2	0	100%	133 35	133 35	0.37	3	0	100%	101 10	89 90	0 20
SVOCs	Anthracene	0 5	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Benzo(a)anthracene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Benzo(a)pyrene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Benzo(b)fluoranthene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Benzo(k)fluoranthene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Benzyl butyl phthalate	3	ug/l												
	Bis(2-ethylhexyl)phthalate	3	ug/l	6	0	100%	16.25	15.10	0.50	7	2	71%	16 93	6.50	1 41
	Chrysene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Di-n-octylphthalate	3	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Fluoranthene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Indeno (1,2,3-cd) pyrene	1	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Phenanthrene	0 5	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	Pyrene	0.5	ug/l	6	6	0%	SID	SID	SID	7	7	0%	SID	SID	SID
	All other SVOCs	0 05-5 0	ug/l	6	6	0%				7	7	0%			

Note: Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012431

Table 4-13. 2000-2001 Critical Source Statistical Results by Category

				Rubber/Miscellaneous Plastics Companies - Control						Rubber/Miscellaneous Plastics Companies - Test					
Class	Class Constituent	DL	Units	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV	No. of Samples	No. of Non-detects	Percent Detects	Mean	Median	CV
Miscellaneous Constituents	TPH as Diesel	0 5	mg/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	TPH as Gas	0 5	mg/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Oil and Grease	1	mg/l	4	0	100%	1 18	1 10	0 19	9	5	44%	0 84	0 50	0 80
Indicator Bacteria	Total Coliform	20	MPN/100ml	4	0	100%	1750 00	1750 00	0 66	9	0	100%	143444 44	110000 00	1 07
	Fecal Coliform	20	MPN/100ml	4	0	100%	977 50	400 00	1 39	9	0	100%	94111 11	110000 00	0 82
	Fecal Streptococcus	20	MPN/100ml	4	0	100%	9150 00	2900 00	1 53	9	0	100%	27600 00	30000 00	0 86
	Fecal Enterococcus	20	MPN/100ml	4	0	100%	8650 00	1900 00	1 65	9	0	100%	15411 11	17000 00	0 87
General Minerals	COD	5	mg/l	2	0	100%	117 35	117 35	0 69	3	0	100%	39 97	41 20	0 36
	pH	14		6	0	100%	5 93	5 78	0 08	12	0	100%	6 43	6 49	0 04
	Specific Conductance	1	umhos/cm	6	0	100%	36 90	25 50	0 60	12	0	100%	92 08	82 40	0 43
	Total Dissolved Solids	2	mg/l	2	0	100%	24 00	24 00	0 47	3	0	100%	55 33	60 00	0 21
	Suspended Solids	2	mg/l	2	0	100%	167 50	167 50	0 76	3	0	100%	93 33	96 00	0 87
	MBAS	0 05	mg/l	2	0	100%	0 27	0 27	0 55	3	0	100%	0 12	0 11	0 17
	Total Organic Carbon	1	mg/l	2	0	100%	6 39	6 39	0 67	3	0	100%	7 54	6 30	0 46
Metals	Dissolved Aluminum	100	ug/l	2	2	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Total Aluminum	100	ug/l	2	0	100%	172 50	172 50	0 14	3	0	100%	423 33	190 00	1 13
	Dissolved Cadmium	1	ug/l	2	2	0%	SID	SID	SID	3	0	100%	2 90	2 37	0 41
	Total Cadmium	1	ug/l	2	2	0%	SID	SID	SID	3	0	100%	3 88	2 51	0 70
	Dissolved Chromium	5	ug/l	2	2	0%	SID	SID	SID	3	2	33%	3 74	2 50	0 57
	Total Chromium	5	ug/l	2	2	0%	SID	SID	SID	3	2	33%	4 23	2 50	0 71
	Dissolved Copper	5	ug/l	2	0	100%	9 10	9 10	0 36	3	1	67%	10 88	8 35	0 91
	Total Copper	5	ug/l	2	0	100%	12 65	12 65	0 23	3	0	100%	17 83	13 30	0 47
	Dissolved Iron	100	ug/l	2	1	50%	130 00	130 00	0 87	3	1	67%	200 00	240 00	0 67
	Total Iron	100	ug/l	2	0	100%	280 00	280 00	0 10	3	0	100%	400 00	340 00	0 74
	Dissolved Lead	5	ug/l	2	2	0%	SID	SID	SID	3	3	0%	SID	SID	SID
	Total Lead	5	ug/l	2	2	0%	SID	SID	SID	3	2	33%	6 37	2 50	1 05
	Dissolved Nickel	5	ug/l	2	2	0%	SID	SID	SID	3	0	100%	9 70	8 10	0 52
	Nickel	5	ug/l	2	2	0%	SID	SID	SID	3	0	100%	10 67	10 80	0 46
	Dissolved Zinc	50	ug/l	2	0	100%	111 50	111 50	0 15	3	0	100%	138 00	140 00	0 08
	Total Zinc	50	ug/l	2	0	100%	141 50	141 50	0 04	3	0	100%	153 00	150 00	0 19
SVOCs	Anthracene	0 5	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Benzo(a)anthracene	1	ug/l	4	4	0%	SID	SID	SID	9	8	11%	SID	SID	SID
	Benzo(a)pyrene	1	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Benzo(b)fluoranthene	1	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Benzo(k)fluoranthene	1	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Benzyl butyl phthalate	3	ug/l												
	Bis(2-ethylhexyl)phthalate	3	ug/l	4	2	50%	9 93	3 20	1 48	9	2	78%	15 34	7 80	1 62
	Chrysene	1	ug/l	4	4	0%	SID	SID	SID	9	8	11%	SID	SID	SID
	Di-n-octylphthalate	3	ug/l	4	4	0%	SID	SID	SID	9	8	11%	SID	SID	SID
	Dibenz(a,h)anthracene	1	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Fluoranthene	1	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Indeno (1,2,3-cd) pyrene	1	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Phenanthrene	0.5	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	Pyrene	0.5	ug/l	4	4	0%	SID	SID	SID	9	9	0%	SID	SID	SID
	All other SVOCs	0 05-5 0	ug/l	4	4	0%				9	9	0%			

Note: Control = No BMP implemented
Test = BMP implemented
CV = Coefficient of variation
DL = Detection Limit
SID = Statistically Invalid Data
Non-detects are replaced with half the detection limit to calculate Mean, Median, and CV

R0012432

Table 4-14. Installed Critical Source BMPs for the 2000-2001 Storm Season

BMP EQUIPMENT/SUPPLIES	WHOLESALE TRADE INDUSTRIES			AUTO REPAIR INDUSTRIES			METAL FABRICATION INDUSTRIES			MOTOR FREIGHT INDUSTRIES			AUTO DEALERSHIP INDUSTRIES		
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15
OIL ABSORBENT FABRICS	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
65 GALLON SALVAGE DRUMS	x	x	x	x	x	x									
SPILL CONTROL PALLETS	x	x	x	x	x	x									
2-DRUM POLY PALLETS	x	x	x	x	x	x									
TARPS	x	x	x	x	x	x									
SAFETY DRUM FUNNEL	x	x	x	x	x	x									
CLEANERS/DEGREASERS	x	x	x	x	x	x									
8' OIL BOOMS	x	x	x	x	x	x				x	x	x	x	x	
COMMERCIAL SHELVING	x	x	x	x	x	x									
ABSORBENT DRUM COVERS	x	x	x	x	x	x									
DRUM PALLETS	x	x	x												
CANOPY		x						x					x	x	
SAND ABSORBENTS							x	x	x	x	x	x	x	x	x
POWERFUL MAGNETS							x	x	x						
DRIP PANS							x	x	x	x	x	x	x	x	x
WOODEN PALLETS							x	x	x						
SELF PROPELLED VACUUM SWEEPER										x	x	x			

Table 5-1a. Station-Constituents Recommended for Discontinuation of Monitoring Mass Emission Stations

Analyte	Stations				
	Ballona Creek	Malibu Creek	Los Angeles River	Coyote Creek	San Gabriel River
Conventionals					
Cyanide	X	X	-	-	X
TPH	-	X	-	-	X
Total Phenols	X	X	X	X	X
MBAS	-	X	-	-	-
Metals					
Aluminum	d	d	d	d	d
Antimony	d and t	d and t	d and t	d and t	d and t
Arsenic	d and t	d and t	d and t	d and t	d and t
Beryllium	d and t	d and t	d and t	d and t	d and t
Cadmium	d and t	d and t	d and t	d and t	d and t
Chromium	d and t	d and t	d and t	d and t	d and t
Chromium 6+	d and t	d and t	d and t	d and t	d and t
Copper	-	d	-	-	d
Lead	d and t	d and t	d	d and t	d and t
Manganese	d and t	d and t	d	d and t	d and t
Mercury	d and t	d and t	d and t	d and t	d and t
Nickel	-	-	-	d	-
Selenium	d and t	d and t	d and t	d and t	d and t
Silver	d and t	d and t	d and t	d and t	d and t
Thallium	d and t	d and t	d and t	d and t	d and t
Pesticides					
All Pesticides					
Diazinon	X	X	X	X	X

Notes:
x = constituent which meets the criterion of less than 25% detection in ten consecutive samples
d and t = dissolved and total
d only = dissolved only
- = fails test
blank cell = not enough data to analyze

R0012434

Table 5-1b. Station Constituents Recommended for Discontinuation of Monitoring
Land Use Stations

Analyte	Stations						
	Sawpit Creek	Project 620	Dominguez Channel	Project 1202	Project 474	Project 404	Project 156
Conventionals							
Total Phenols	X		X				
MBAS	X	-	-				
Metals							
Aluminum	d	d	-	d	-	d	d
Antimony	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Arsenic	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Beryllium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Cadmium	d and t	d and t	-	d and t	d and t	d and t	d and t
Chromium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Chromium 6+	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Copper	d	-	-	-	-	-	-
Iron	-	-	-	-	-	d	-
Lead	d and t	d and t	d	d	d and t	d and t	d and t
Manganese	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Mercury	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Nickel	d and t	d and t	-	-	d and t	d	d and t
Selenium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Silver	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Thallium	d and t	d and t	d and t	d and t	d and t	d and t	d and t
Zinc	d and t	d and t	-	-	-	-	-
Pesticides							
All Pesticides	X	X	X	X	X	X	X

Notes:
x = constituent which meets the criterion of less than 25% detection in ten consecutive samples
d and t = dissolved and total
d only = dissolved only
- = fails test
blank cell = not enough data to analyze

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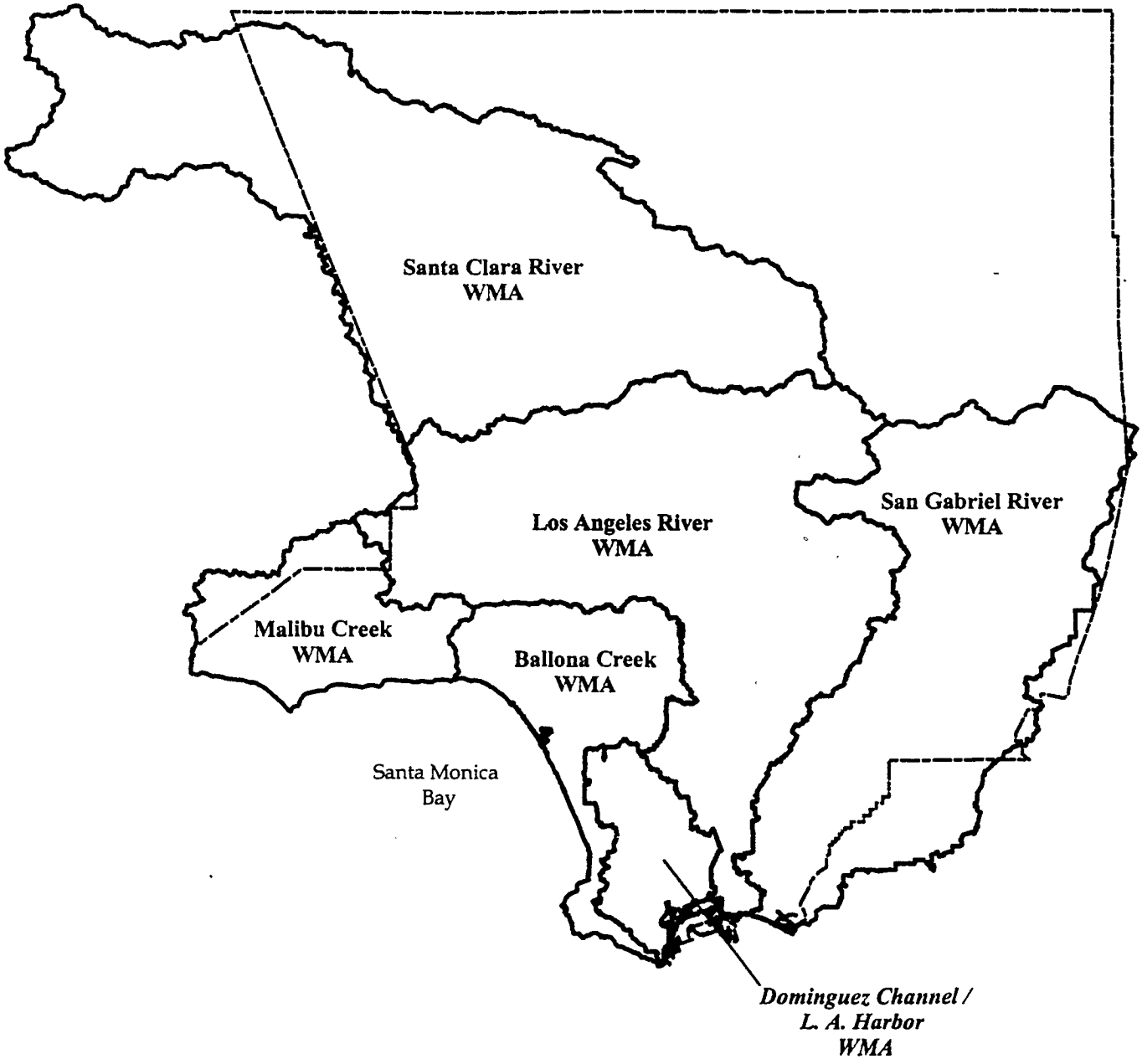

Figure 1-1

Los Angeles County 1996 Municipal NPDES Stormwater Permit Area

N
W E
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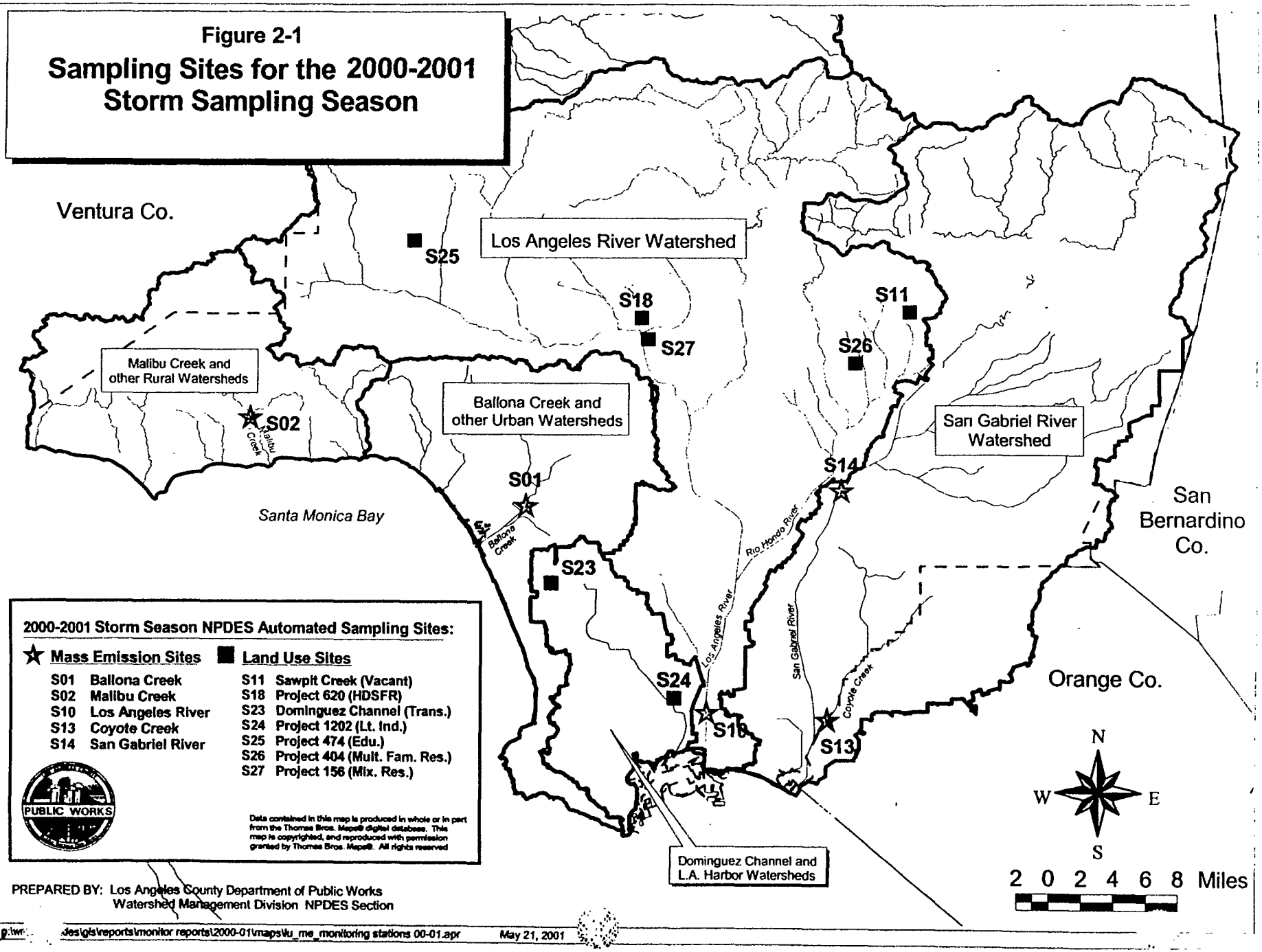
0 3 6 9 12 15 Miles

R0012436

Figure 2-1
Sampling Sites for the 2000-2001 Storm Sampling Season



2000-2001 Storm Season NPDES Automated Sampling Sites:

Mass Emission Sites

S01	Ballona Creek
S02	Malibu Creek
S10	Los Angeles River
S13	Coyote Creek
S14	San Gabriel River

Land Use Sites

S11	Sawpit Creek (Vacant)
S18	Project 620 (HDSFR)
S23	Dominguez Channel (Trans.)
S24	Project 1202 (Lt. Ind.)
S25	Project 474 (Edu.)
S26	Project 404 (Mult. Fam. Res.)
S27	Project 156 (Mix. Res.)

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PREPARED BY: Los Angeles County Department of Public Works
Watershed Management Division NPDES Section

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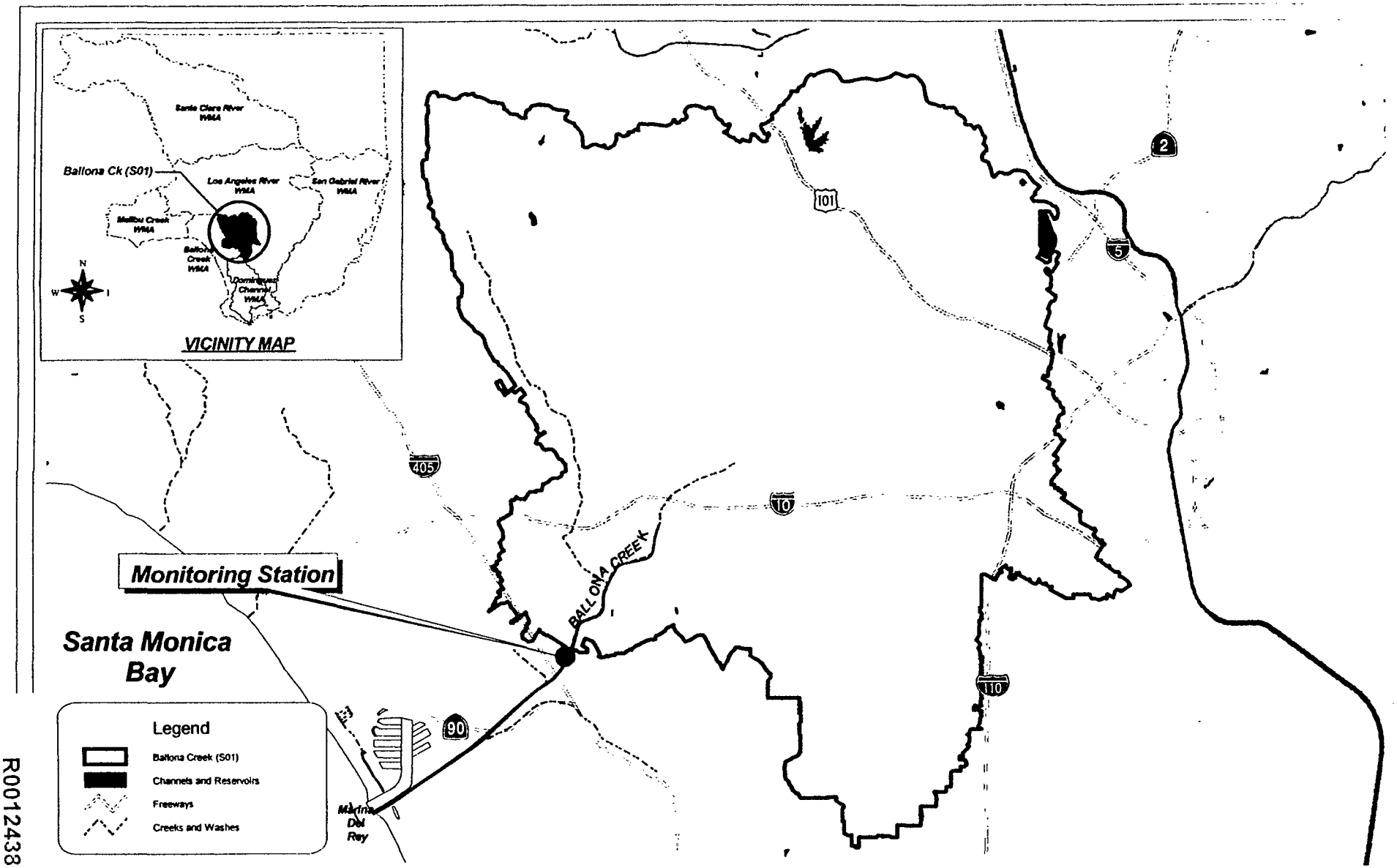

R0012438

Figure 2-2

BALLONA CREEK (S01)
at Sawtelle Blvd.
Los Angeles
(Mass Emission Monitoring Site)
1990 Population = 1.5 Million

Land Use Distribution	Area (Acres)	Percent
High Density Residential	22,722	40 0%
Light Industrial	1,959	3 5%
Vacant	6,303	11 1%
Retail/Commercial	5,646	9 9%
Multi-Family Residential	7,009	12 3%
Transportation	851	1 5%
Education	1,556	2 7%
Mixed Residential	3,810	6 7%
Other	6,988	12 3%
Total	56,844	100 0%

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N W E S

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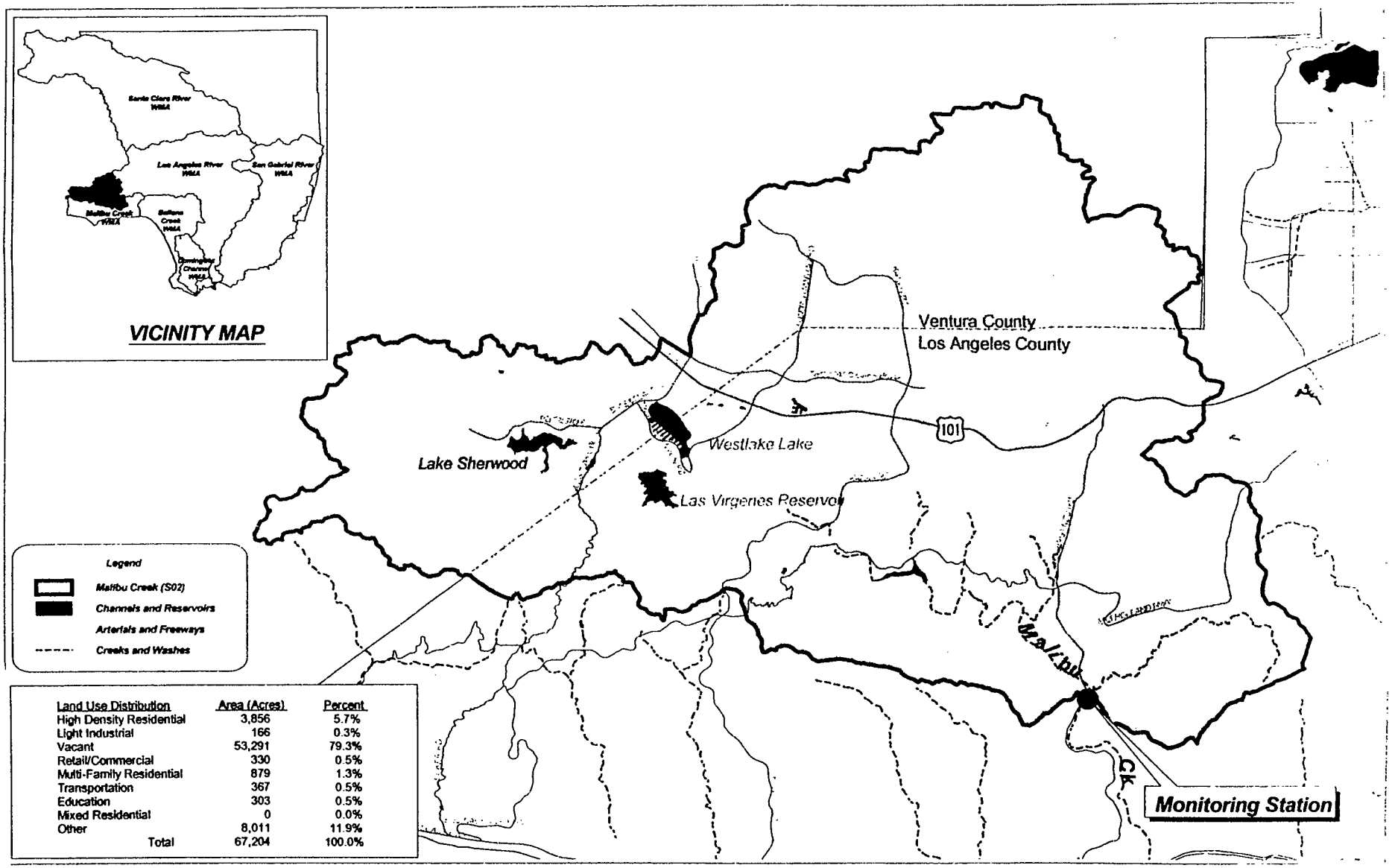

Land Use Distribution	Area (Acres)	Percent
High Density Residential	3,856	5.7%
Light Industrial	166	0.3%
Vacant	53,291	79.3%
Retail/Commercial	330	0.5%
Multi-Family Residential	879	1.3%
Transportation	367	0.5%
Education	303	0.5%
Mixed Residential	0	0.0%
Other	8,011	11.9%
Total	67,204	100.0%

R0012439

Figure 2-3

MALIBU CREEK (S02) at Piuma Rd.

Unincorporated L.A. County (Mass Emission Monitoring Site)

199[illegible] Population = 64,000

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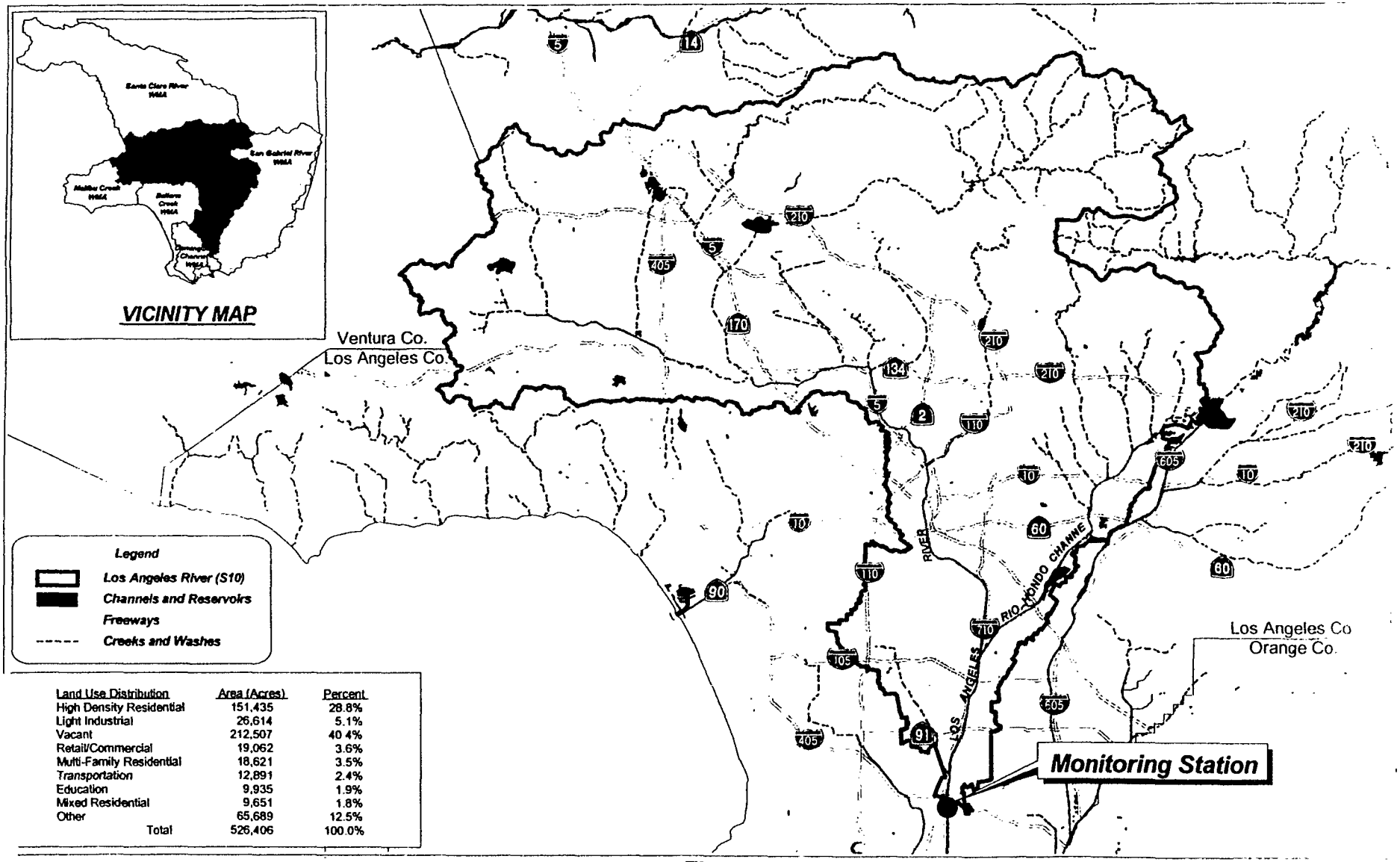

Land Use Distribution	Area (Acres)	Percent
High Density Residential	151,435	28.8%
Light Industrial	26,614	5.1%
Vacant	212,507	40.4%
Retail/Commercial	19,062	3.6%
Multi-Family Residential	18,621	3.5%
Transportation	12,891	2.4%
Education	9,935	1.9%
Mixed Residential	9,651	1.8%
Other	65,689	12.5%
Total	526,406	100.0%

R0012440

Figure 2-4

LOS ANGELES RIVER (S10)
at Wardlow Rd.
Long Beach
(Mass Emission Monitoring Site)
1990 Population = 4.2 Million

N W E S

5 0 5 Miles

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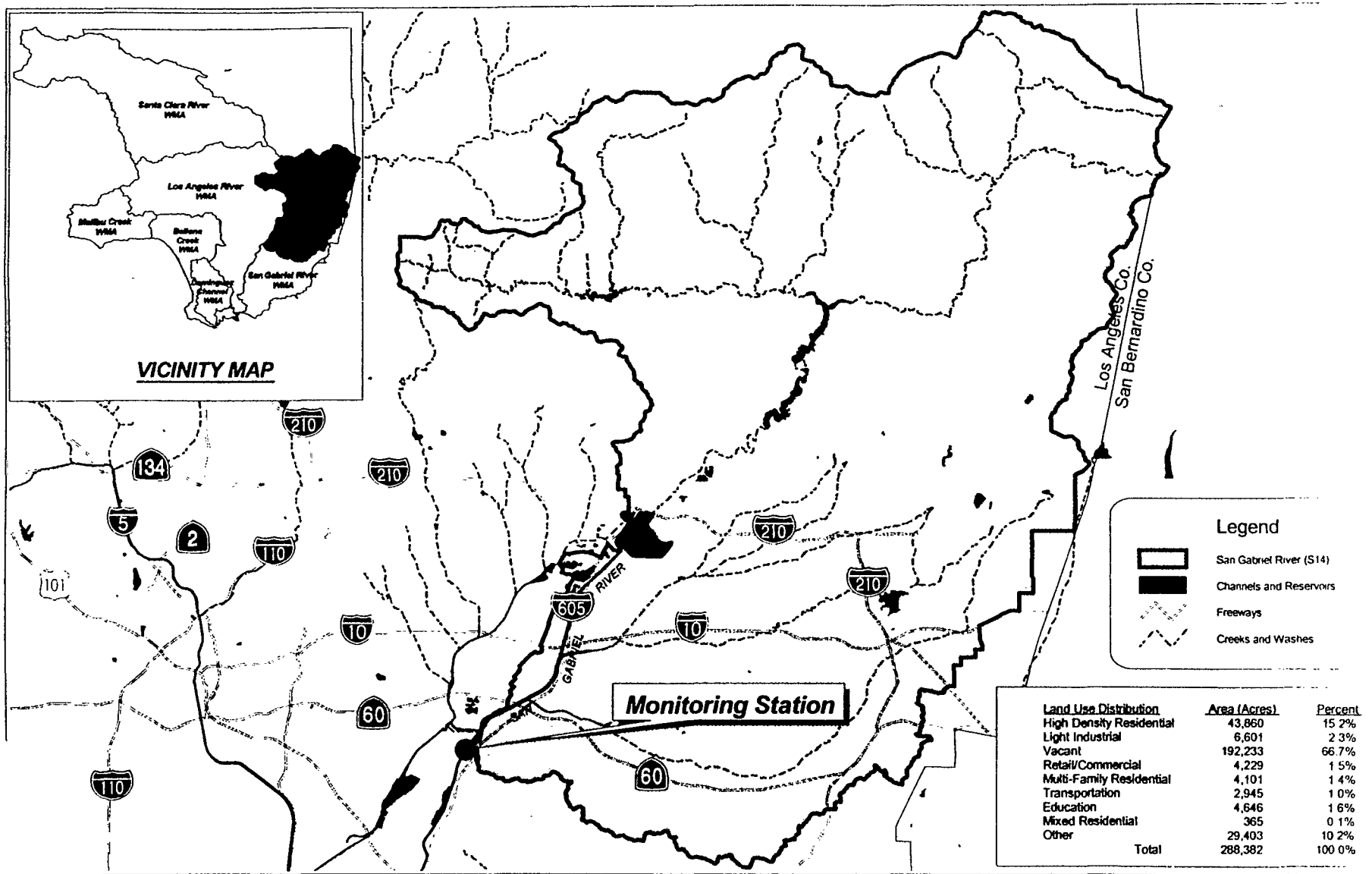

Figure 2-5

SAN GABRIEL RIVER (S14) at San Gabriel Pkwy.

Pico Rivera

(Mass Emission Monitoring Site)

1990 Population = 844,000

LOS ANGELES COUNTY PUBLIC WORKS Public Service That Works

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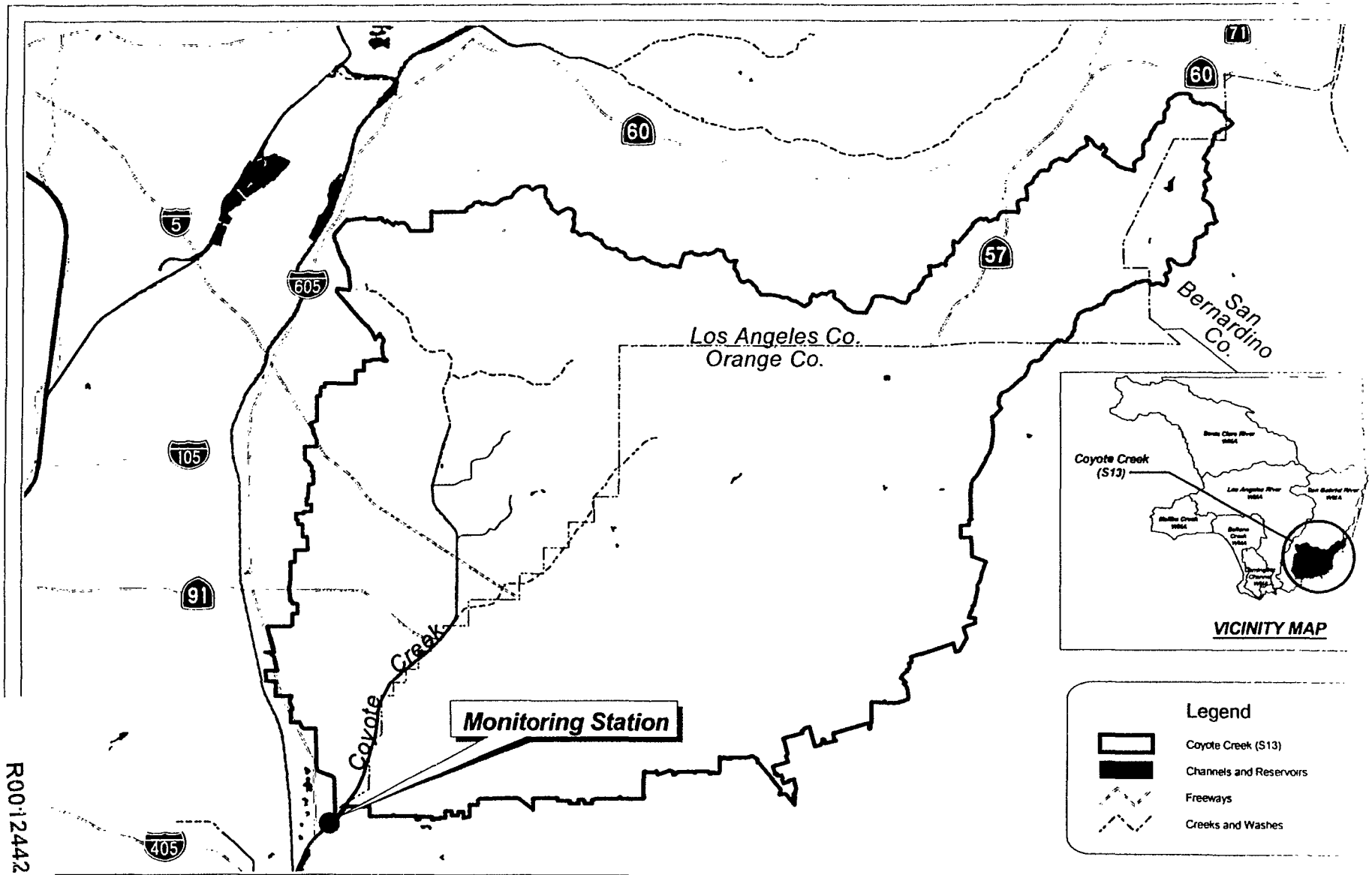

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Figure 2-6

COYOTE CREEK (S13) at Spring St.

Long Beach

(Mass Emission Monitoring Site)

1990 Population = 876,000

Land Use Distribution	Area (Acres)	Percent
High Density Residential	36,402	38 3%
Light Industrial	8,000	8 4%
Vacant	13,550	14 3%
Retail/Commercial	5,366	5 6%
Multi-Family Residential	5,836	6 1%
Transportation	1,718	1 8%
Education	4,129	4 3%
Mixed Residential	155	0 2%
Other	19,954	21 0%
Total	95,111	100 0%

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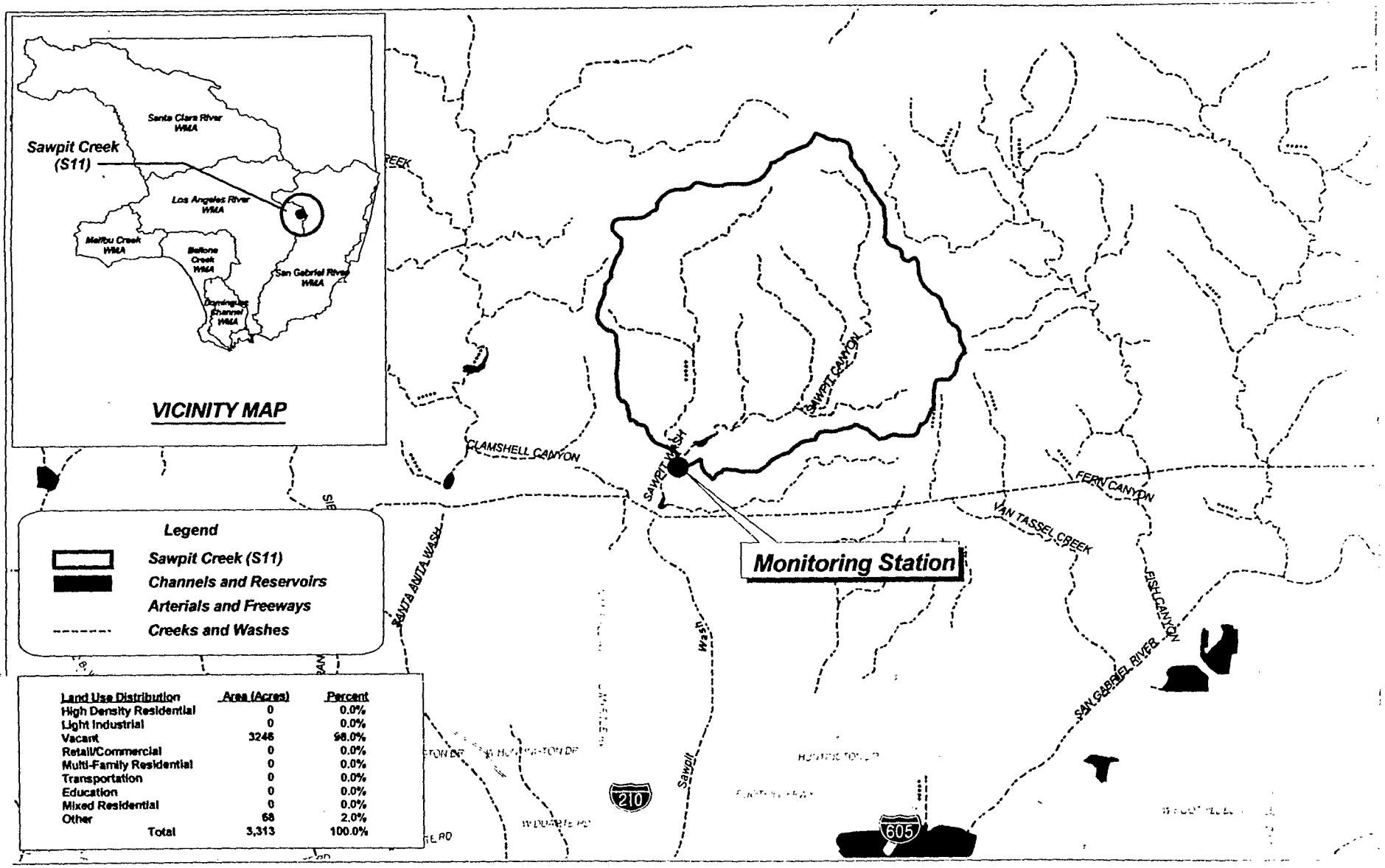

Land Use Distribution	Area (Acres)	Percent
High Density Residential	0	0.0%
Light Industrial	0	0.0%
Vacant	3248	98.0%
Retail/Commercial	0	0.0%
Multi-Family Residential	0	0.0%
Transportation	0	0.0%
Education	0	0.0%
Mixed Residential	0	0.0%
Other	68	2.0%
Total	3,313	100.0%

Figure 2-7

SAWPIT CREEK (S11) at Monrovia Cr.

Monrovia

(Vacant Land Use Monitoring Site)

1990 Population = 2,000

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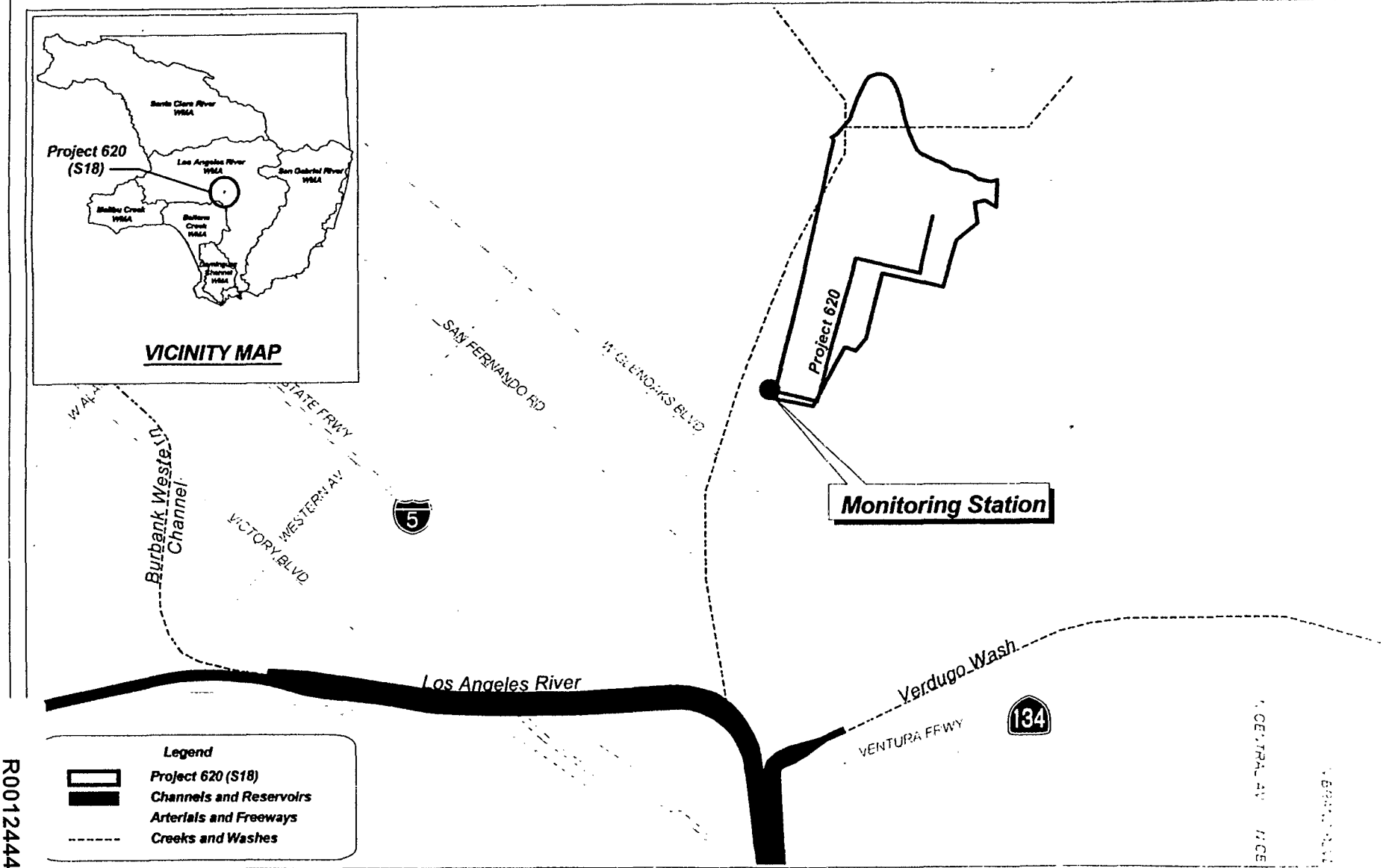

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N W E S

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Figure 2-8

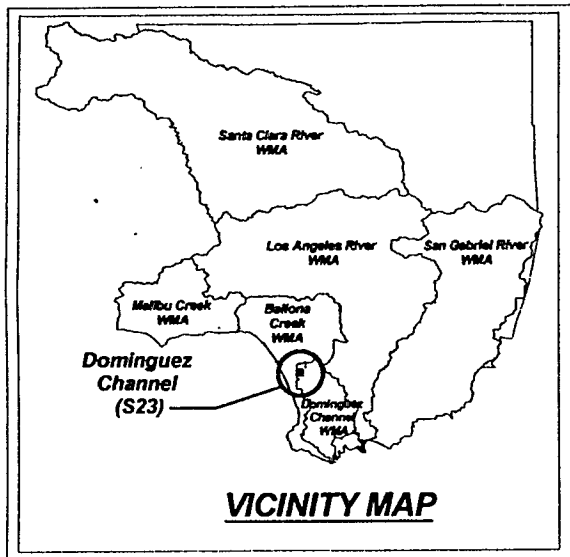
PROJECT 620 (S18) at Glenwood Rd.

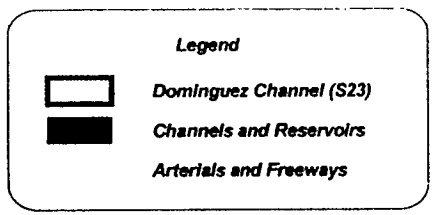
Glendale

(High Density Single Family Residential Land Use Monitoring Site)

1990 Population = 3,000

Land Use Distribution	Area (Acres)	Percent
High Density Residential	120.4	100.0%
Light Industrial	0.0	0.0%
Vacant	0.0	0.0%
Retail/Commercial	0.0	0.0%
Multi-Family Residential	0.0	0.0%
Transportation	0.0	0.0%
Education	0.0	0.0%
Mixed Residential	0.0	0.0%
Other	0.0	0.0%
Total	120.4	100.0%





Land Use Distribution	Area (Acres)	Percent
High Density Residential	5	0.6%
Light Industrial	153	17.0%
Vacant	0	0.0%
Retail/Commercial	1	0.1%
Multi-Family Residential	0	0.0%
Transportation	678	75.2%
Education	0	0.0%
Mixed Residential	0	0.0%
Other	65	7.1%
Total	902	100.0%

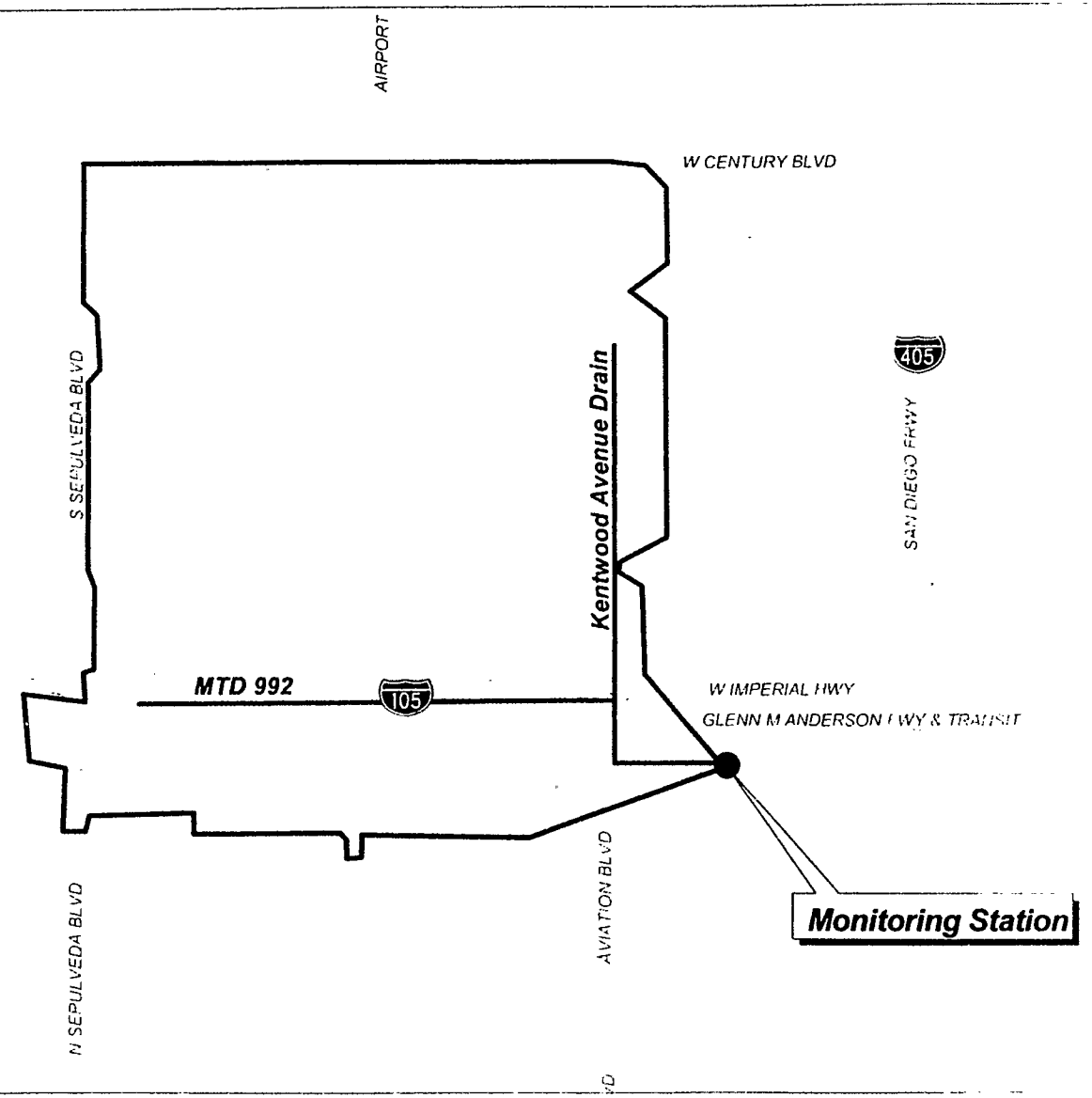


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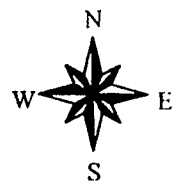
Figure 2-9

DOMINGUEZ CHANNEL (S23) at 116th St.

Unincorporated L.A. County

(Transportation Land Use Monitoring Site)

1990 Population = 2,000



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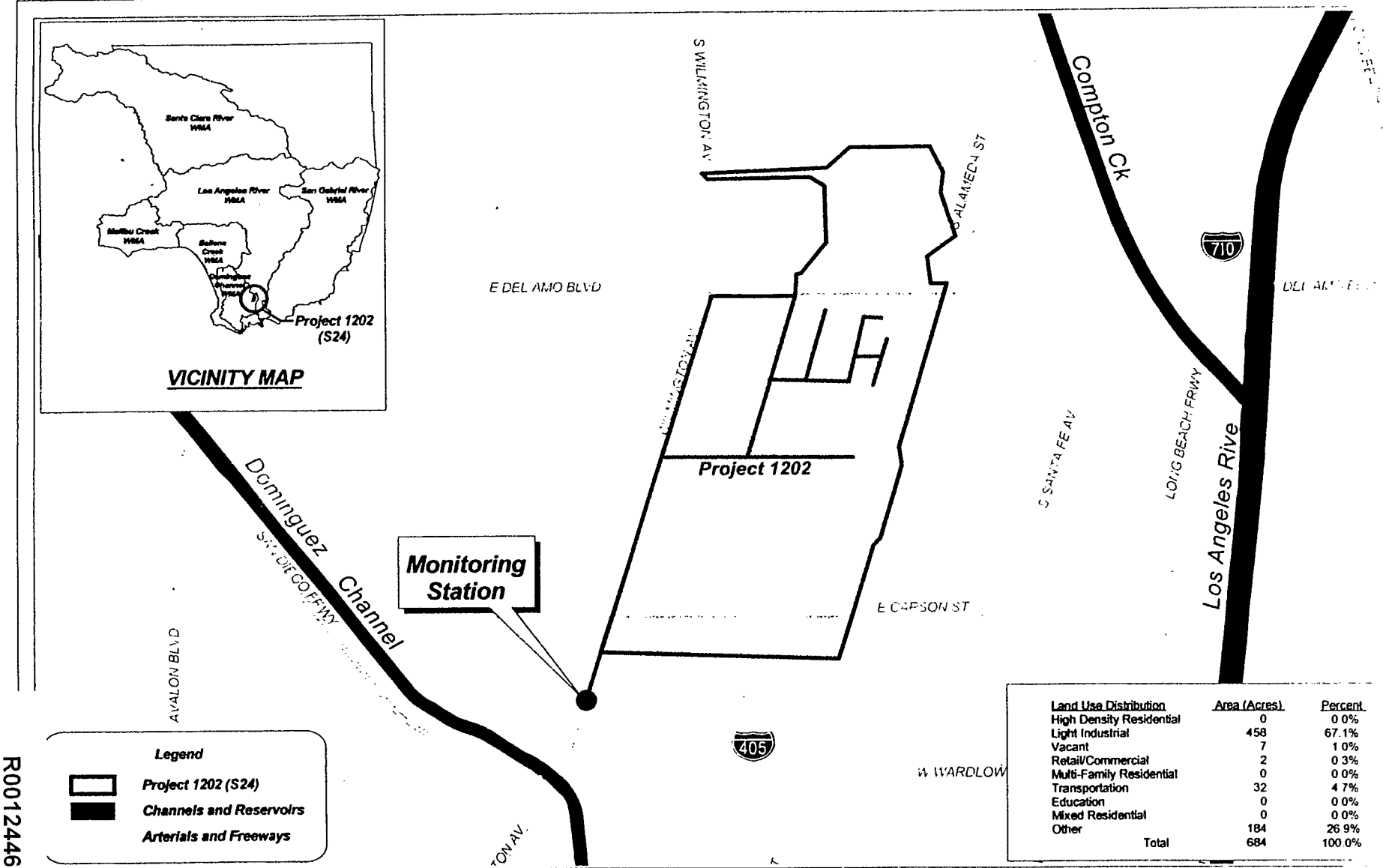

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Figure 2-10

PROJECT 1202 (S24) at Wilmington Ave.

Carson

(Light Industrial Land Use Monitoring Site)

1990 Population = 3,000

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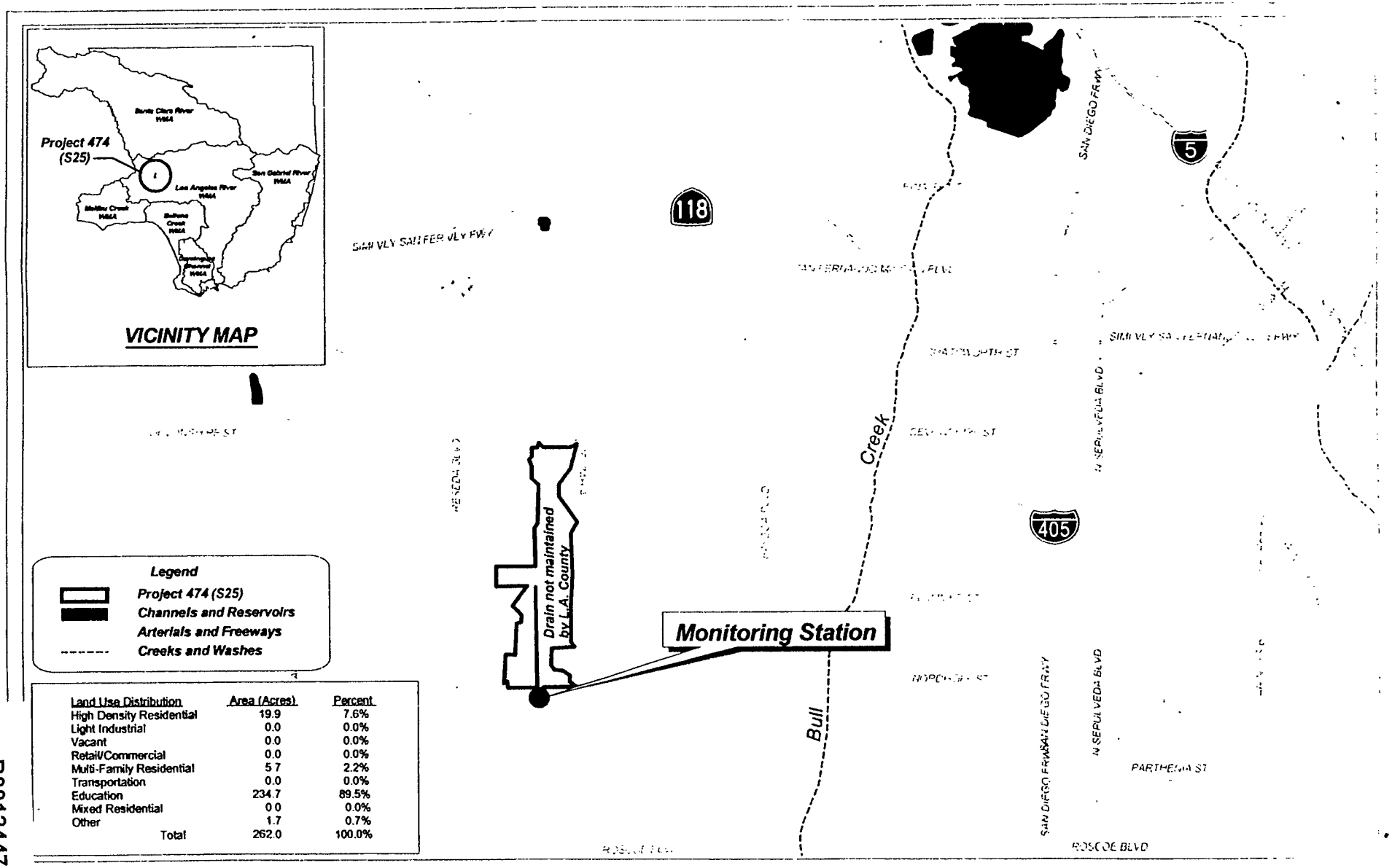

Land Use Distribution	Area (Acres)	Percent
High Density Residential	19.9	7.6%
Light Industrial	0.0	0.0%
Vacant	0.0	0.0%
Retail/Commercial	0.0	0.0%
Multi-Family Residential	5.7	2.2%
Transportation	0.0	0.0%
Education	234.7	89.5%
Mixed Residential	0.0	0.0%
Other	1.7	0.7%
Total	262.0	100.0%

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Figure 2-11

PROJECT 474 (S25) at Nordoff St.

Los Angeles (Educational Land Use Monitoring Site) 199[illegible]opulation = 4,000

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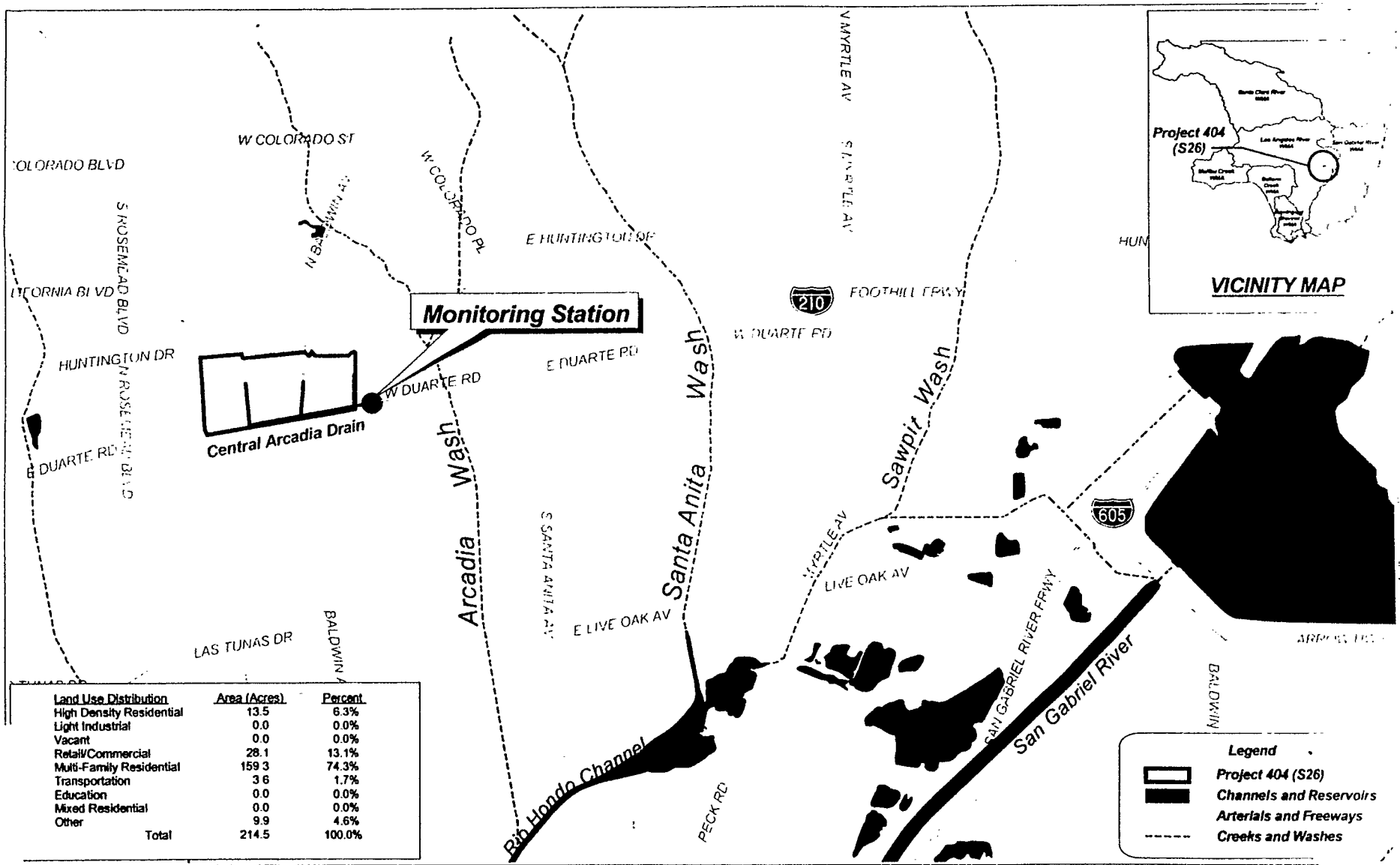

Land Use Distribution	Area (Acres)	Percent
High Density Residential	13.5	6.3%
Light Industrial	0.0	0.0%
Vacant	0.0	0.0%
Retail/Commercial	28.1	13.1%
Multi-Family Residential	159.3	74.3%
Transportation	3.6	1.7%
Education	0.0	0.0%
Mixed Residential	0.0	0.0%
Other	9.9	4.6%
Total	214.5	100.0%

Figure 2-12

PROJECT 404 (S26)
at La Cadena Ave.
Arcadia
(Multi-Family Residential Land Use Monitoring Site)
1990 Population = 4,000

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0.4 0 0.4 Miles

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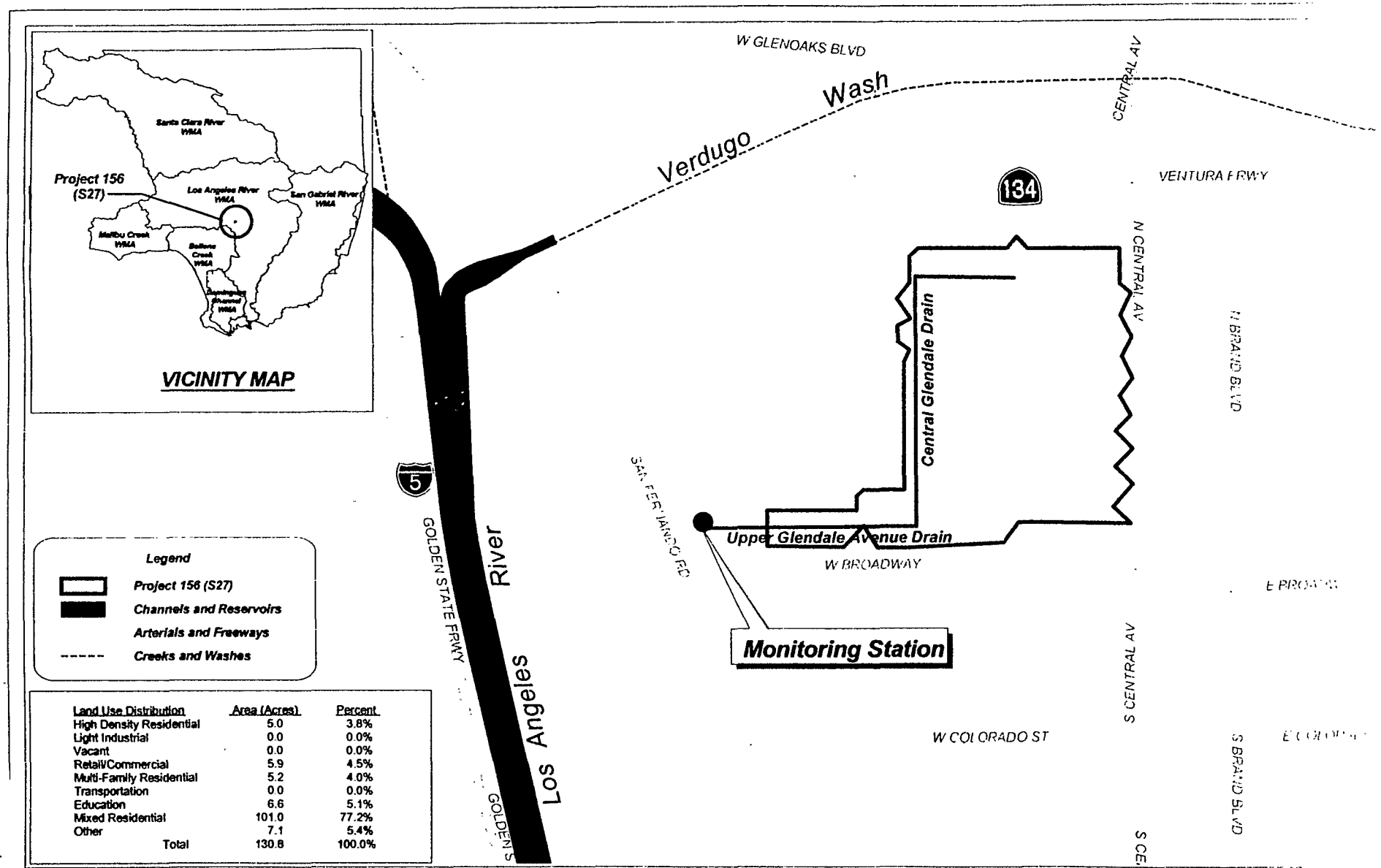

Figure 2-13

PROJECT 156 (S27) at Concord St. Glendale (Mixed Residential Land Use Monitoring Site) 1 Population = 3,000

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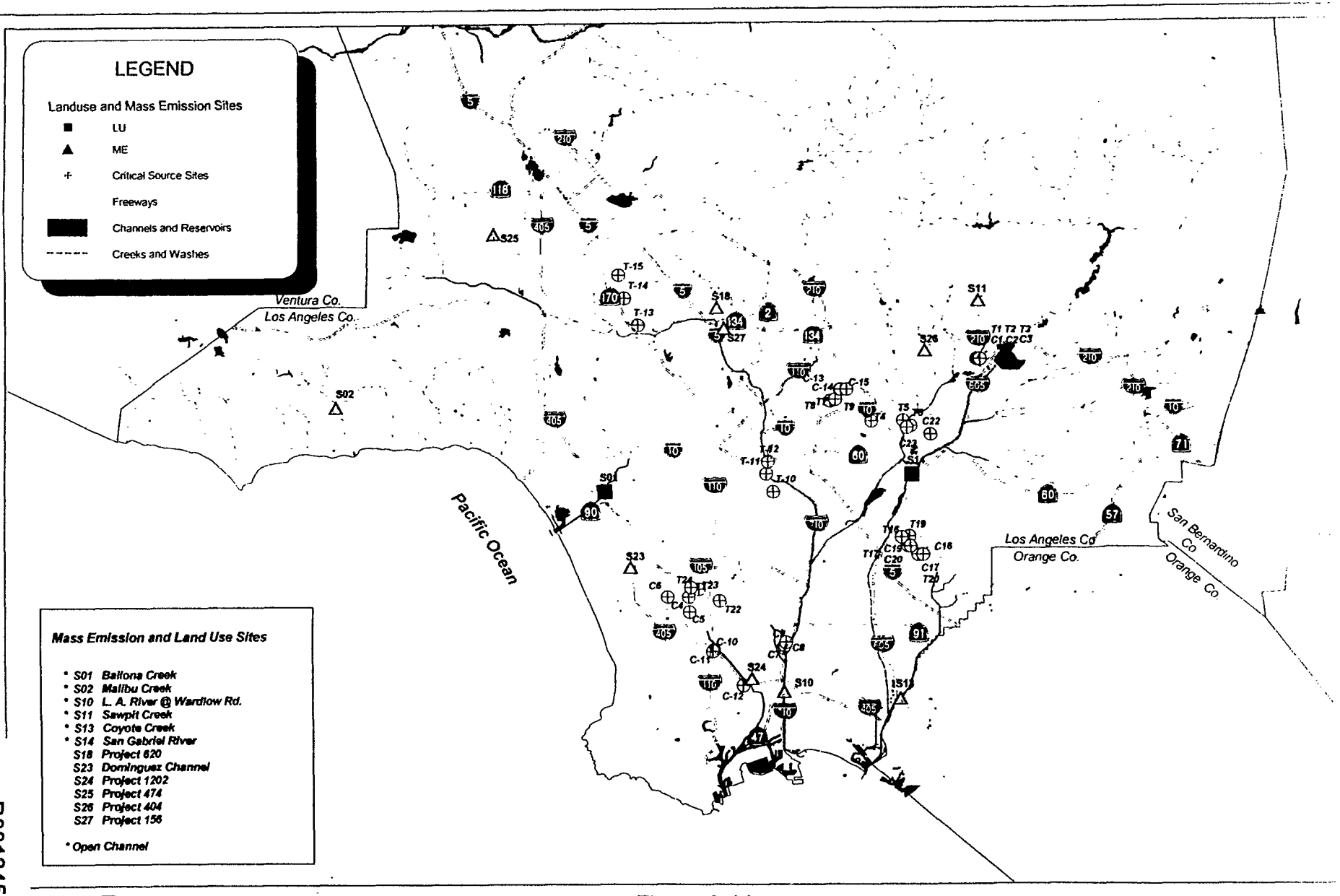

Figure 2-14

2000-2001 Sampling Site Locations

Mass Emission, Land Use, and Critical Source Sampling

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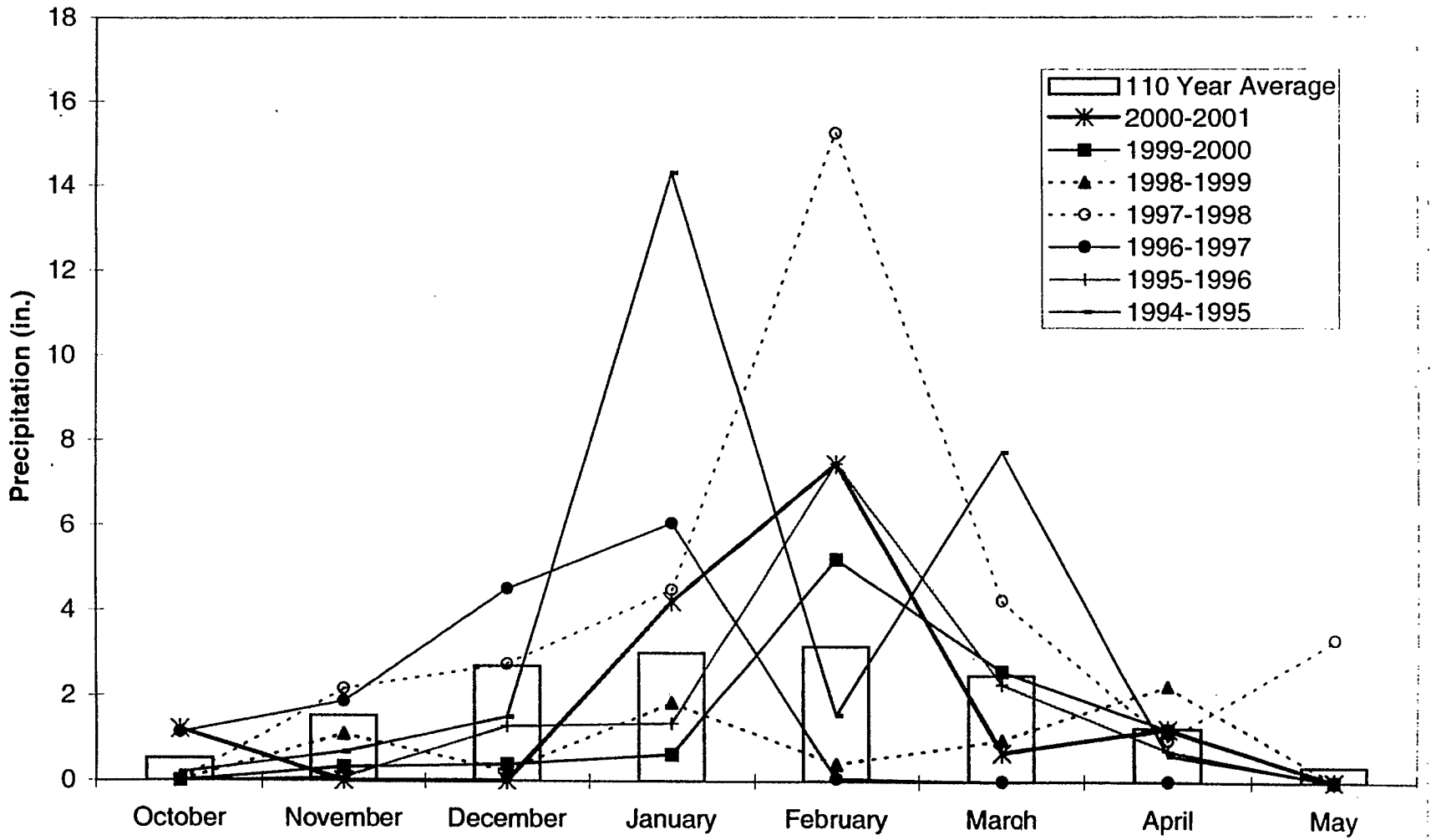
Figure 4-1a
Historic Monthly Wet Season Rainfall at Station #716, Ducommun St., Los Angeles



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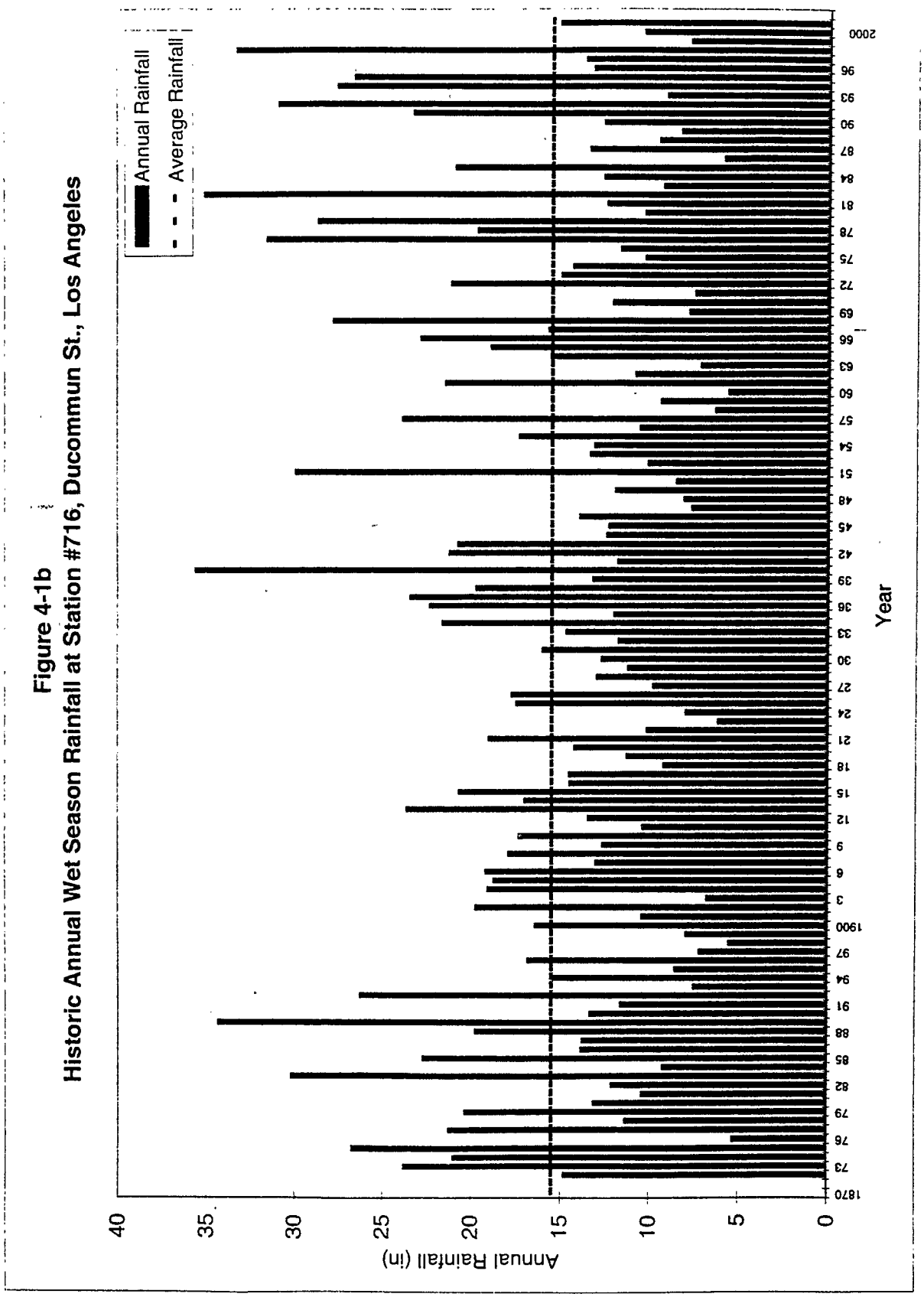
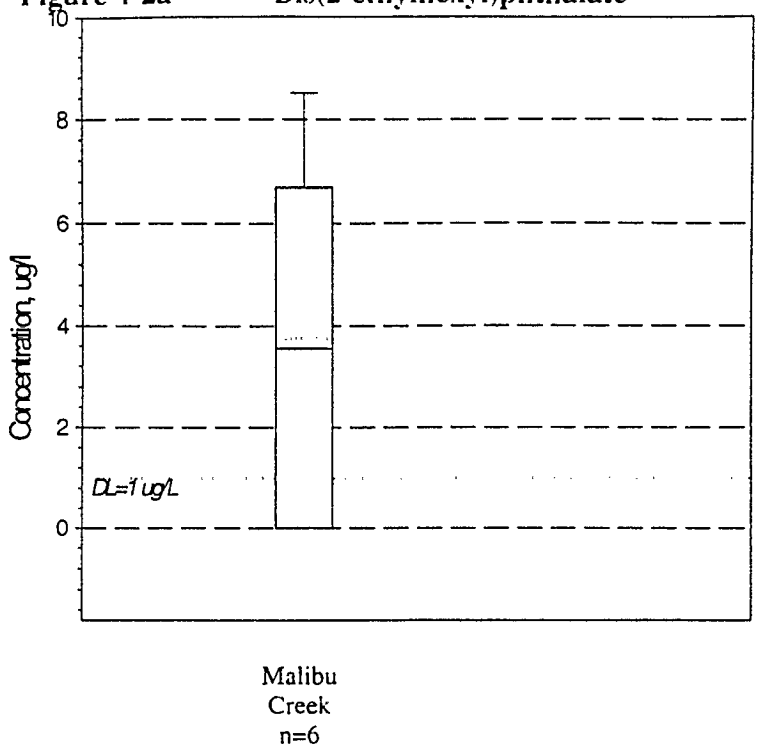


Figure 4-1b
Historic Annual Wet Season Rainfall at Station #716, Ducommun St., Los Angeles

Figure 4-2a **Bis(2-ethylhexyl)phthalate**



Common Objectives
Ocean Plan: 3.5 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

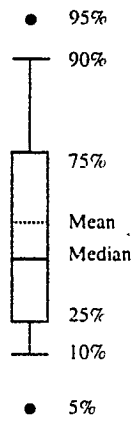
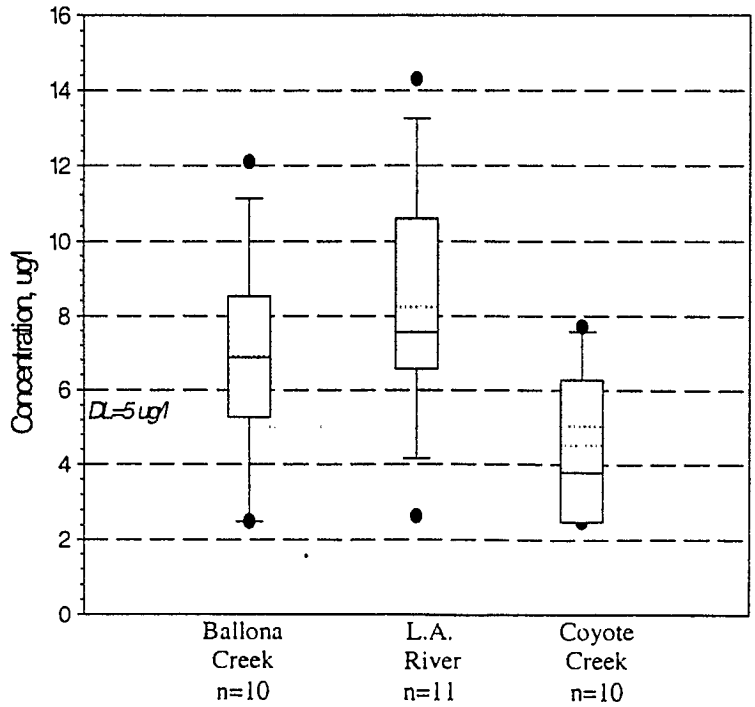


Figure 4-2b **Dissolved Copper**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 9 ug/L
CA Toxics Rule (Saltwater): 3.1 ug/L

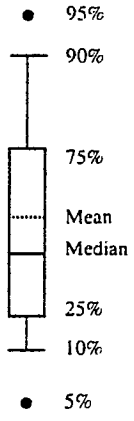


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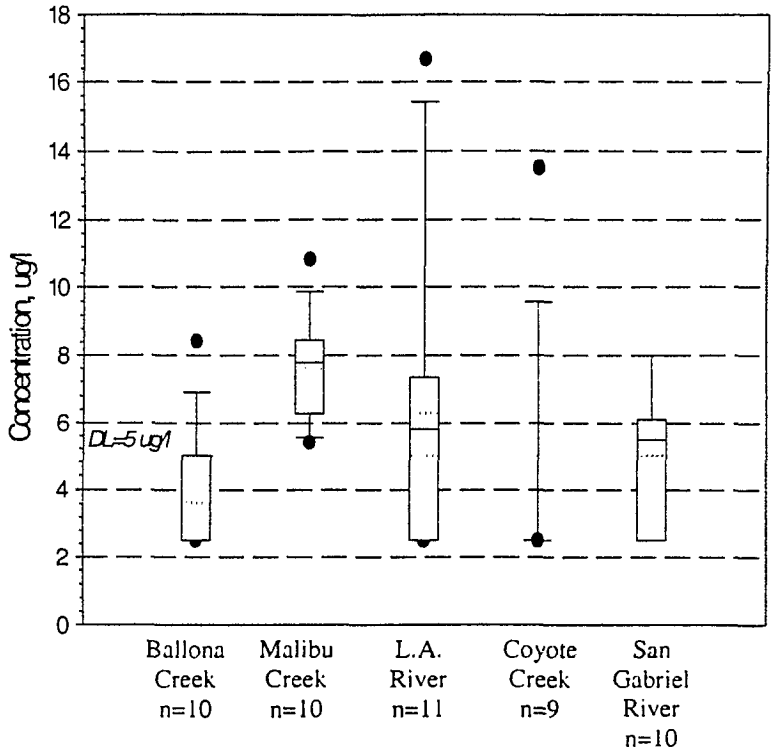
Figure 4-2c **Dissolved Nickel**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 52 ug/L
CA Toxics Rule (Saltwater): 8.2 ug/L

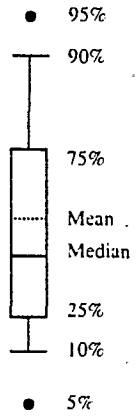
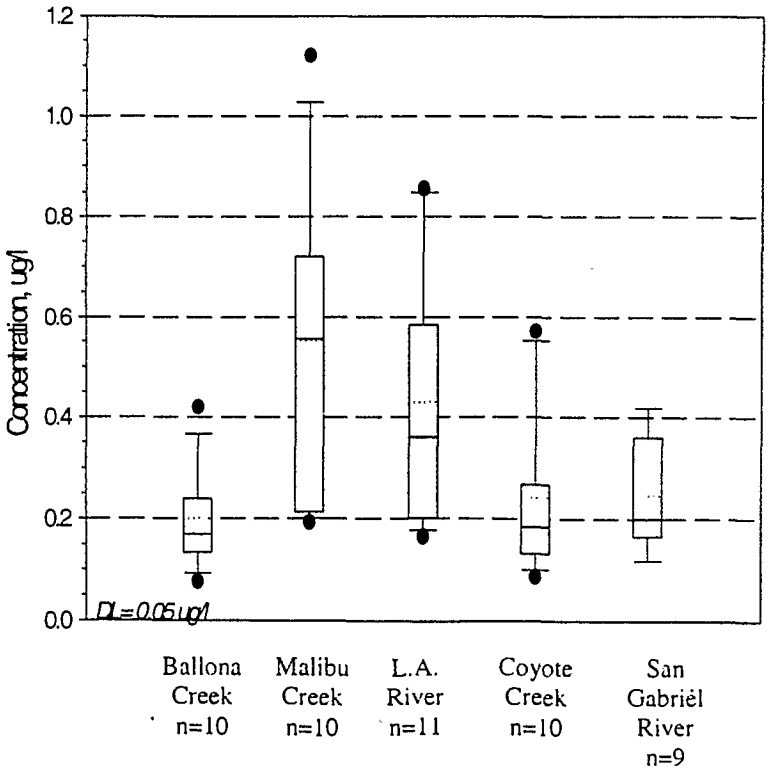


Figure 4-2d **Dissolved Phosphorus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

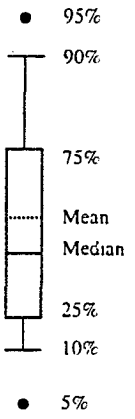


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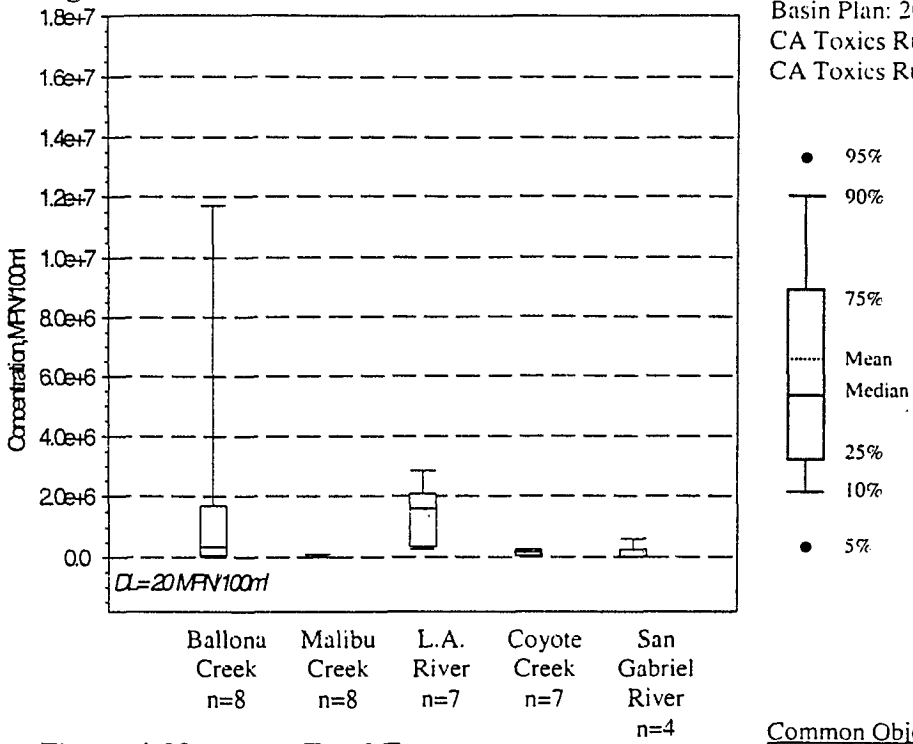
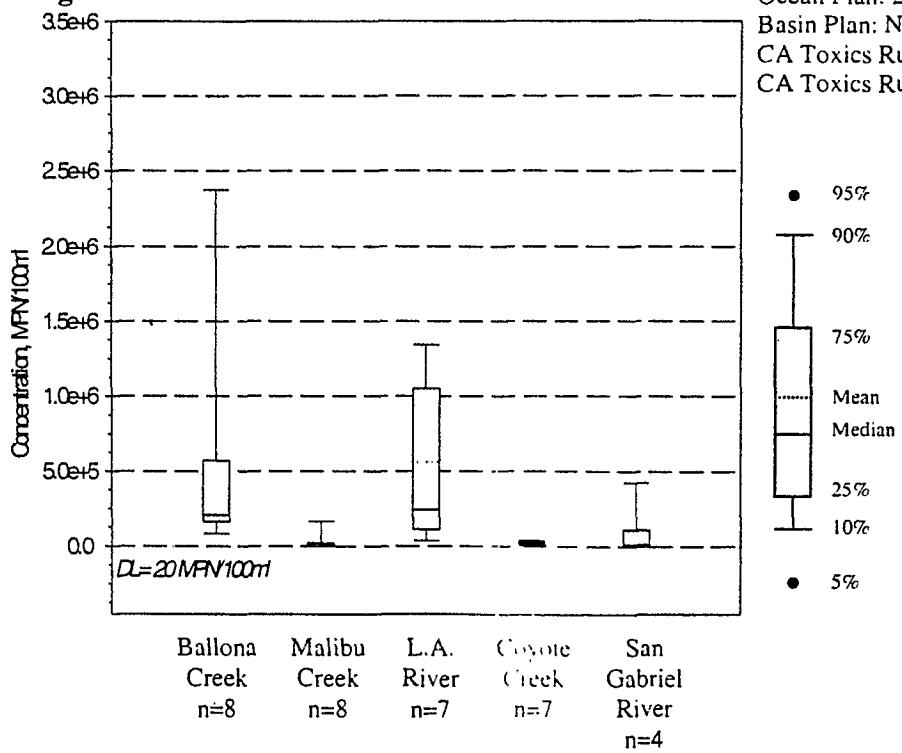
Figure 4-2e **Fecal Coliform**



Common Objectives
Ocean Plan: 200 MPN/100ml
Basin Plan: 200 MPN/100ml
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

Figure 4-2f **Fecal Enterococcus**



Common Objectives
Ocean Plan: 24 MPN/100ml
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

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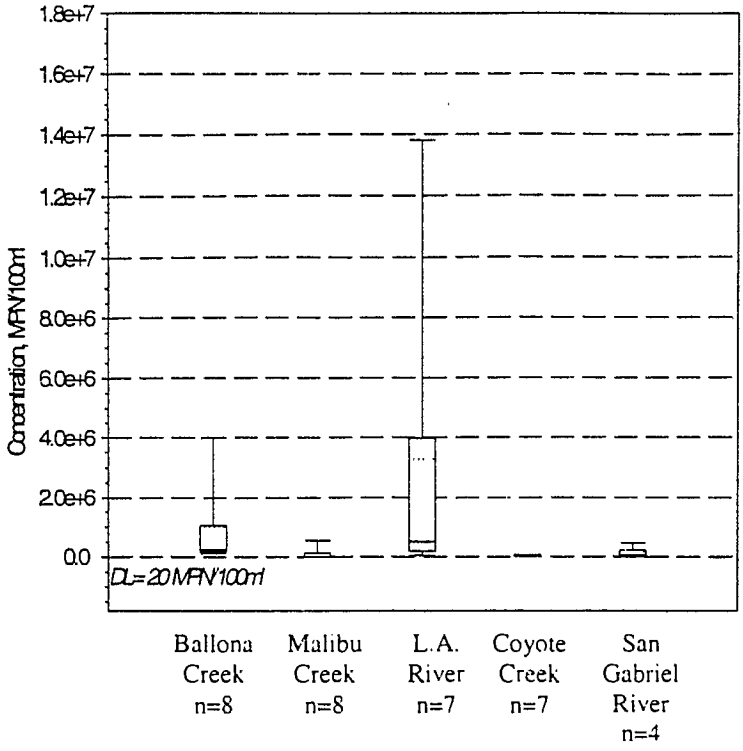
Figure 4-2g **Fecal Streptococcus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

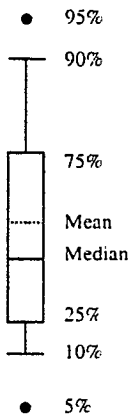
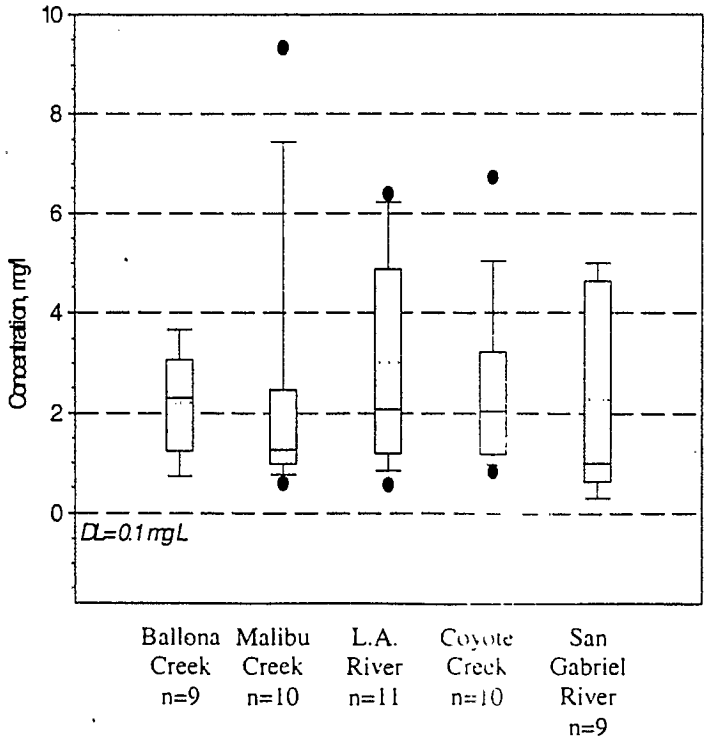


Figure 4-2h **Kjeldahl-N**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

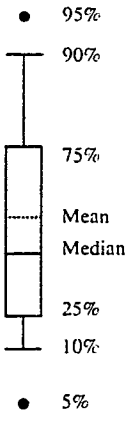


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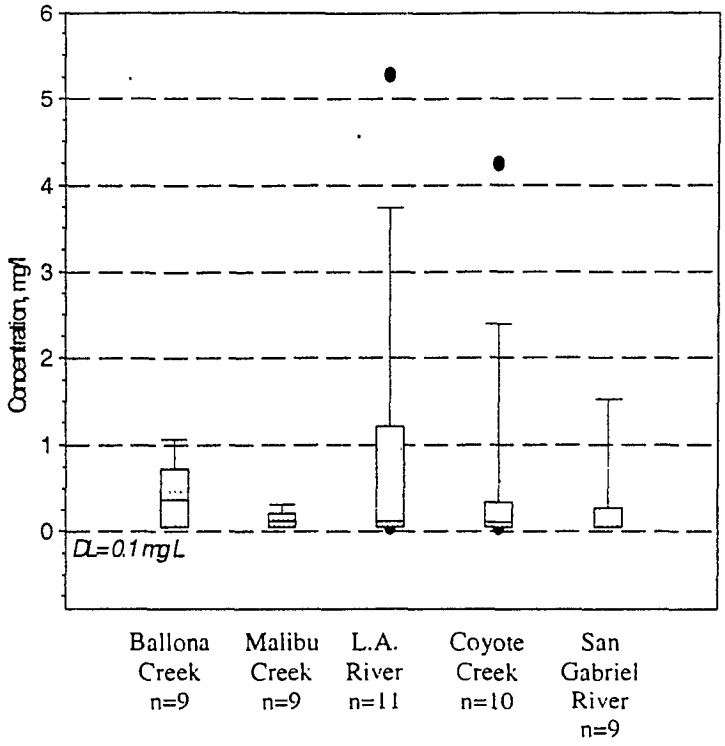
Figure 4-2i **NH3-N**



Common Objectives
Ocean Plan: 2.4 mg/L
Basin Plan: 2.7 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

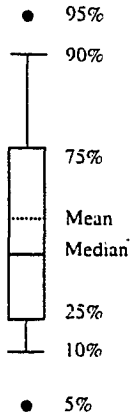
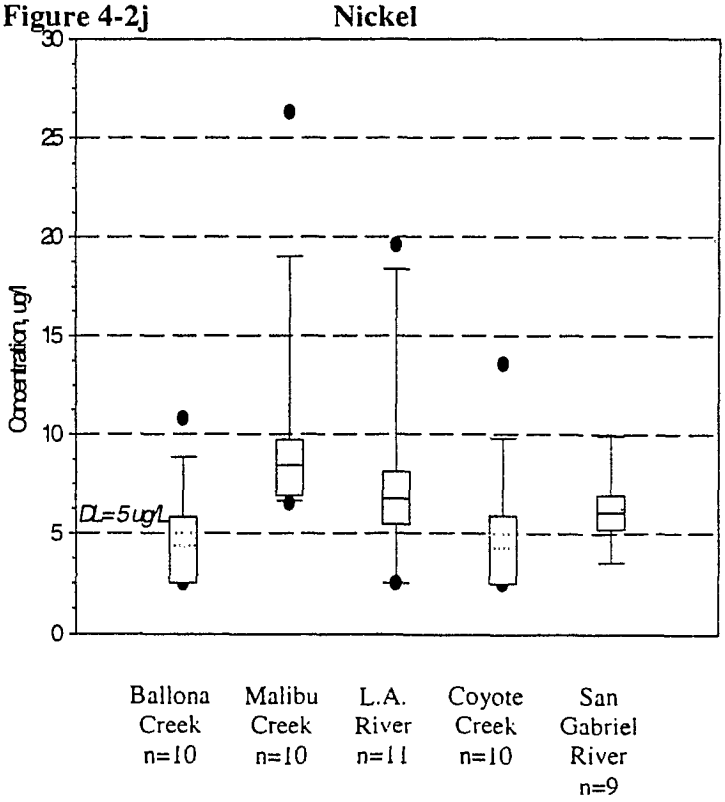


Figure 4-2j **Nickel**



Common Objectives
Ocean Plan: 20 ug/L
Basin Plan: 100 ug/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

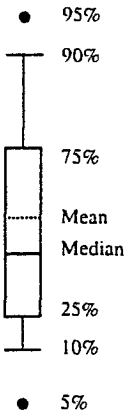


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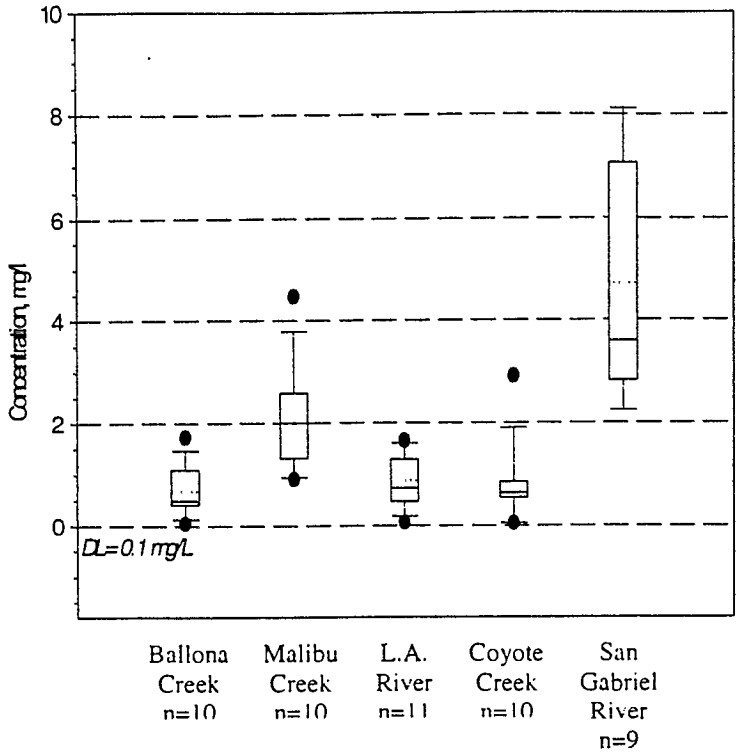
Figure 4-2k **Nitrate-N**



Common Objectives
Ocean Plan: N/A
Basin Plan: 10 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

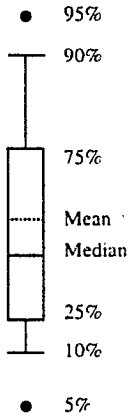
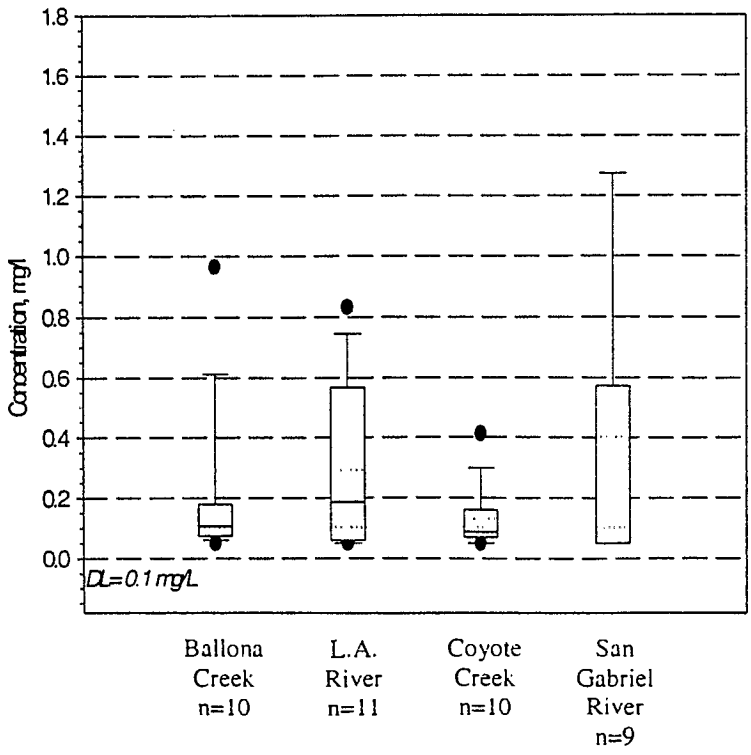


Figure 4-2l **Nitrite-N**



Common Objectives
Ocean Plan: N/A
Basin Plan: 1 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

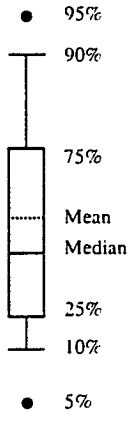


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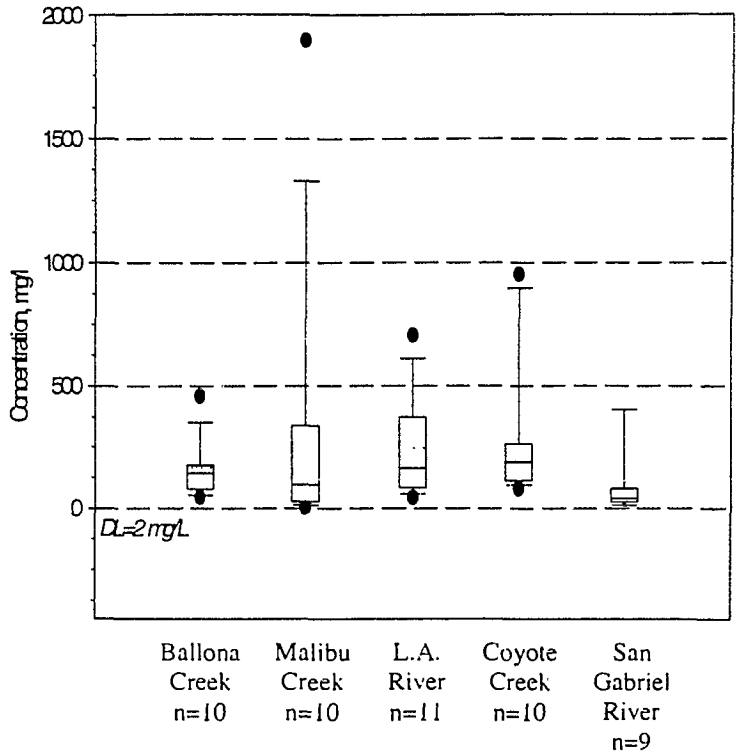
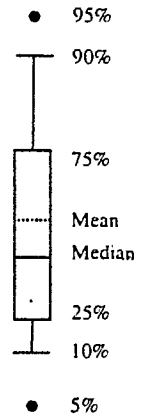
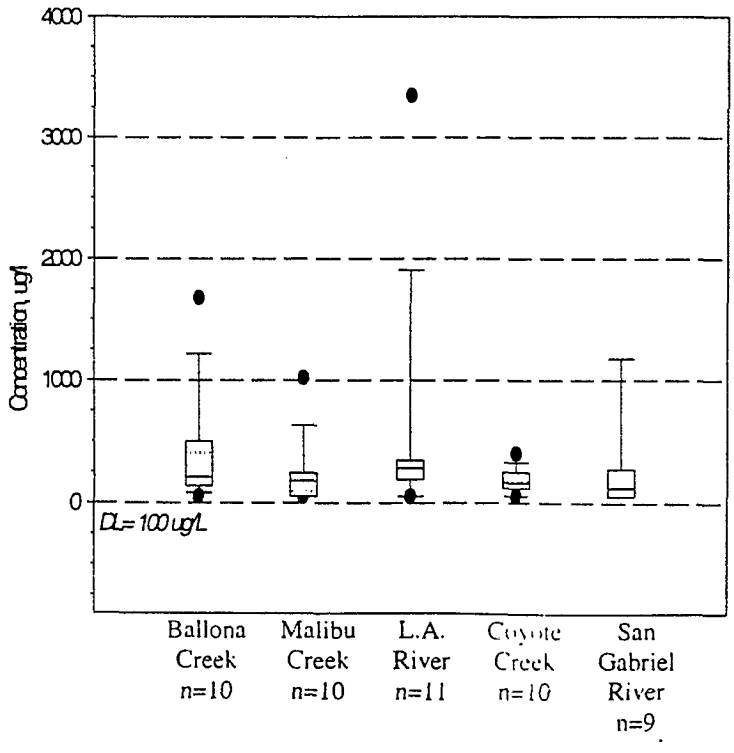
Figure 4-2m **Suspended Solids**

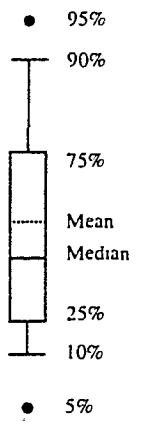




Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

Figure 4-2n **Total Aluminum**





Common Objectives
Ocean Plan: N/A
Basin Plan: 1000 ug/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

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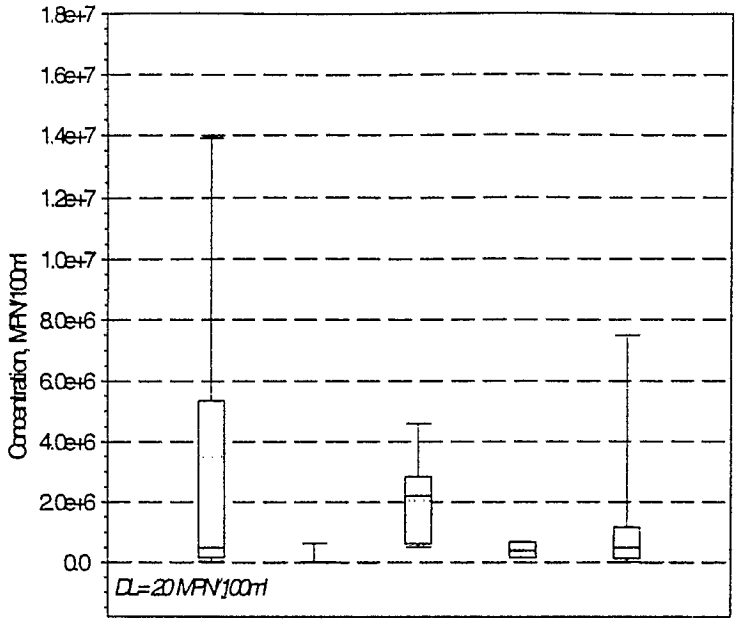
Figure 4-2o **Total Coliform**



Common Objectives
Ocean Plan: 1000 MPN/100ml
Basin Plan: 70 MPN/100ml
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

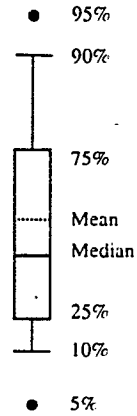
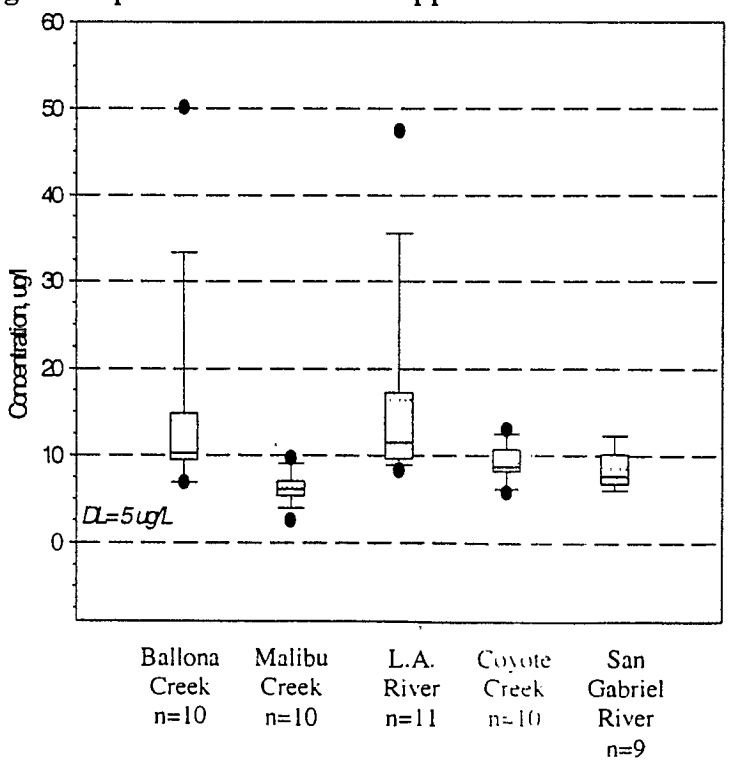


Figure 4-2p **Total Copper**



Common Objectives
Ocean Plan: 12 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

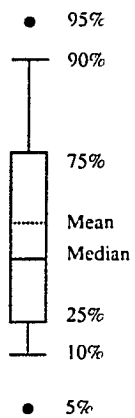


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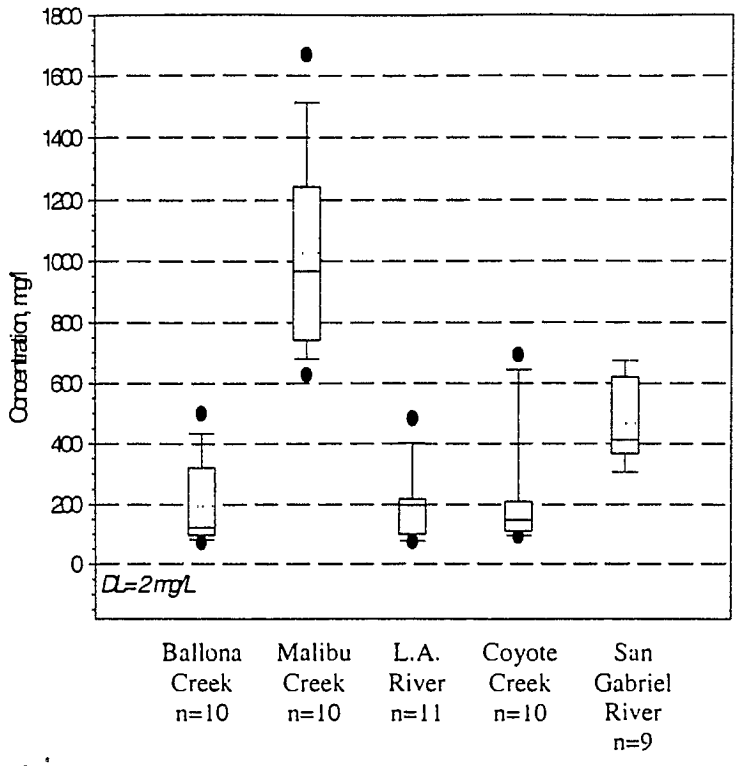
Figure 4-2q **Total Dissolved Solids**



Common Objectives
Ocean Plan: N/A
Basin Plan: 250 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

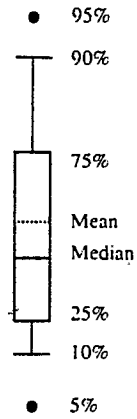
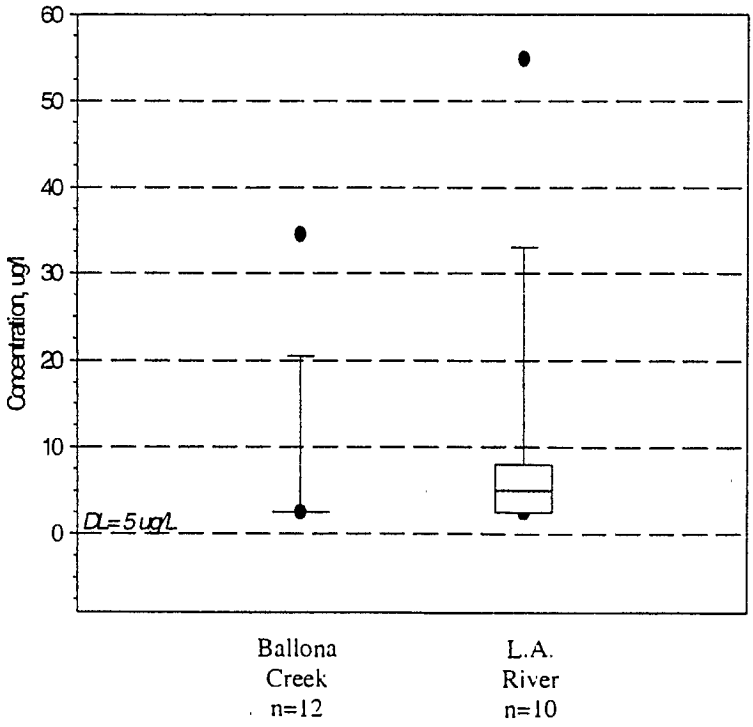


Figure 4-2r **Total Lead**



Common Objectives
Ocean Plan: 8 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

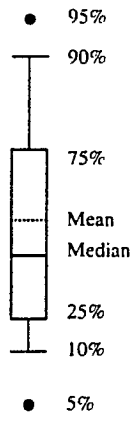


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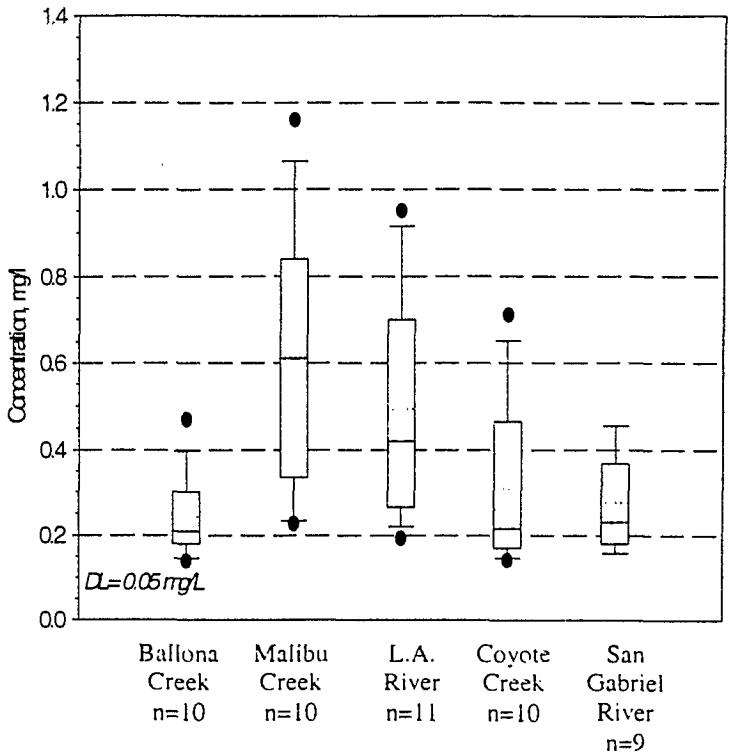
Figure 4-2s **Total Phosphorus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

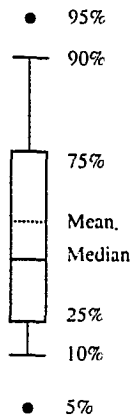
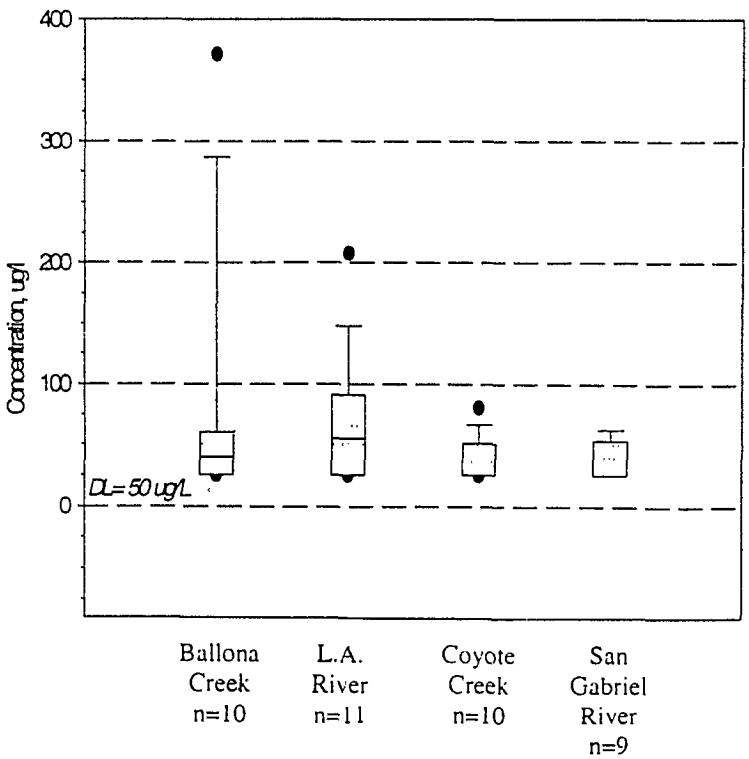


Figure 4-2t **Total Zinc**



Common Objectives
Ocean Plan: 80 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

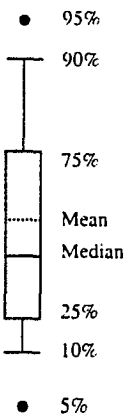


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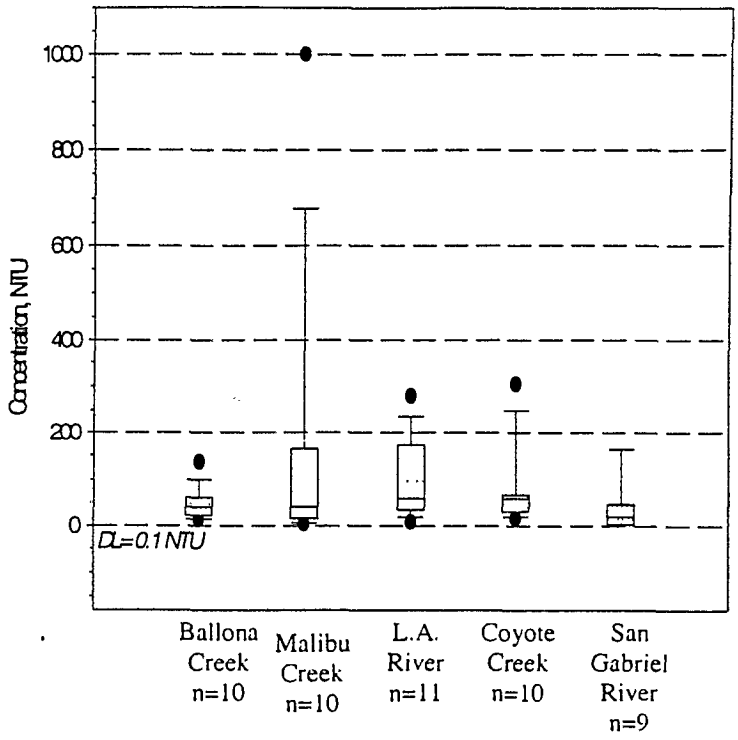
Figure 4-2u **Turbidity**



Common Objectives
Ocean Plan: 75 NTU
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

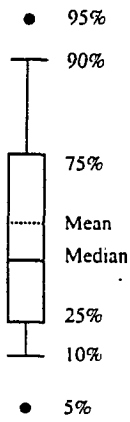


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Figure 4-3a. STORMWATER BACTERIA COUNTS TOTAL COLIFORM

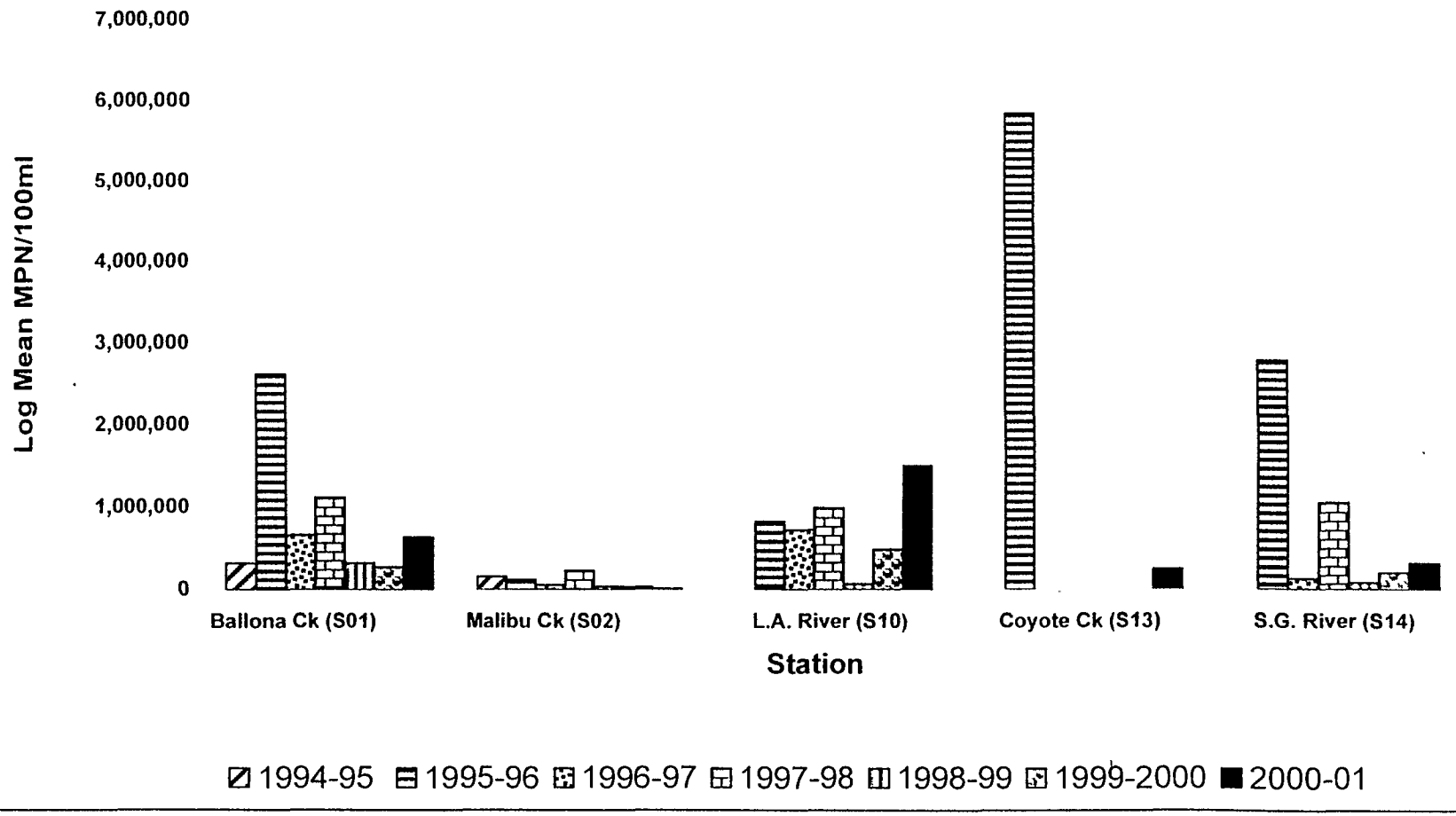

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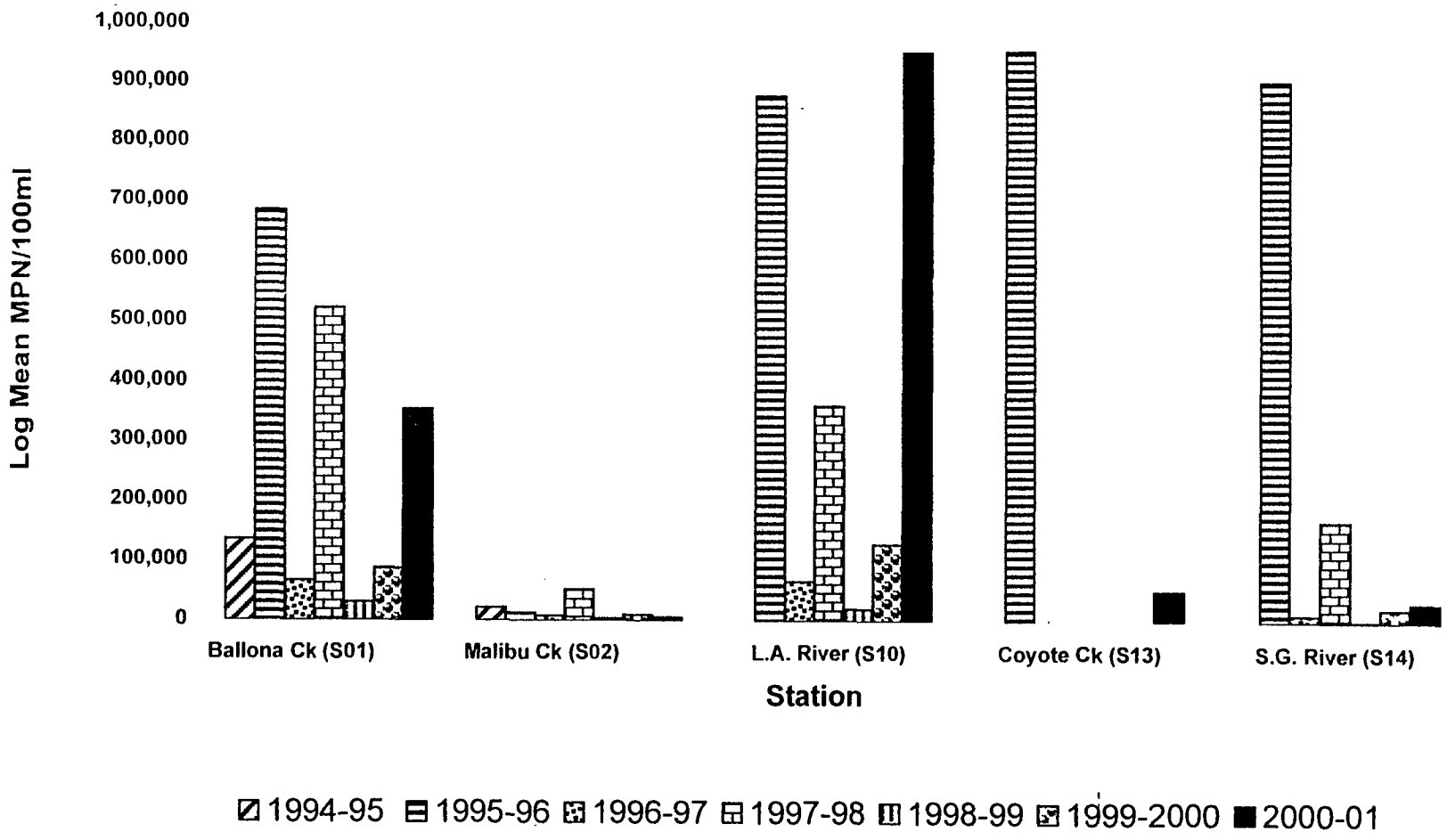
Figure 4-3b. STORMWATER BACTERIA COUNTS
FECAL COLIFORM

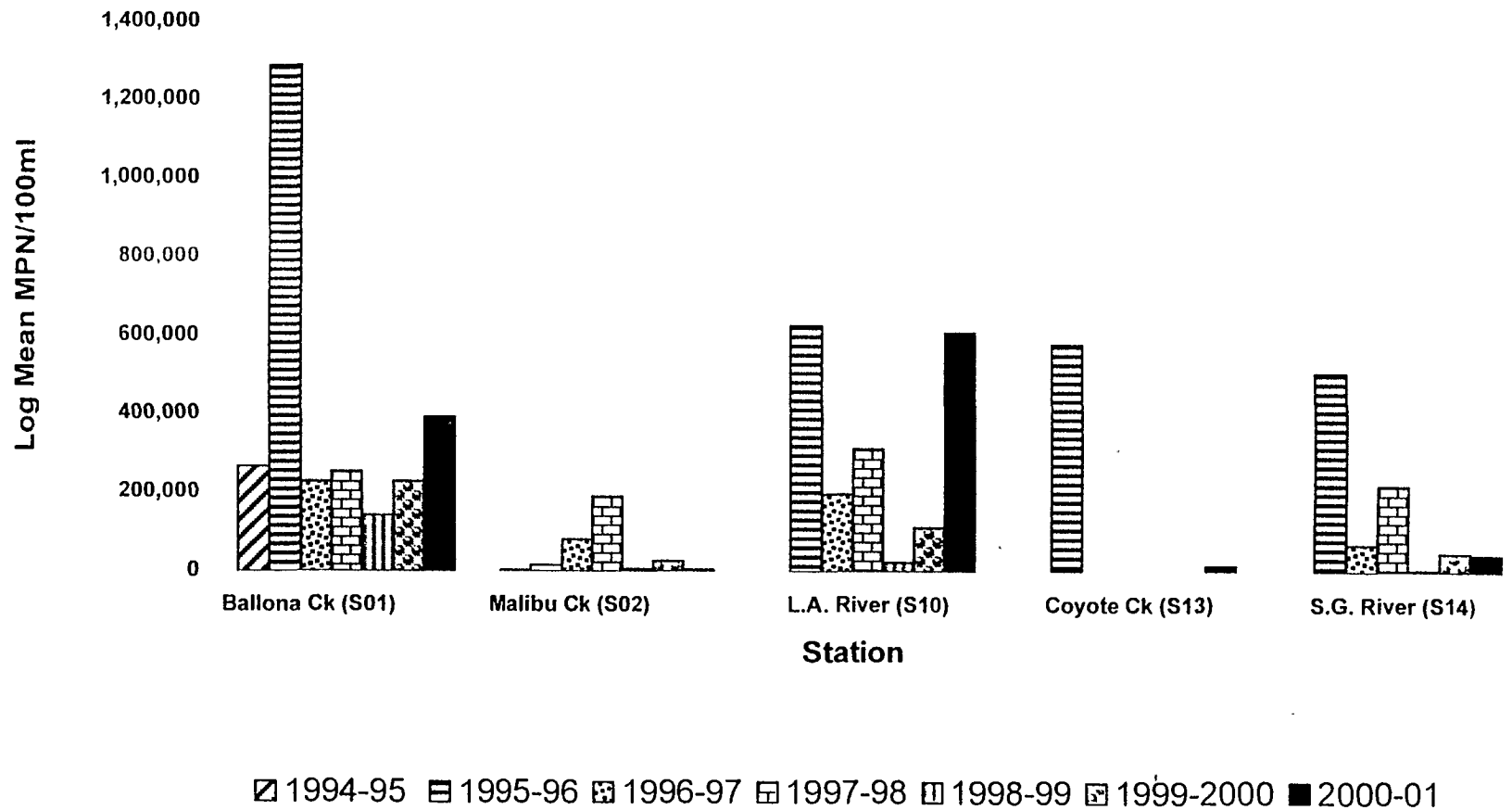


R0012465

TJ Bacteria_94-00.xls

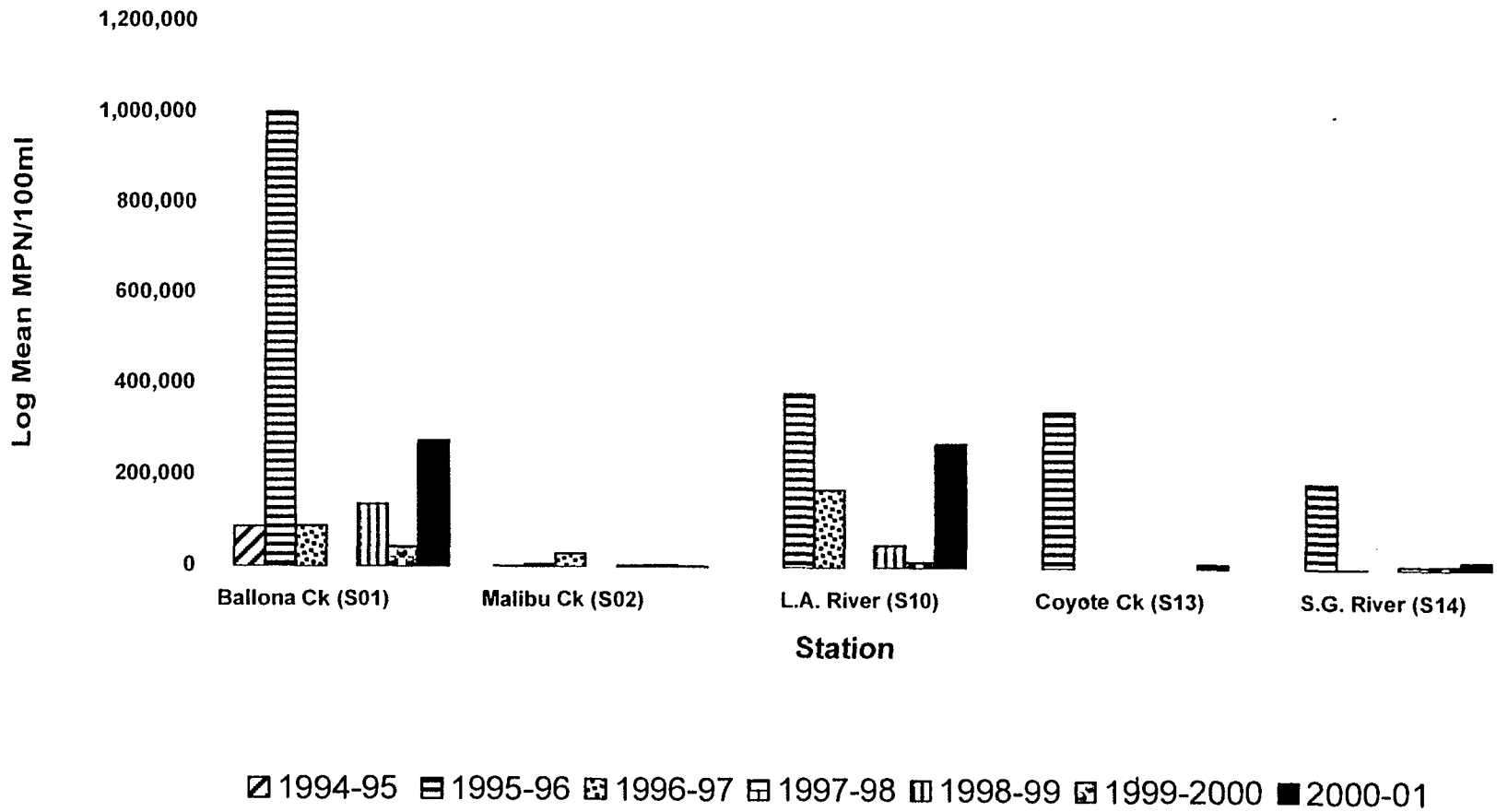
6/27/01

Figure 4-3c. STORMWATER BACTERIA COUNTS
FECAL STREPTOCOCCUS



R0012466

Figure 4-3d. STORMWATER BACTERIA COUNTS
FECAL ENTEROCOCCUS



R0012467

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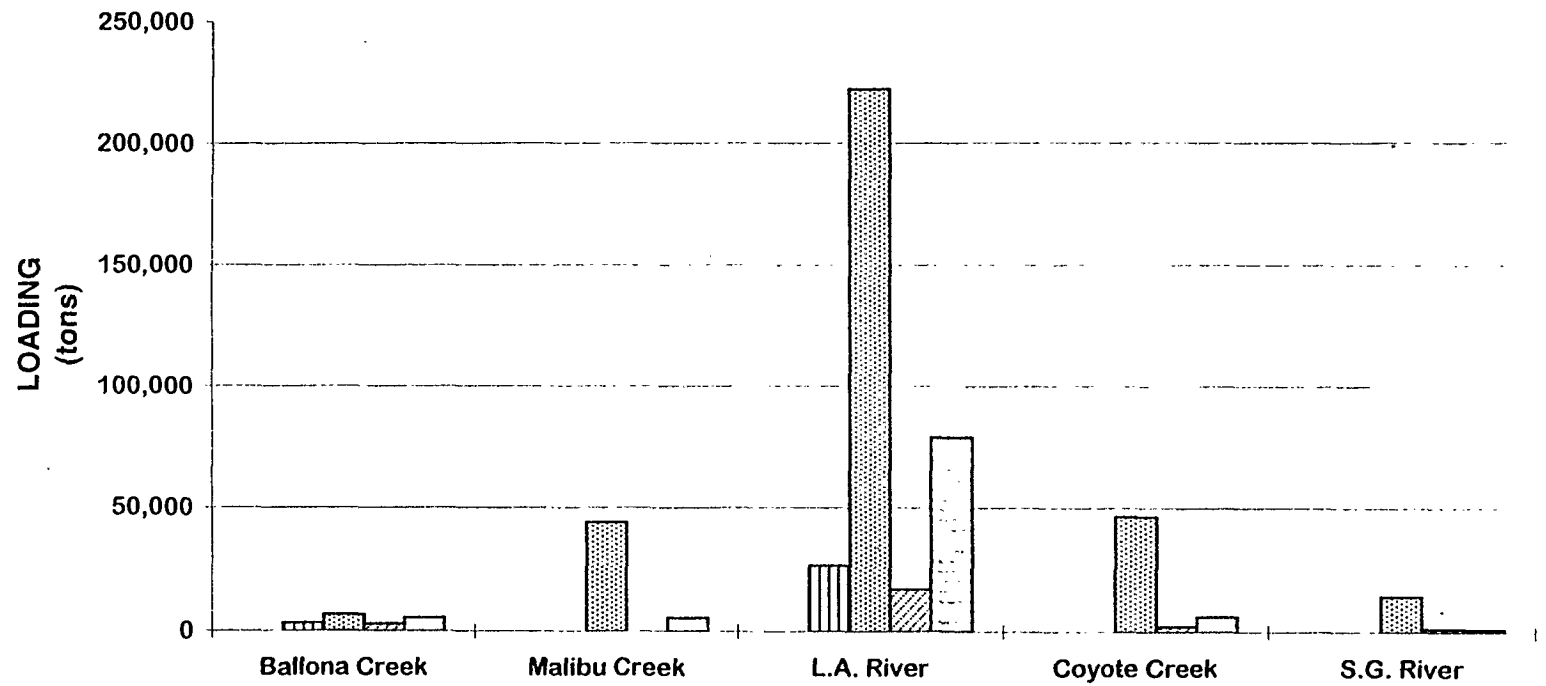
6/27/01

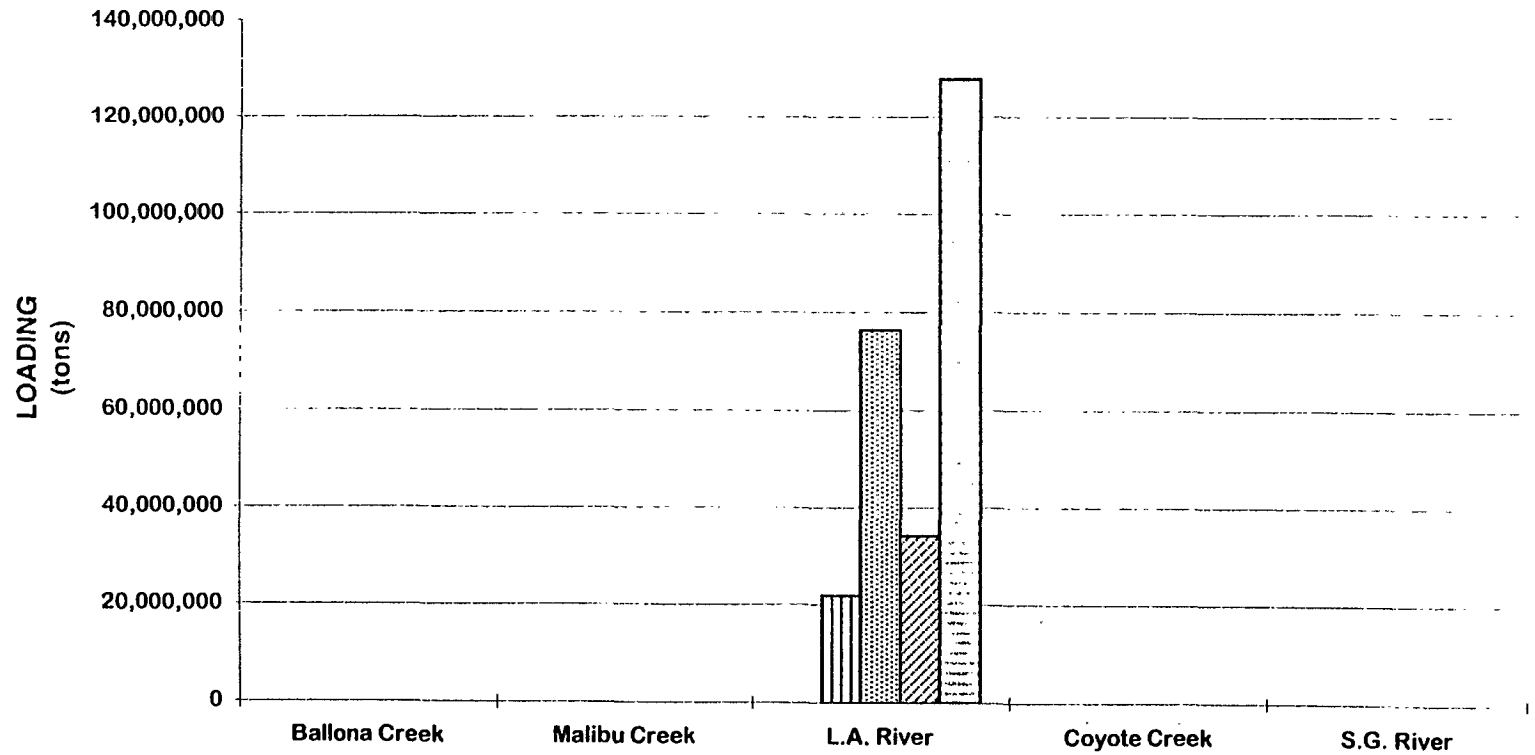
Figure 4-4a. MASS EMISSION LOADINGS TOTAL SUSPENDED SOLIDS



Note: No runoff data for 1995-96.

R0012468

Figure 4-4b. MASS EMISSION LOADINGS TOTAL DISSOLVED SOLIDS

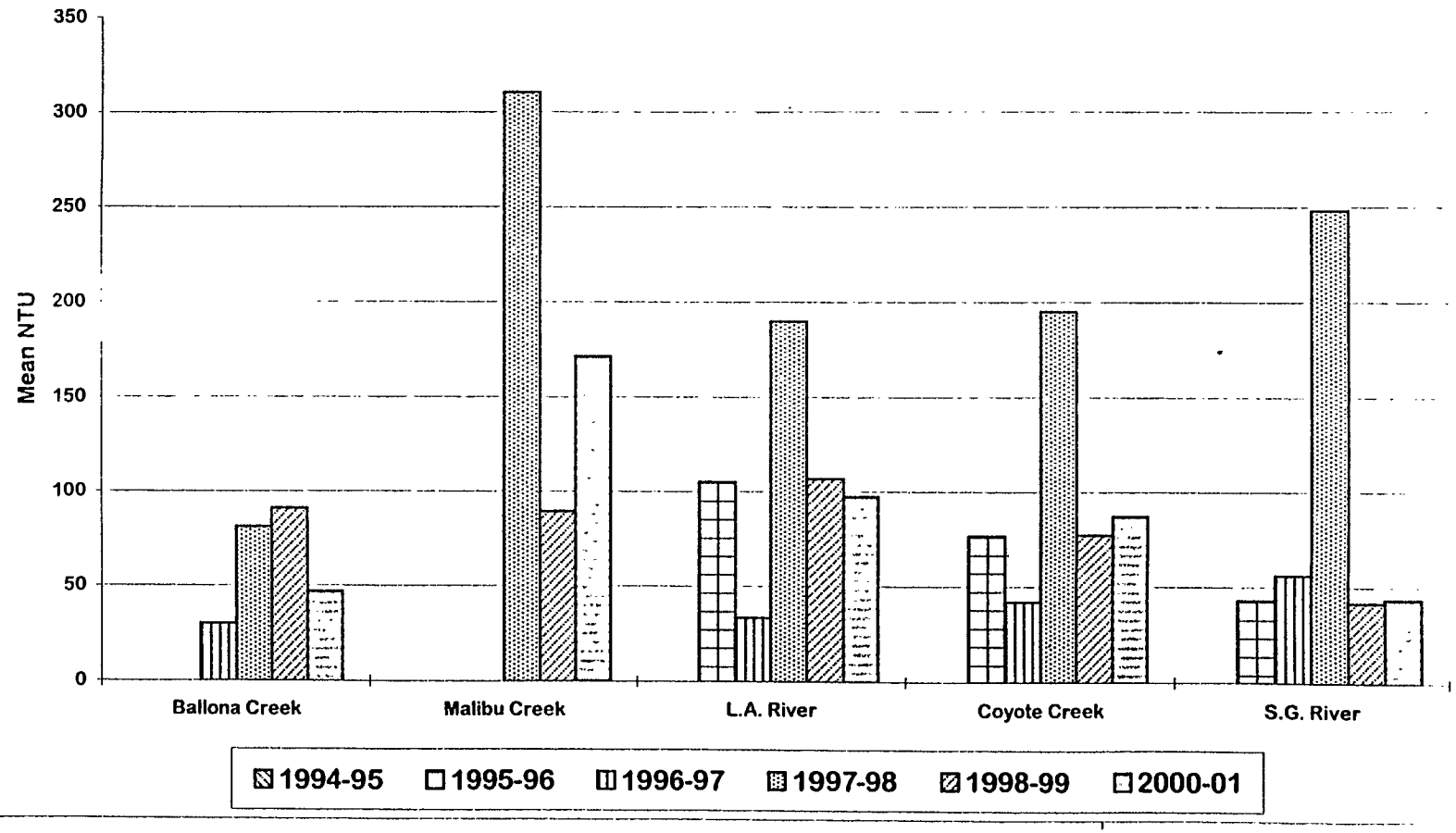


Note: No runoff data for 1995-96.

R0012469

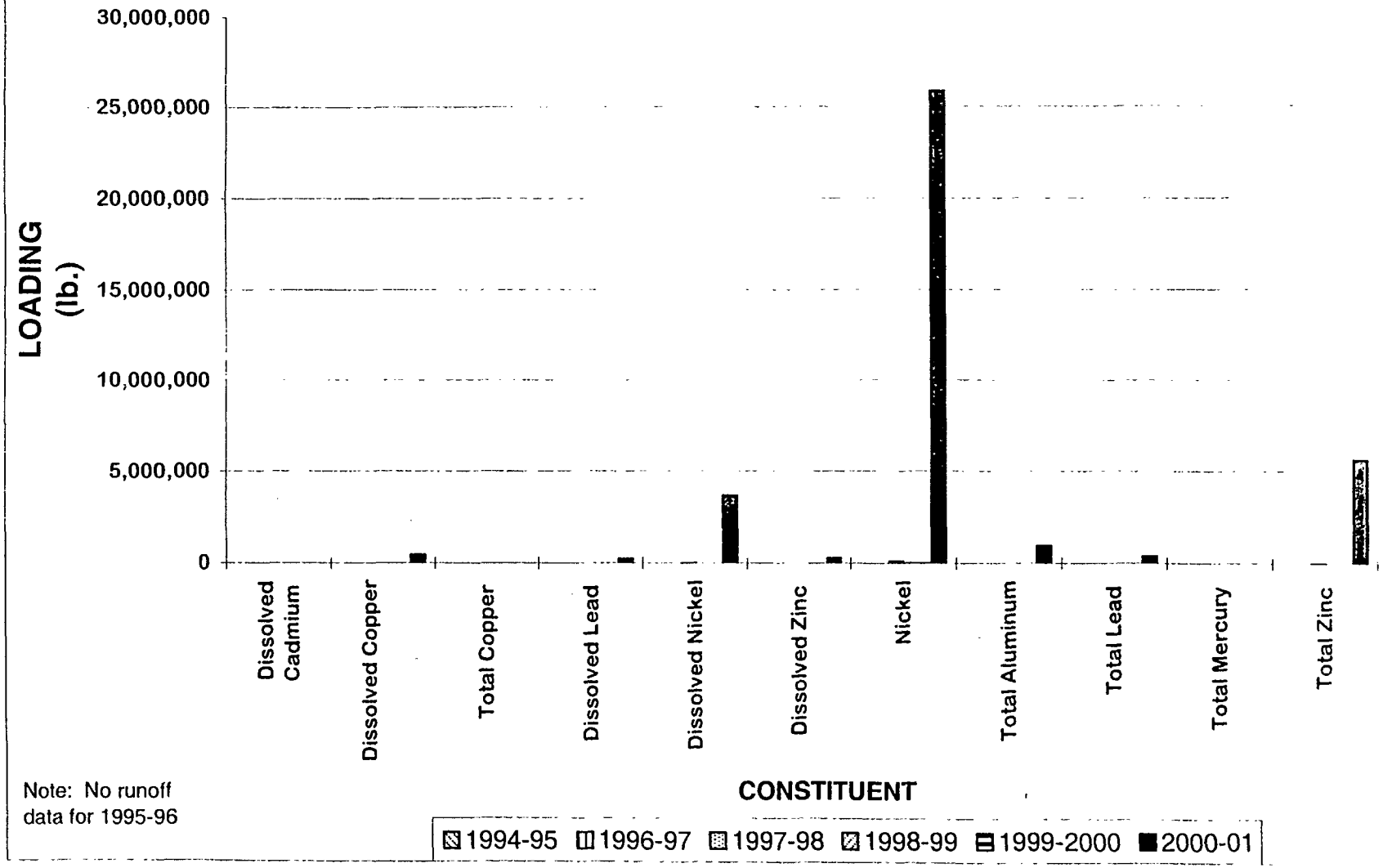
Fig 4-4 to 4-9 (ME_load).xls

Figure 4-5. MASS EMISSION MEAN TURBIDITY



R0012470

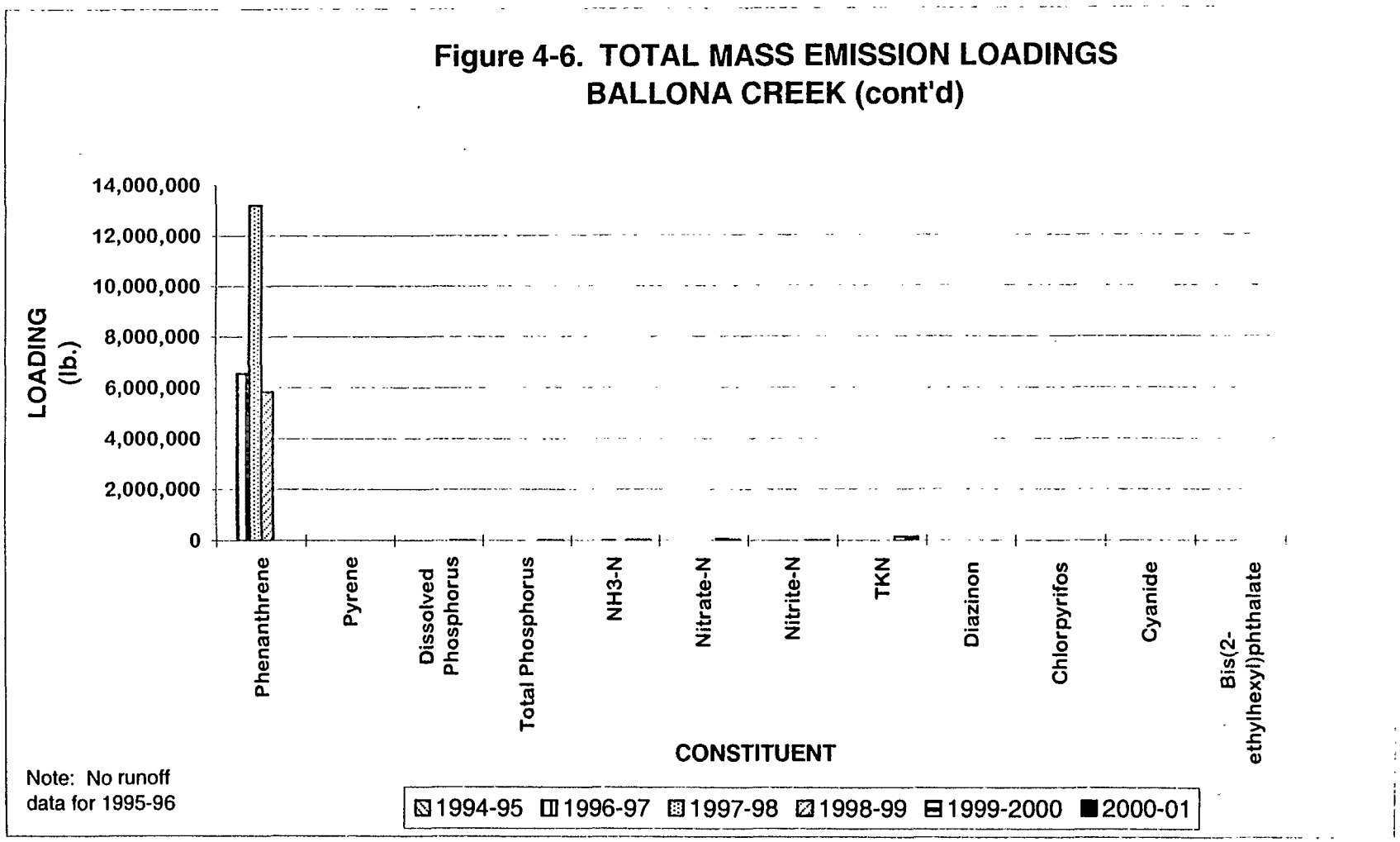
Figure 4-6. TOTAL MASS EMISSION LOADINGS BALLONA CREEK



Note: No runoff data for 1995-96

R0012471

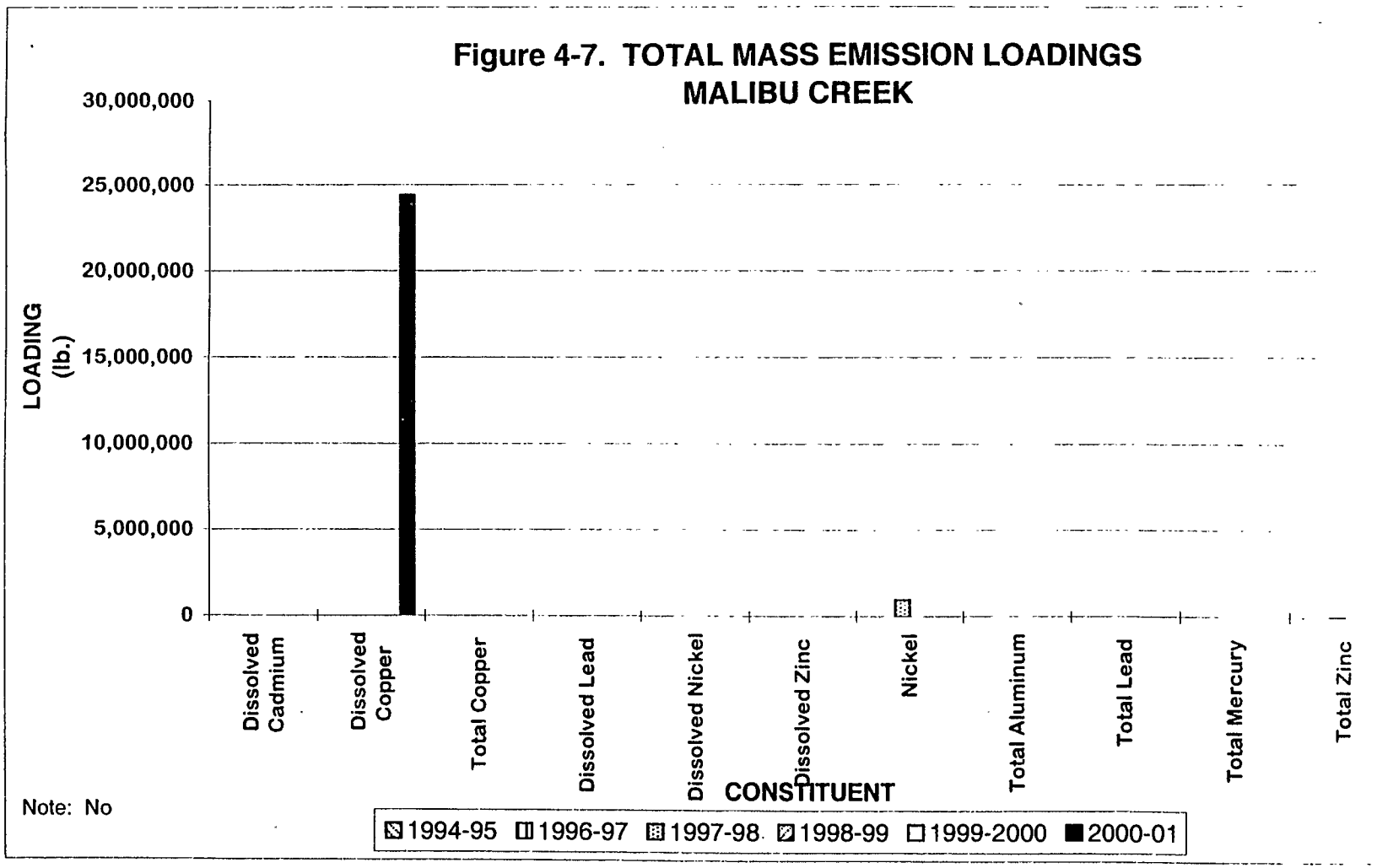
Figure 4-6. TOTAL MASS EMISSION LOADINGS
BALLONA CREEK (cont'd)



Note: No runoff data for 1995-96

R0012472

Figure 4-7. TOTAL MASS EMISSION LOADINGS
MALIBU CREEK



Note: No

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Fig 4-4 to 4-9 (ME_load).xls

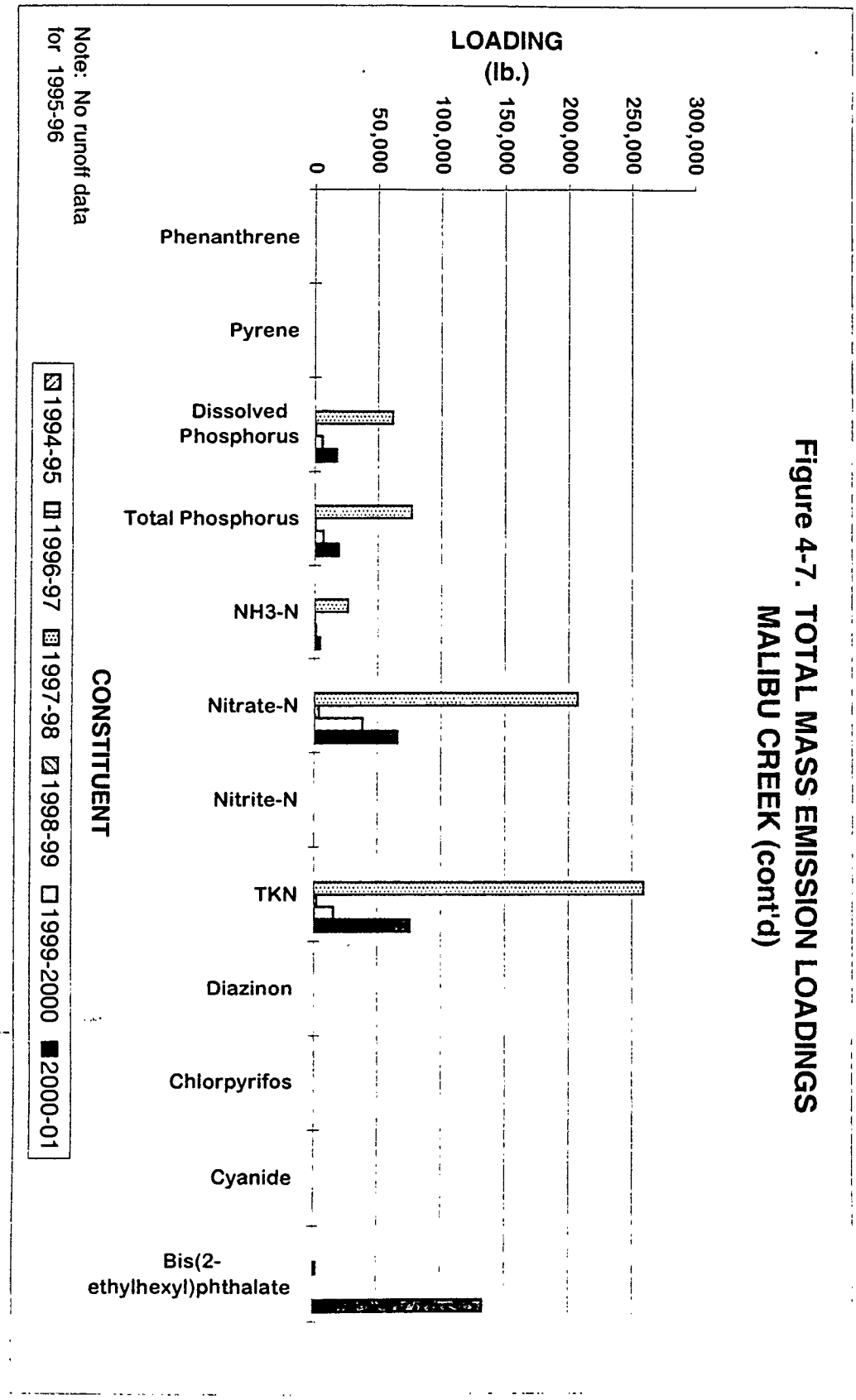
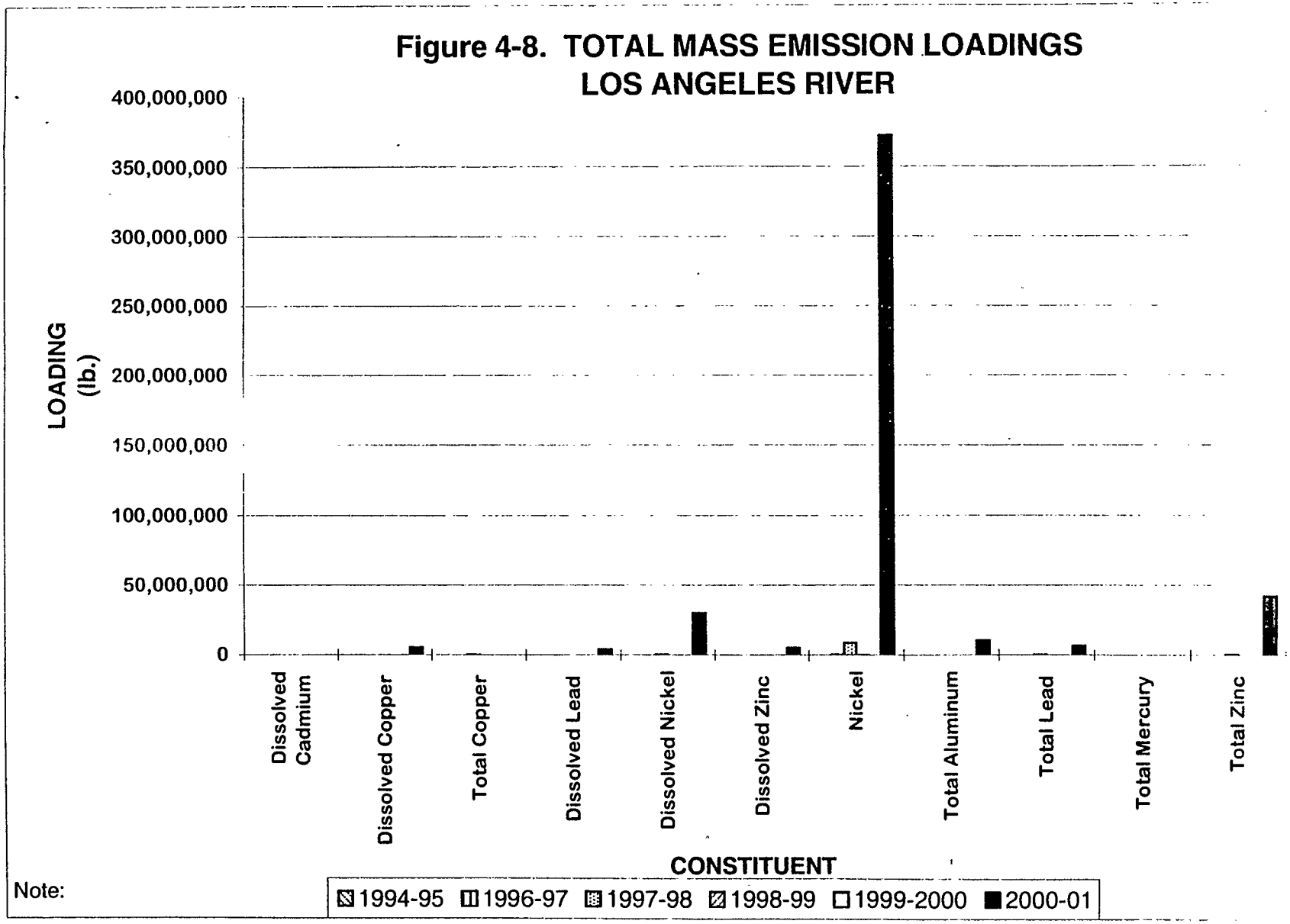


Figure 4-7. TOTAL MASS EMISSION LOADINGS
MALIBU CREEK (cont'd)

Figure 4-8. TOTAL MASS EMISSION LOADINGS LOS ANGELES RIVER



Note:

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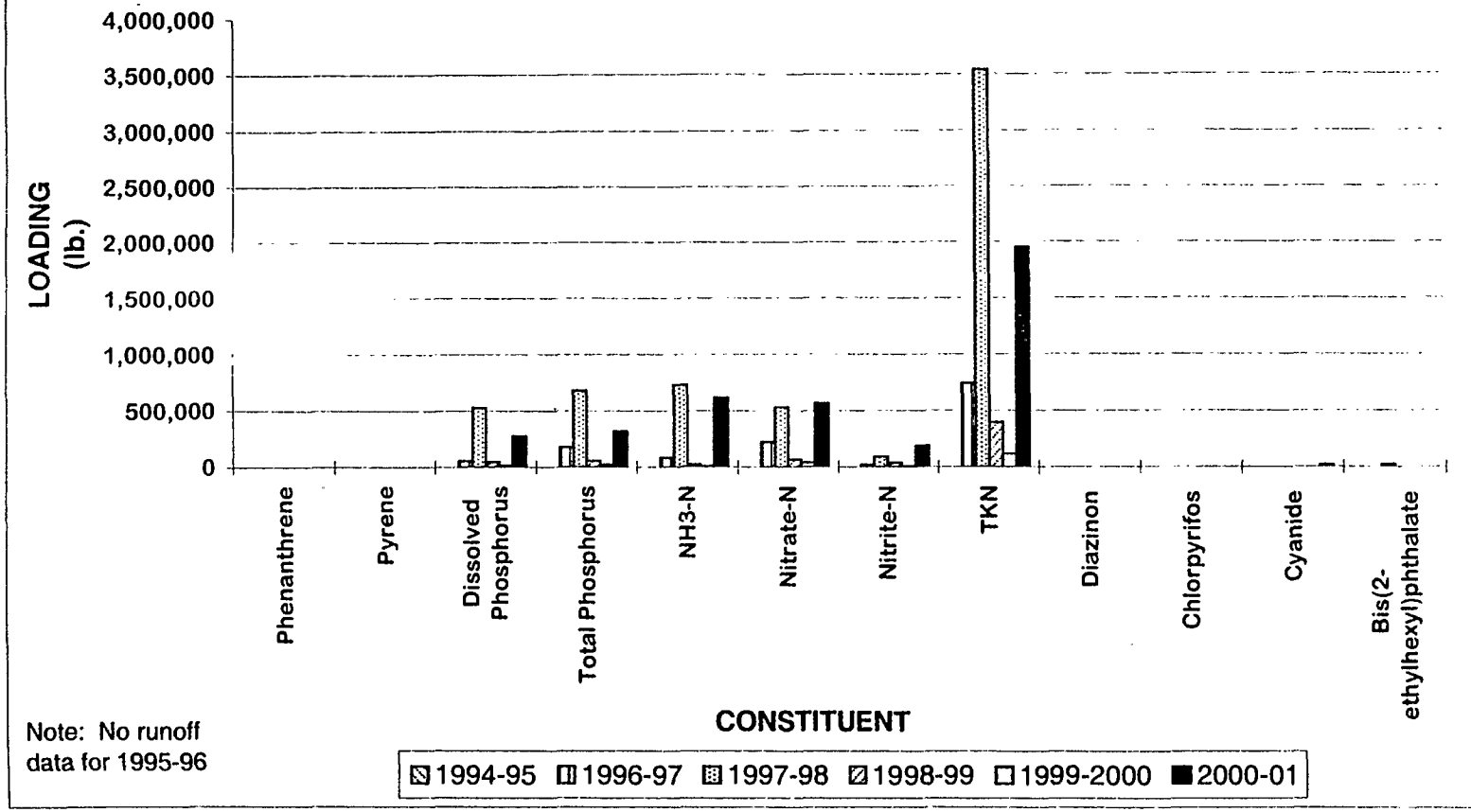
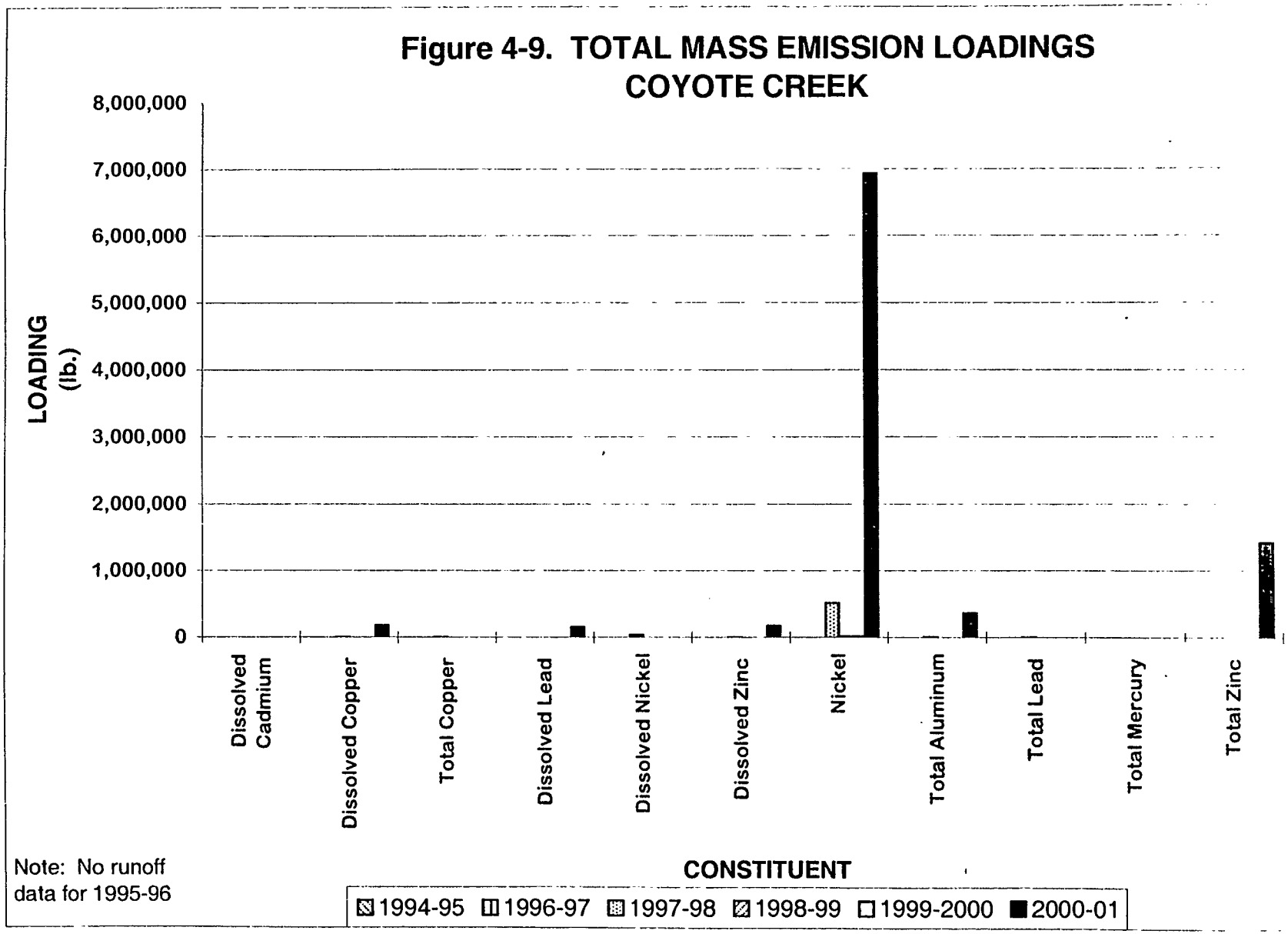
Figure 4-8. TOTAL MASS EMISSION LOADINGS LOS ANGELES RIVER (cont'd)



Note: No runoff data for 1995-96

R0012476

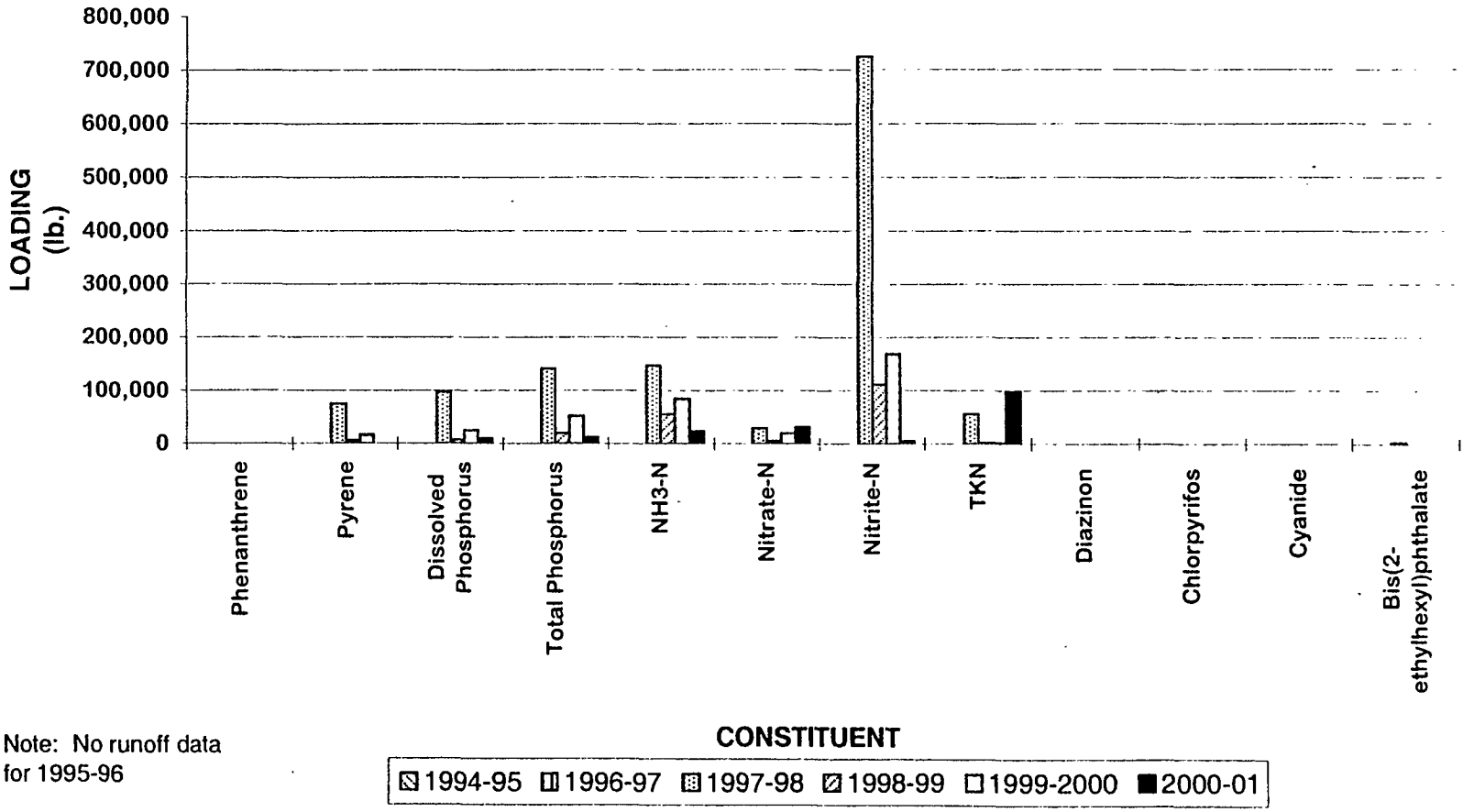
Figure 4-9. TOTAL MASS EMISSION LOADINGS COYOTE CREEK



Note: No runoff data for 1995-96

R0012477

Figure 4-9. TOTAL MASS EMISSION LOADINGS COYOTE CREEK (cont'd)

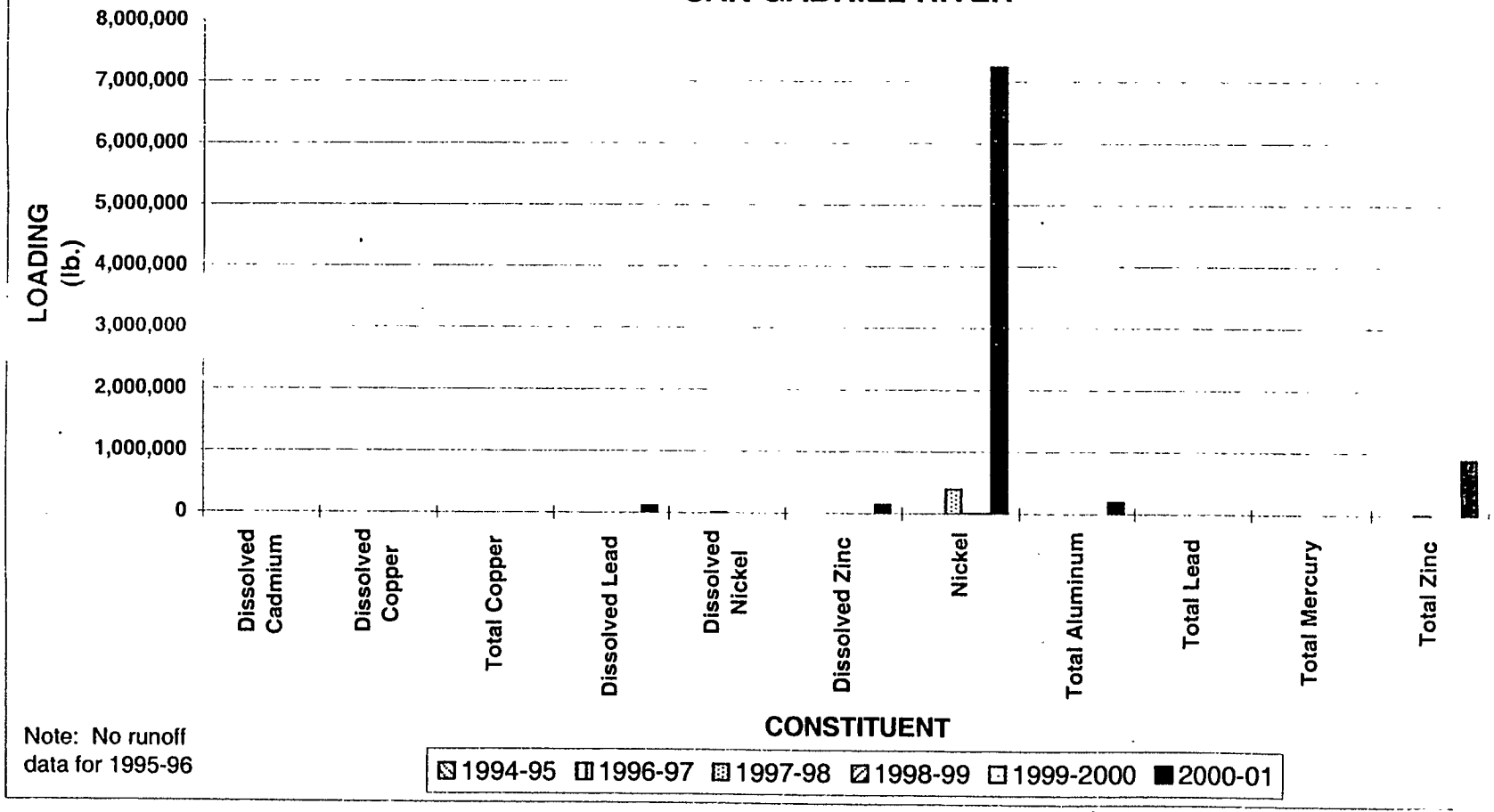


Note: No runoff data for 1995-96

R0012478

Fig 4-4 to 4-9 (ME_load) xls

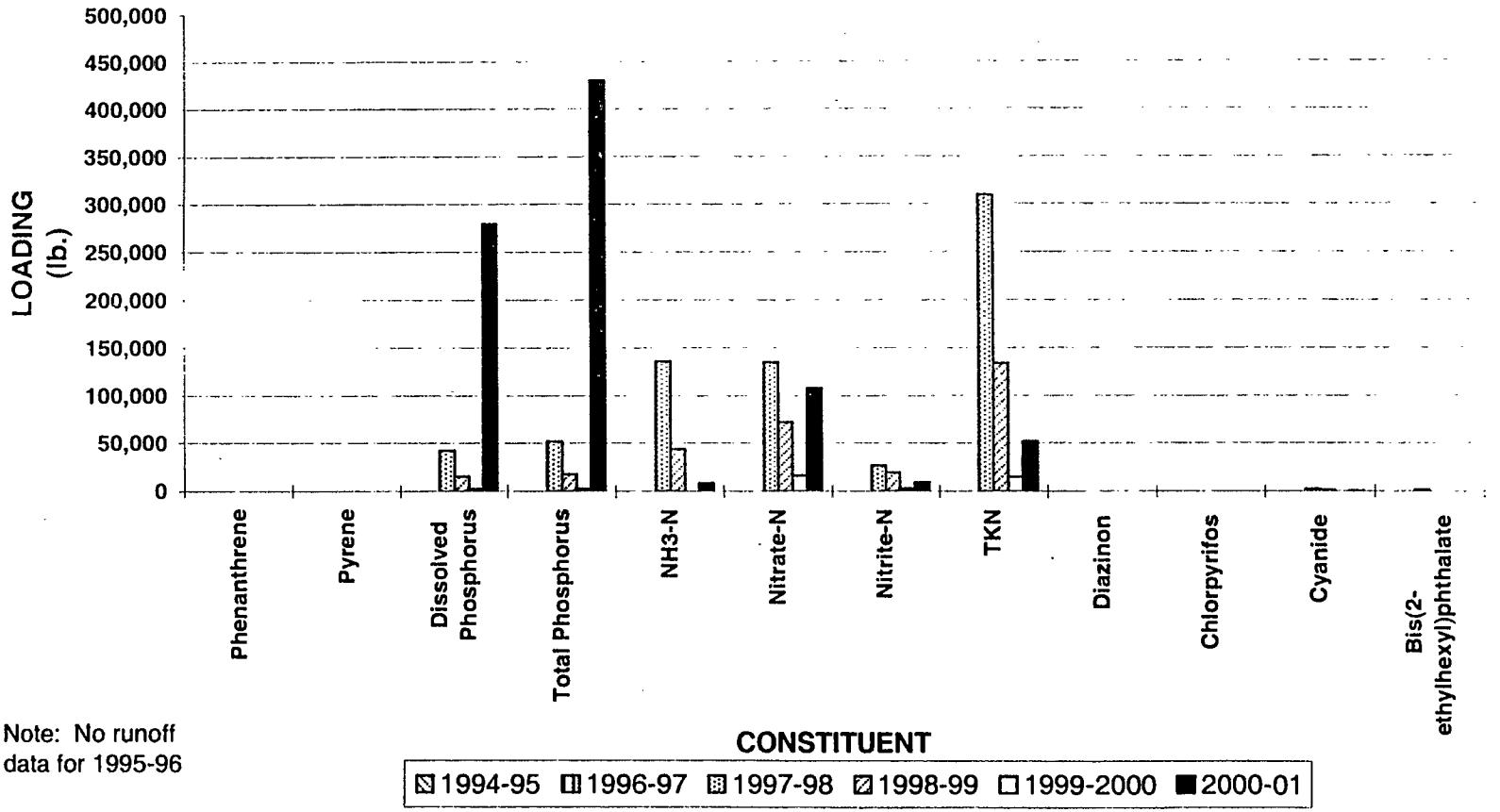
Figure 4-10. TOTAL MASS EMISSION LOADINGS SAN GABRIEL RIVER



Note: No runoff data for 1995-96

R0012479

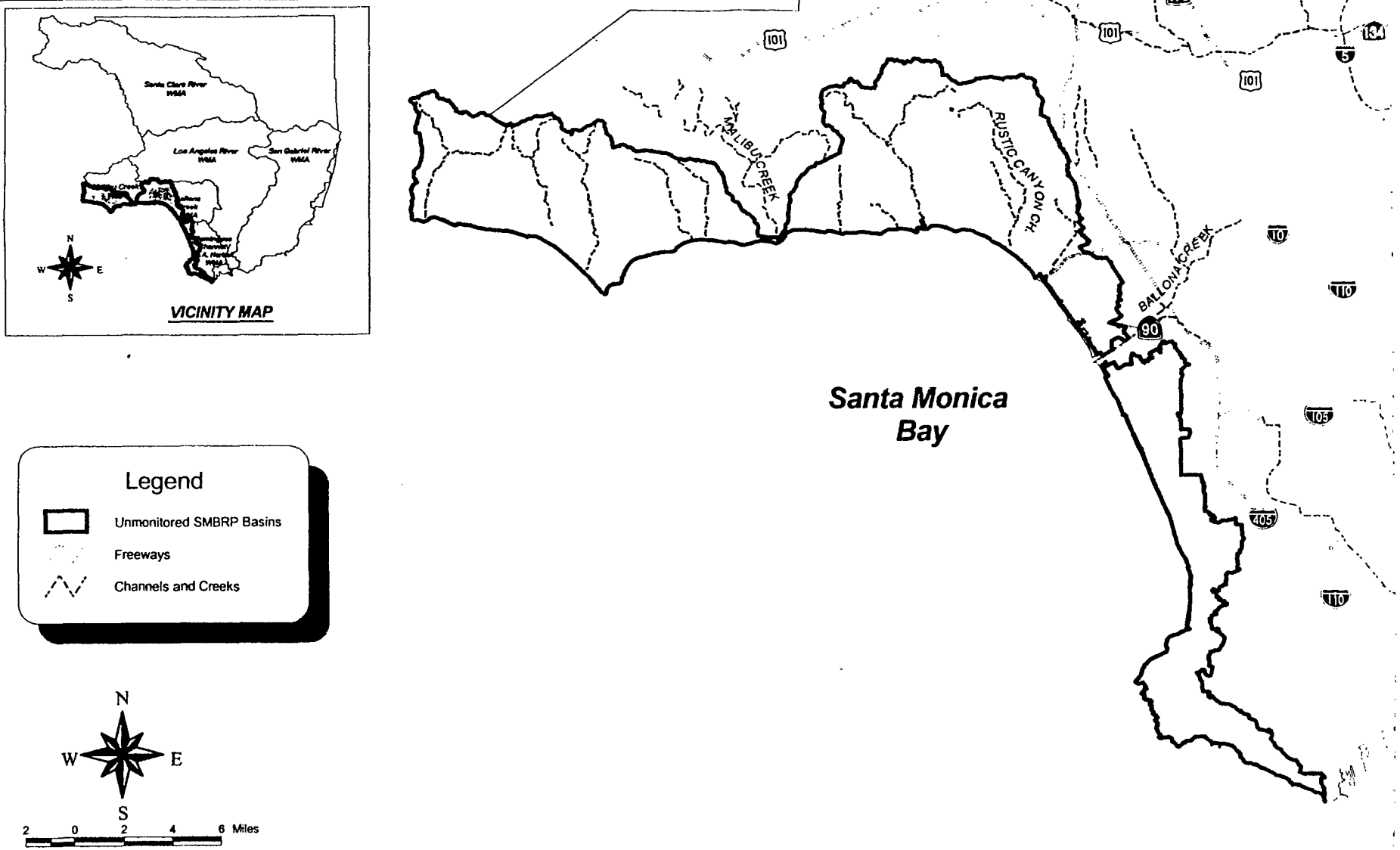
Figure 4-10. TOTAL MASS EMISSION LOADINGS SAN GABRIEL RIVER (cont'd)



Note: No runoff data for 1995-96

R0012480

Fig 4-4 to 4-9 (ME_load).xls



R0012481

Figure 4-11

UNMONITORED SANTA MONICA BAY BASINS (Unmonitored Watersheds)

Land Use Distribution	Area (Acres)	Percent
High Density Residential	17,382	15.5%
Light Industrial	702	0.6%
Vacant	71,269	63.4%
Retail/Commercial	1,843	1.6%
Multi-Family Residential	3,771	3.4%
Transportation	2,401	2.1%
Education	1,455	1.3%
Mixed Residential	1,005	0.9%
Other	12,[illegible]	11.2%
Total	112,[illegible]	100.0%

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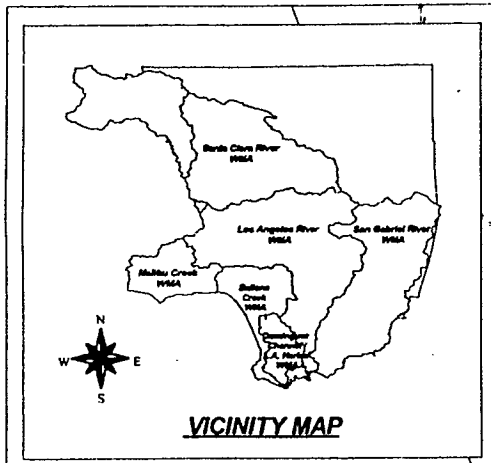

VICINITY MAP

R0012482

LOS ANGELES COUNTY PUBLIC WORKS Public Service That Works

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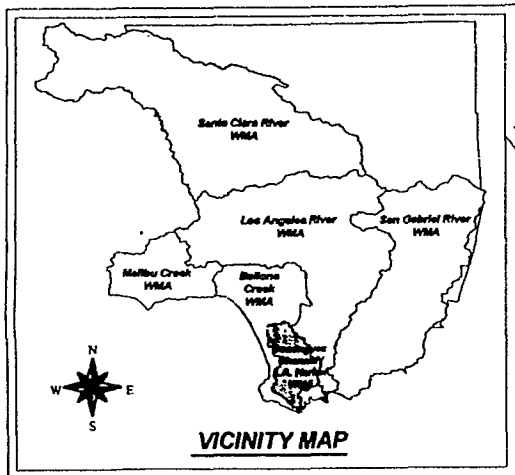
Figure 4-12

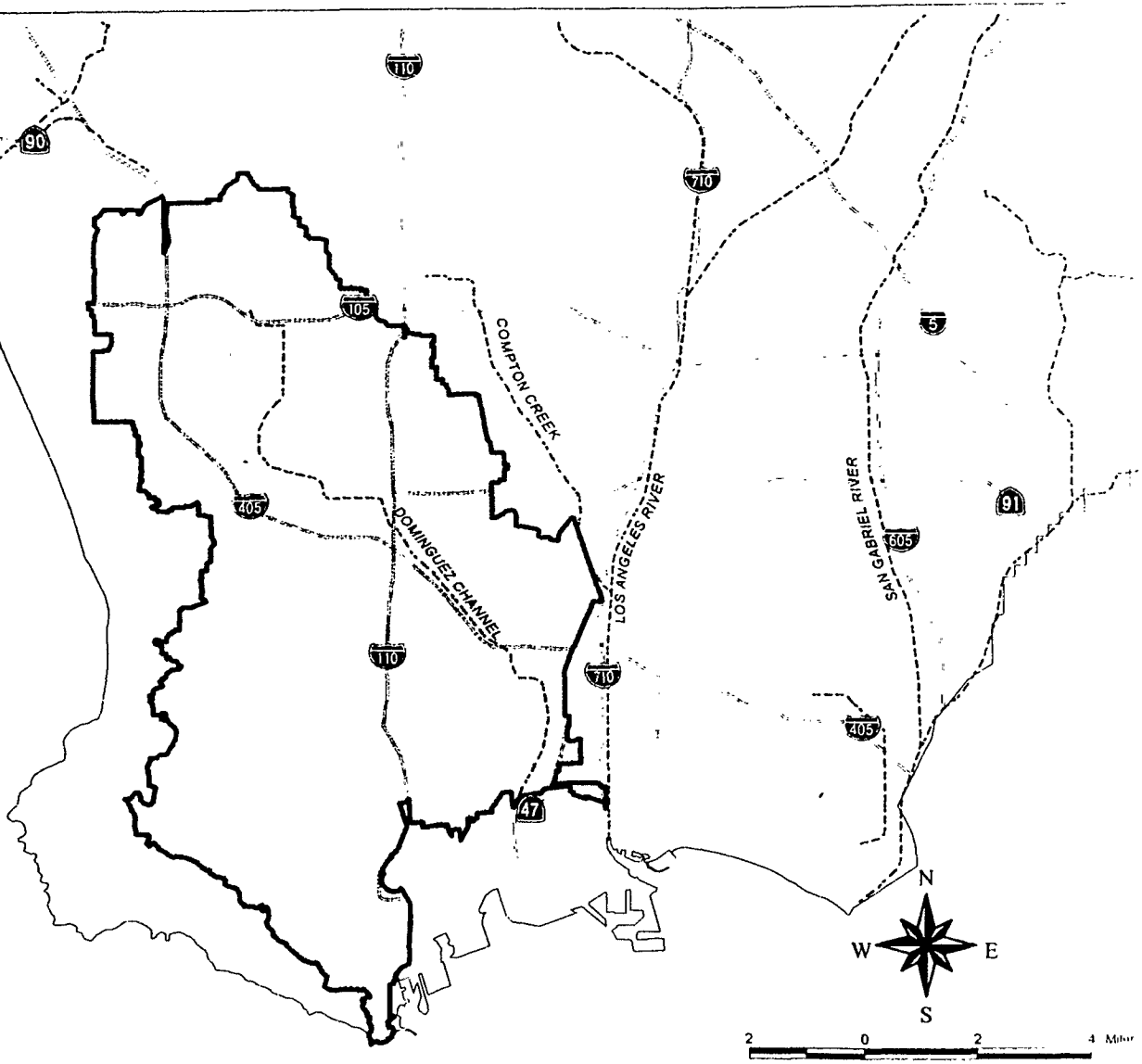
SANTA CLARA RIVER (Unmonitored Watershed)

Land Use Distribution	Area (Acres)	Percent
High Density Residential	7,669	1.8%
Light Industrial	1,155	0.3%
Vacant	368,430	88.2%
Retail/Commercial	842	0.2%
Multi-Family Residential	1,139	0.3%
Transportation	1,843	0.4%
Education	653	0.2%
Mixed Residential	12	0.0%
Other	36,131	8.6%
Total	736,384	100.0%



VICINITY MAP

Santa Monica Bay



Legend

- Dominguez Channel/L.A. Harbor WMA
- Freeways
- Channels and Creeks

R0012483

LOS ANGELES COUNTY PUBLIC WORKS Public Service That Works

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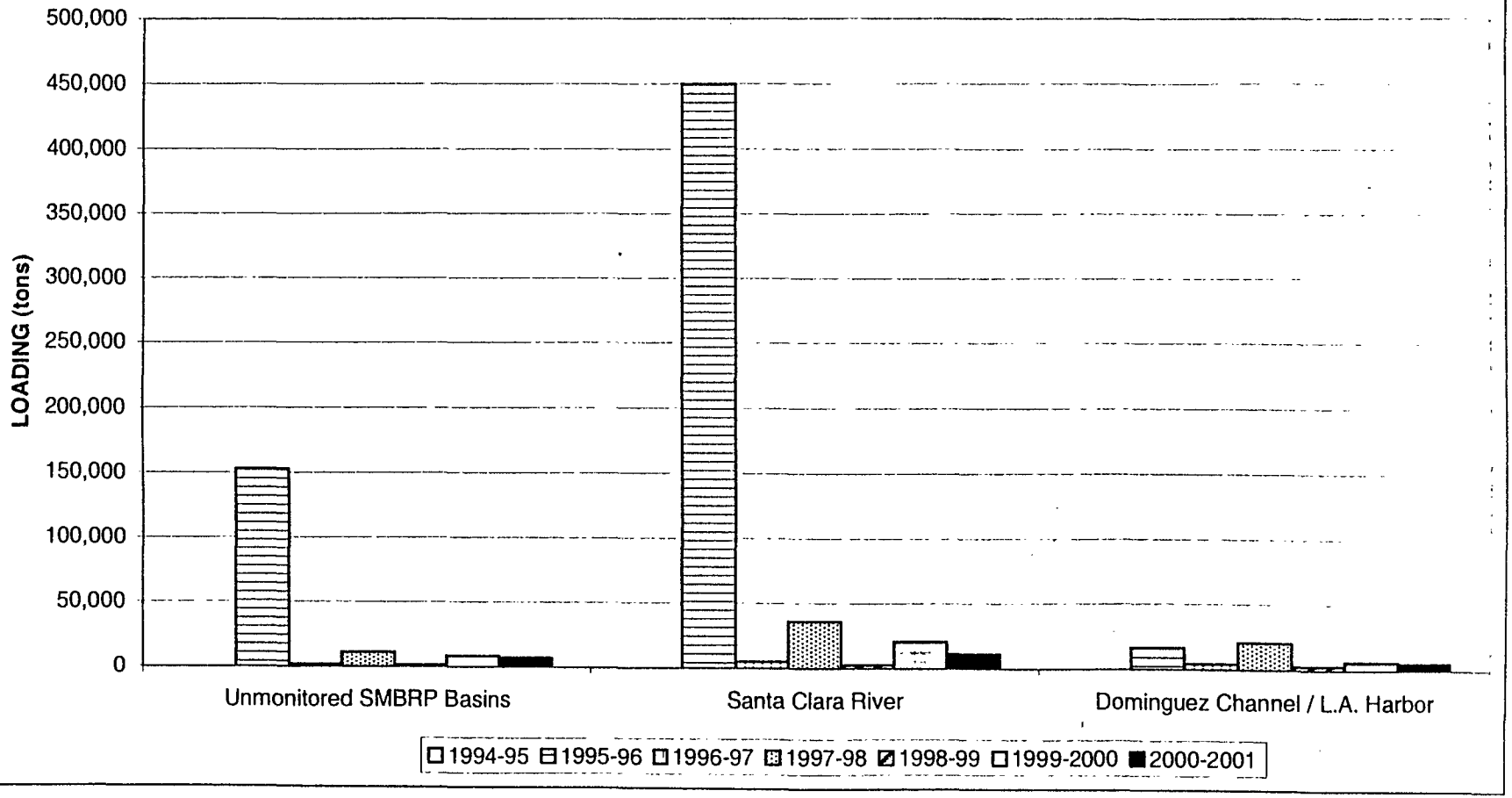
Figure 4-13

DOMINGUEZ CHANNEL/L.A. HARBOR WMA (Unmonitored Watershed)

Land Use Distribution	Area (Acres)	Percent
High Density Residential	24,044	34.1%
Light Industrial	9,285	13.2%
Vacant	1,780	2.5%
Retail/Commercial	4,358	6.2%
Multi-Family Residential	4,099	5.8%
Transportation	3,294	4.7%
Education	2,602	3.7%
Mixed Residential	2,985	4.2%
Other	17,918	25.4%
Total		100.0%

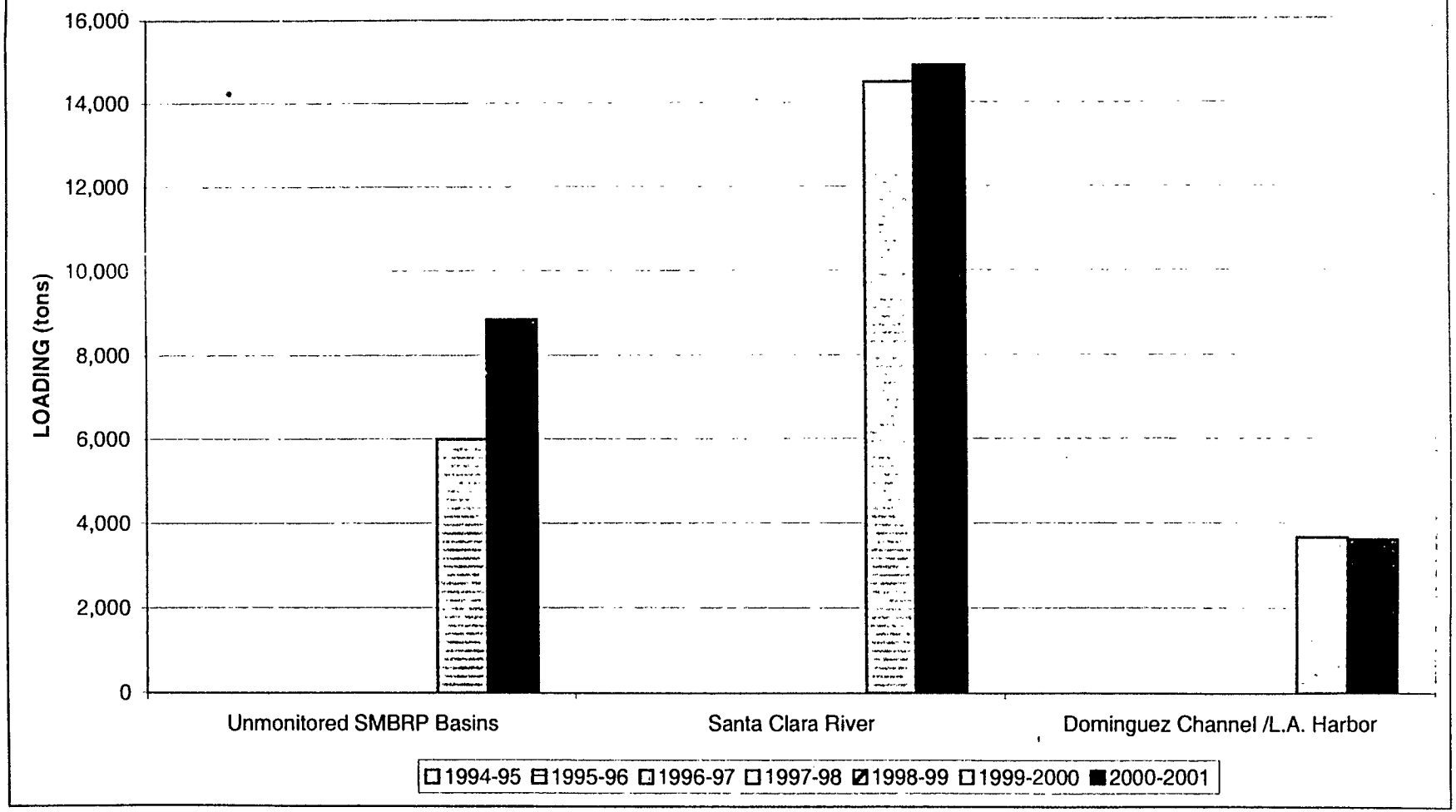
Figure 4-14. ESTIMATED TOTAL MASS EMISSION LOADINGS TOTAL SUSPENDED SOLIDS



R0012484

Figure 4-14.xls

Figure 4-15. ESTIMATED TOTAL MASS EMISSION LOADINGS TOTAL DISSOLVED SOLIDS



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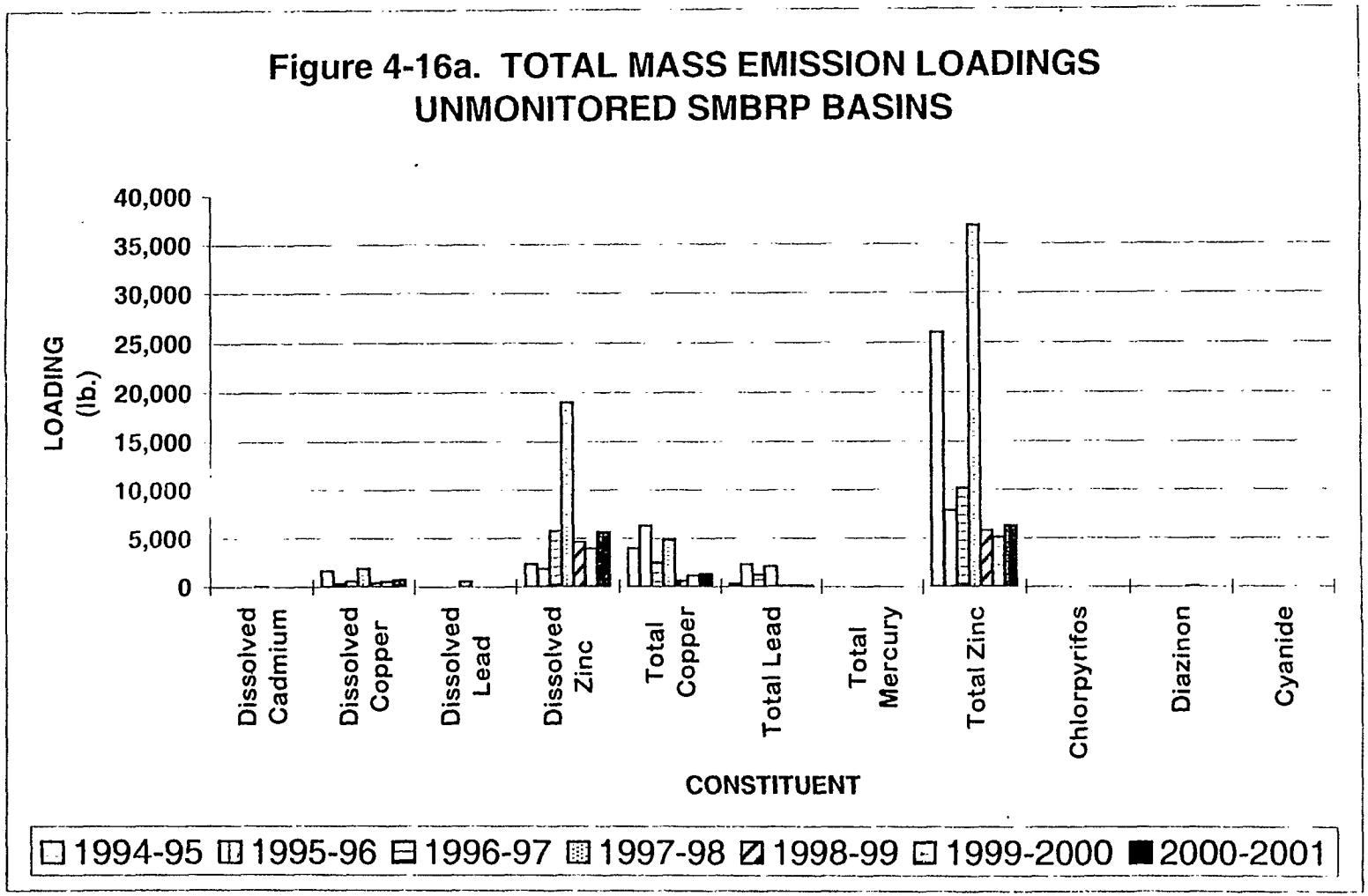
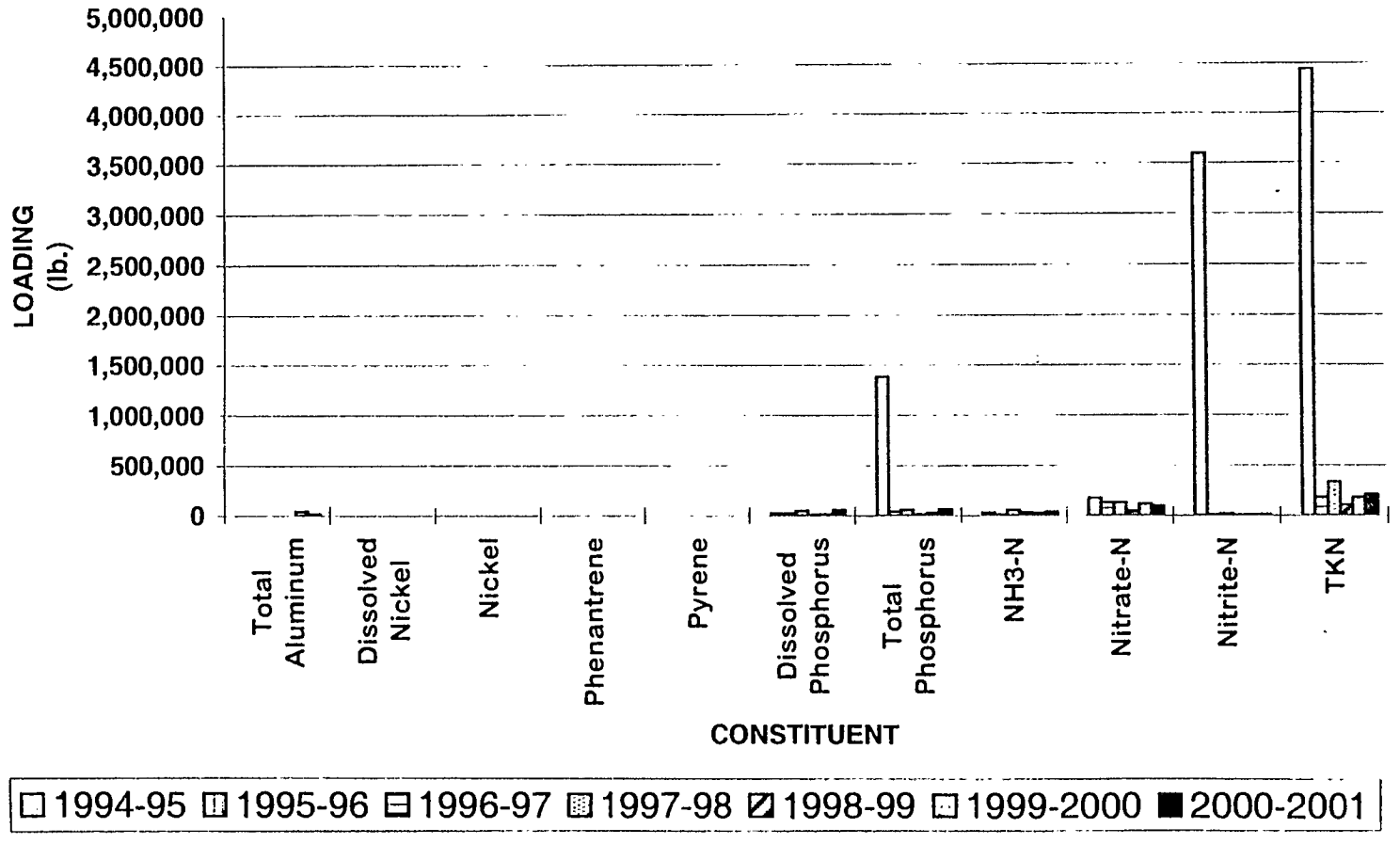
ure 4-15.xls



R0012486

Figure 4-16a.xls

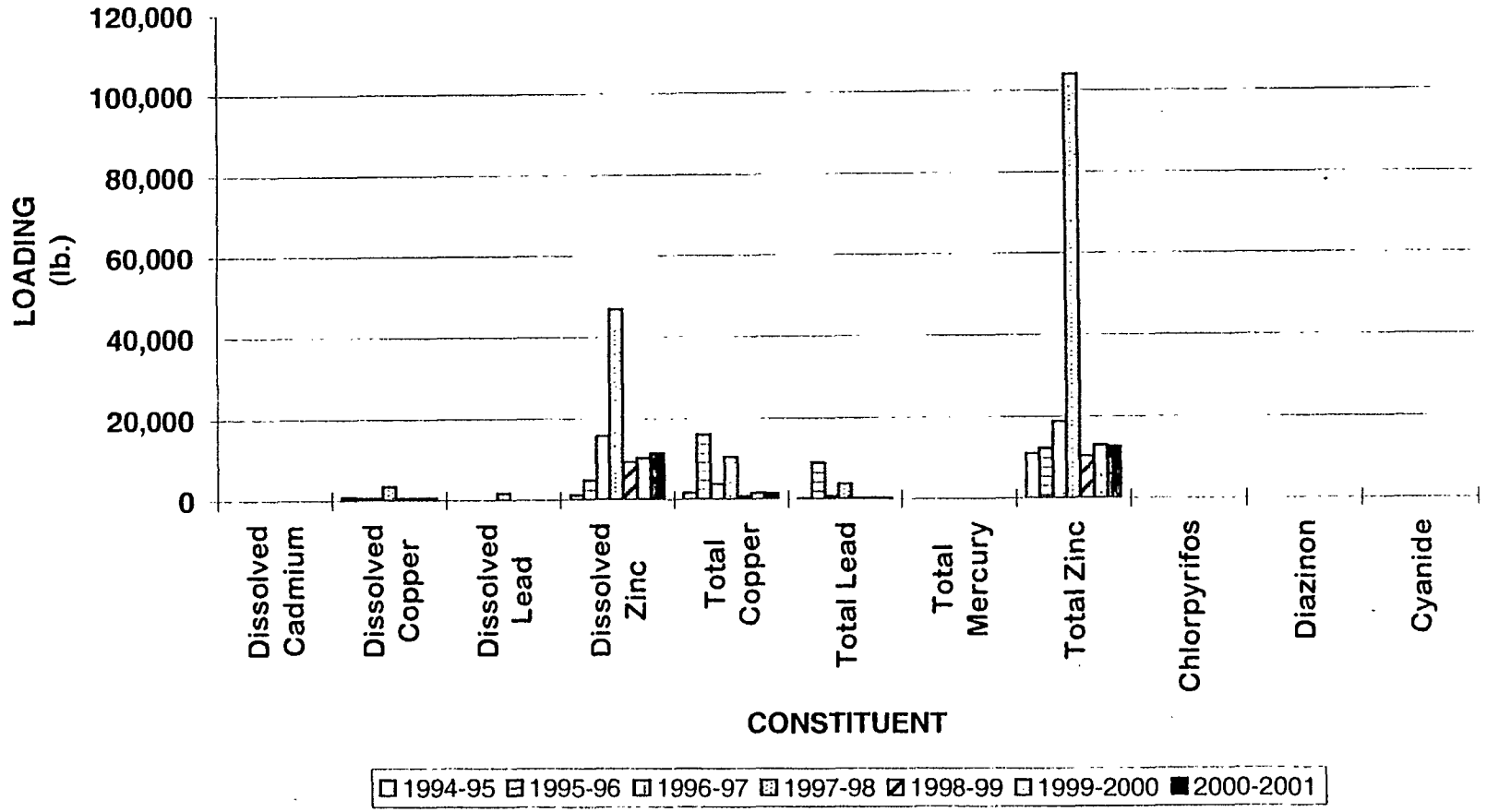
Figure 4-16a. TOTAL MASS EMISSION LOADINGS UNMONITORED SMBRP BASINS (cont'd)



R0012487

Figure 4-16a.xls

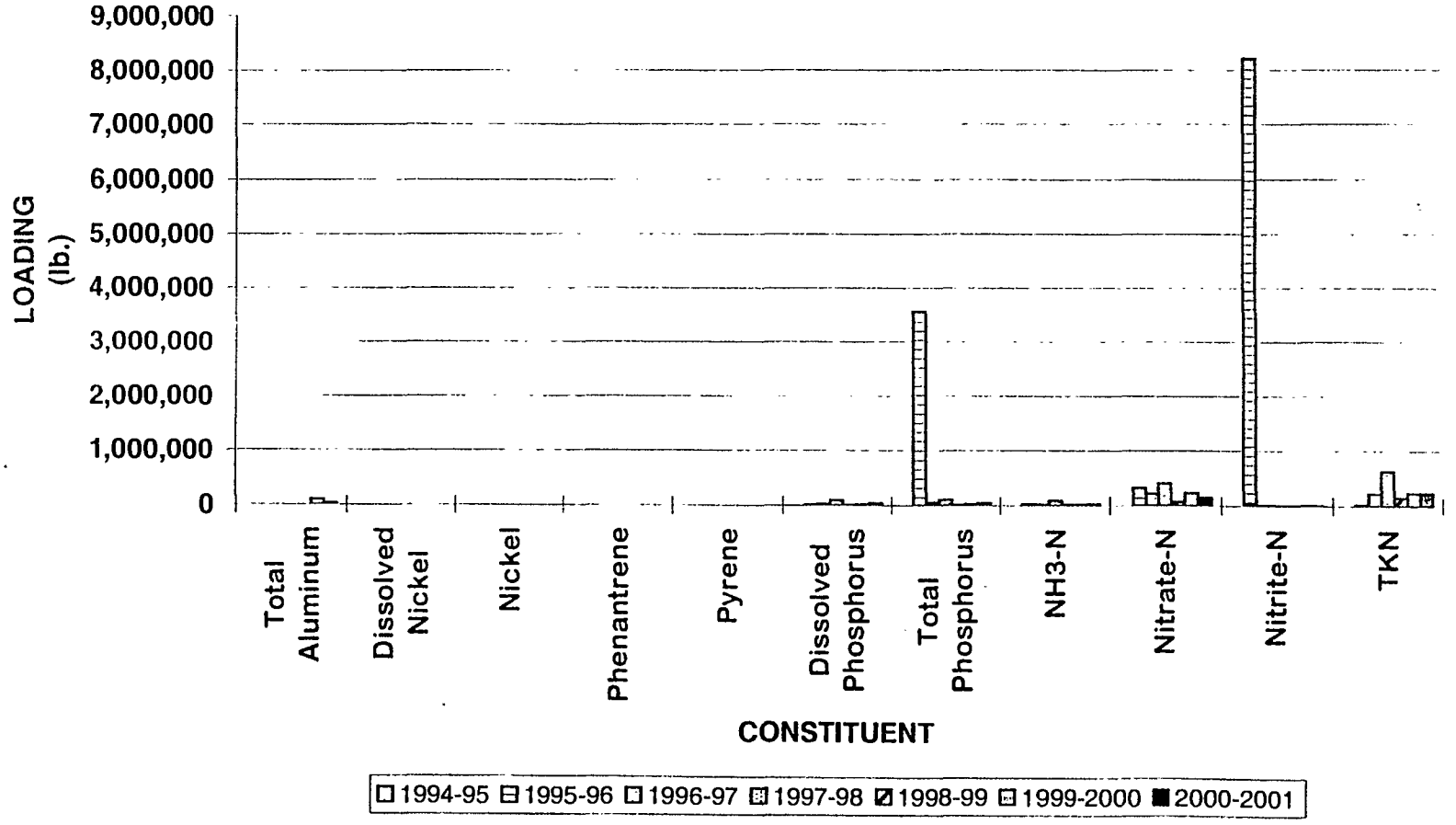
Figure 4-16b. TOTAL MASS EMISSION LOADINGS SANTA CLARA RIVER



R0012488

Figure 4-16b.xls

Figure 4-16b. TOTAL MASS EMISSION LOADINGS SANTA CLARA RIVER (cont'd)



R0012489

Figure 4-16b.xls

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Figure 4-16c.xls

Figure 4-16c. TOTAL MASS EMISSION LOADINGS DOMINGUEZ CHANNEL / L.A. HARBOR WMA (cont'd)

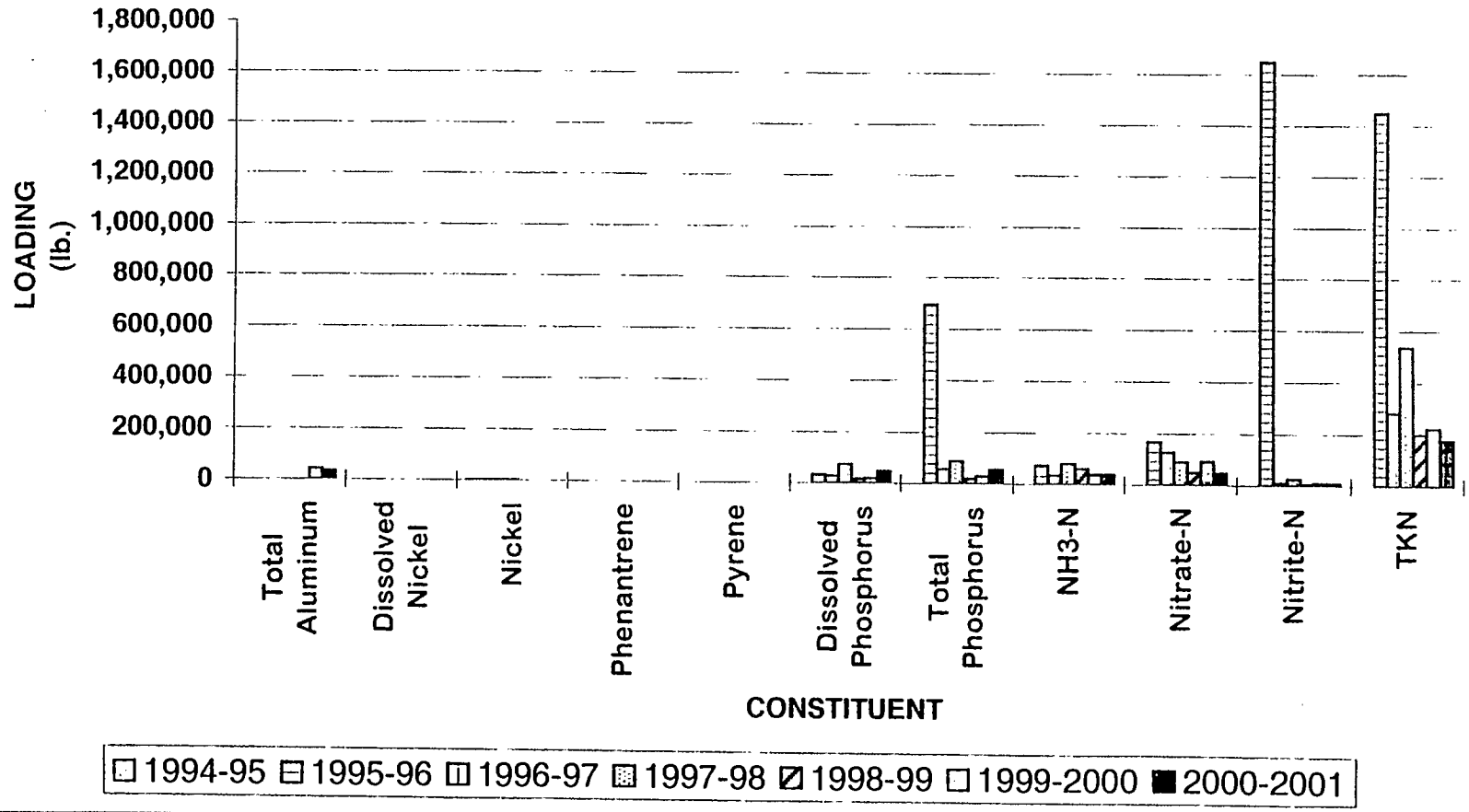

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Figure 4-17a **Bis(2-ethylhexyl)phthalate**

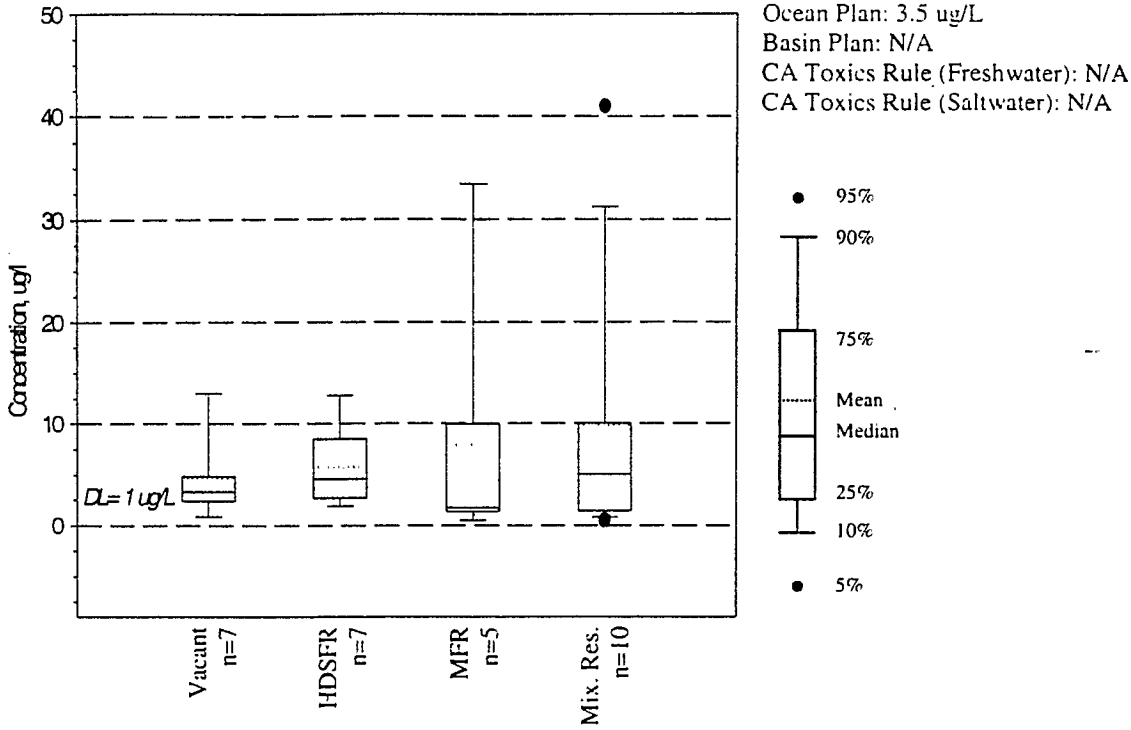

Figure 4-17b **Dissolved Copper**

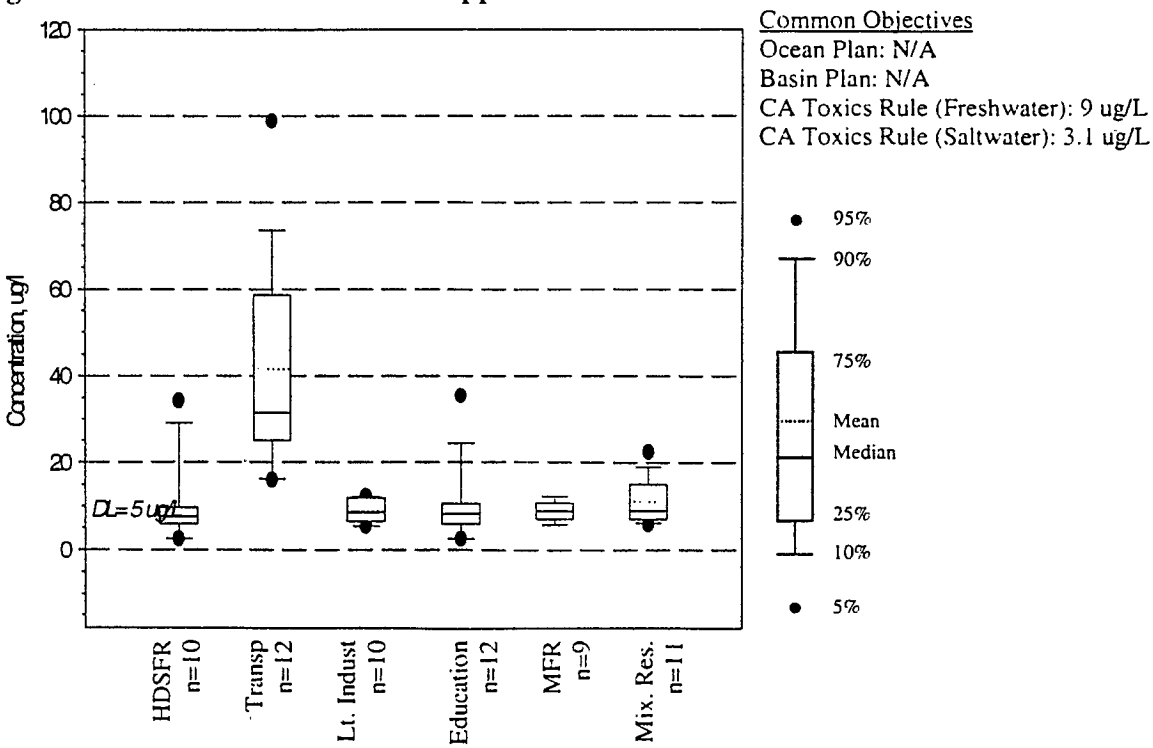

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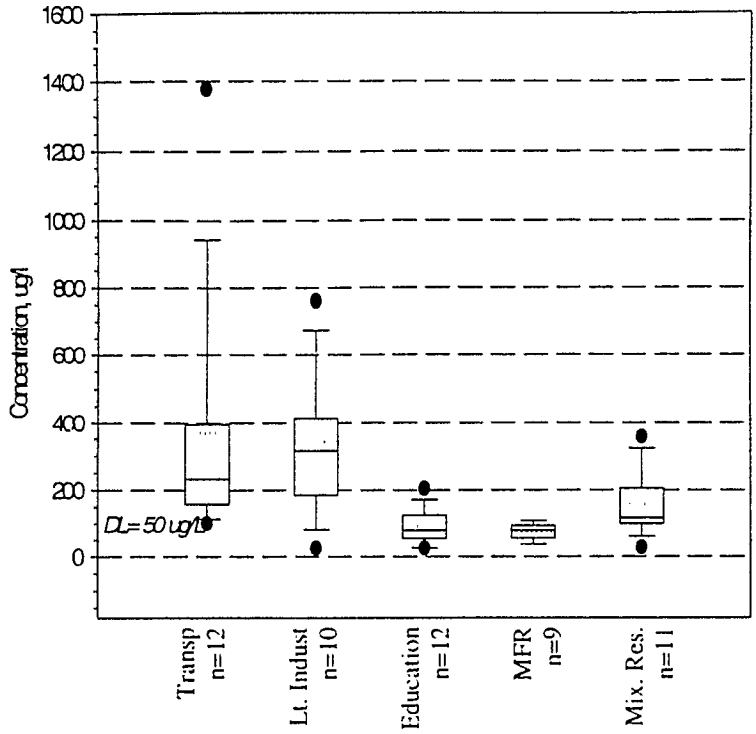
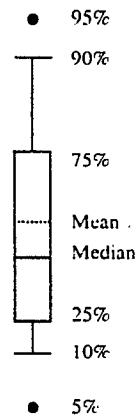
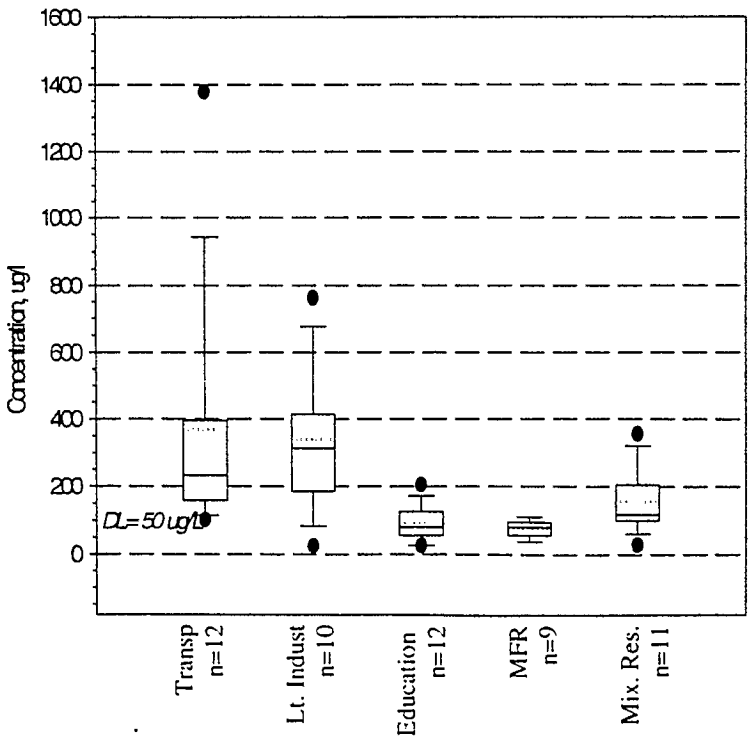
Figure 4-17c **Dissolved Zinc**

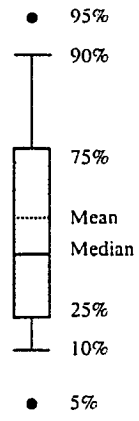




Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 120 ug/L
CA Toxics Rule (Saltwater): 81 ug/L.

Figure 4-17d **Dissolved Nickel**





Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 52 ug/L
CA Toxics Rule (Saltwater): 8.2 ug/L

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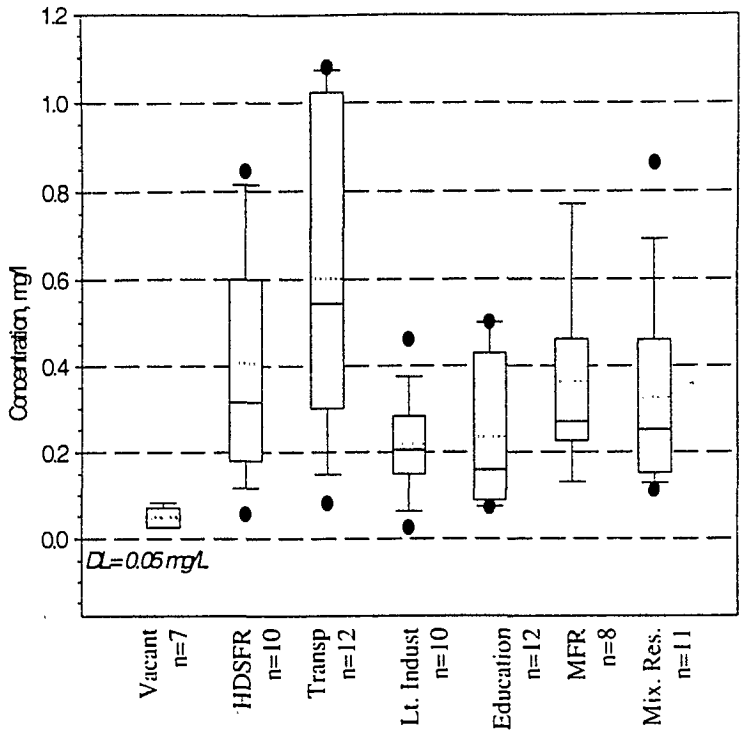
Figure 4-17e **Dissolved Phosphorus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

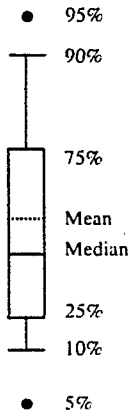
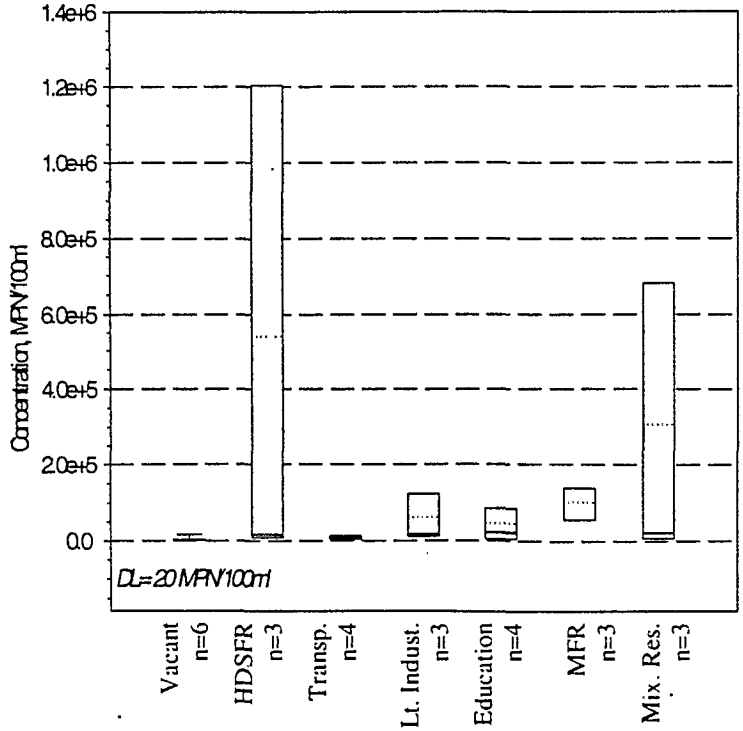


Figure 4-17f **Fecal Coliform**



Common Objectives
Ocean Plan: 200 MPN/100ml
Basin Plan: 200 MPN/100ml
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

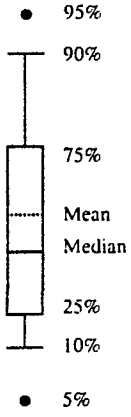
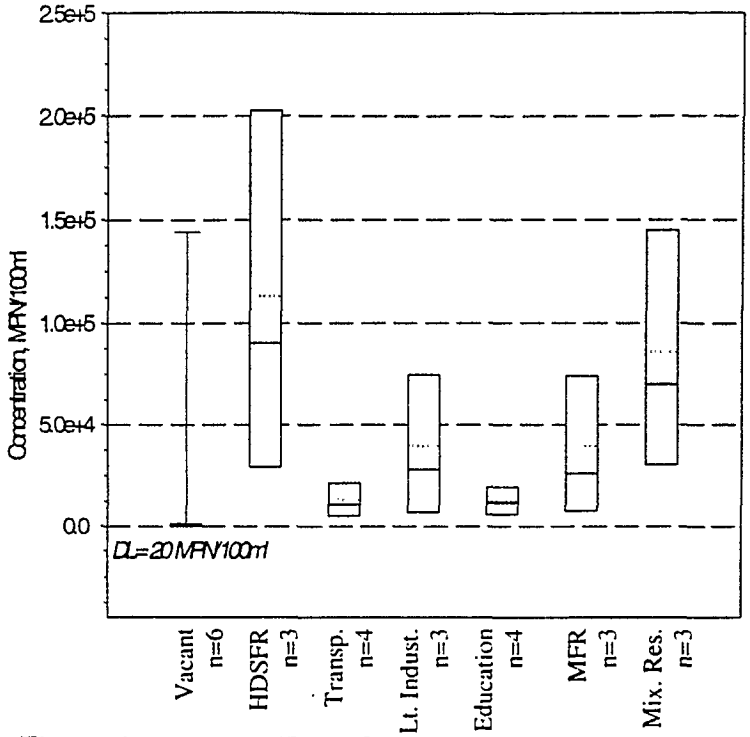


Figure 4-17g **Fecal Enterococcus**



Common Objectives
Ocean Plan: 24 MPN/100ml
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

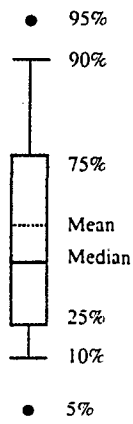
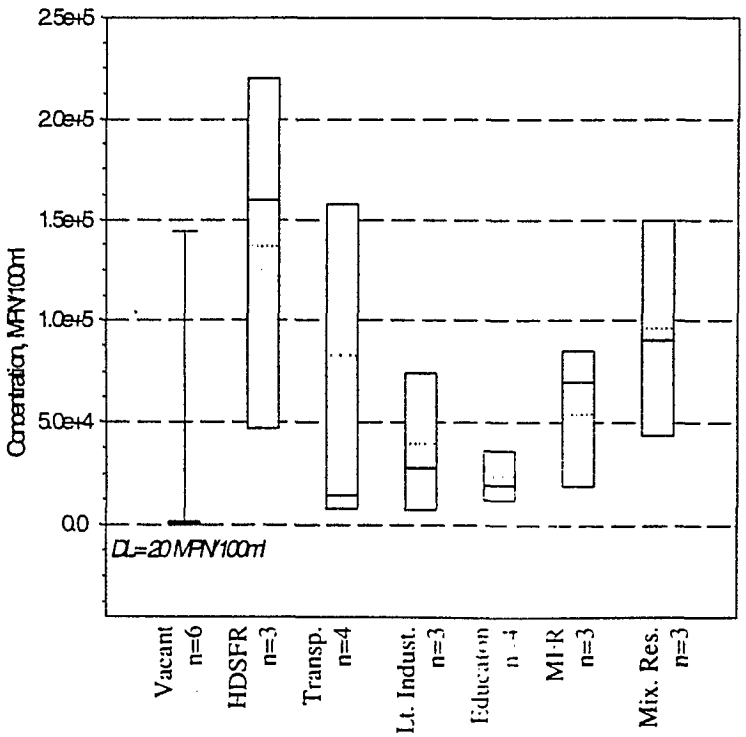


Figure 4-17h **Fecal Streptococcus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

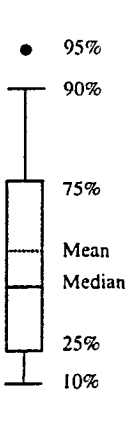


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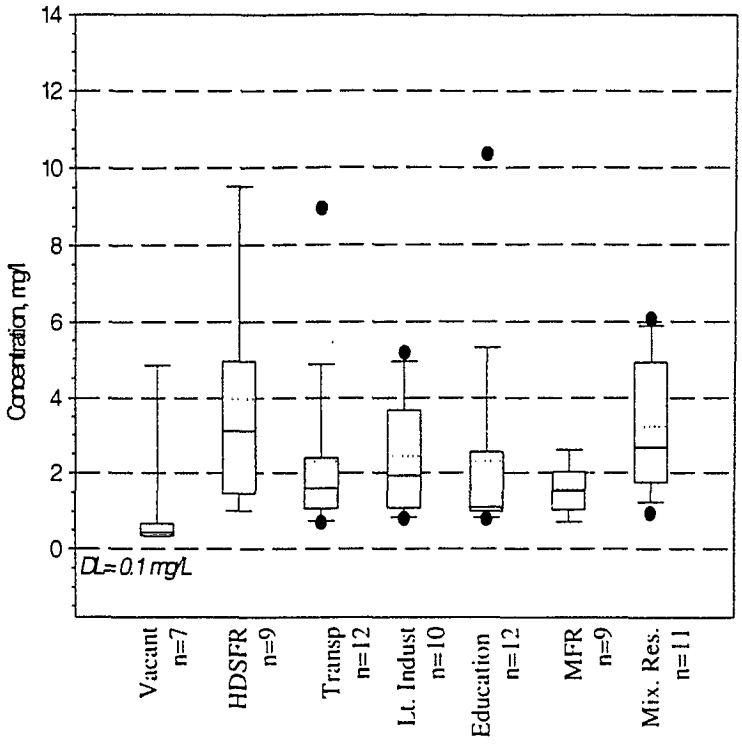
Figure 4-17i **Kjeldahl-N**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

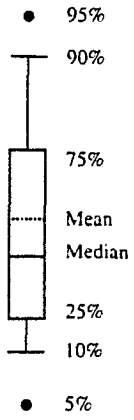
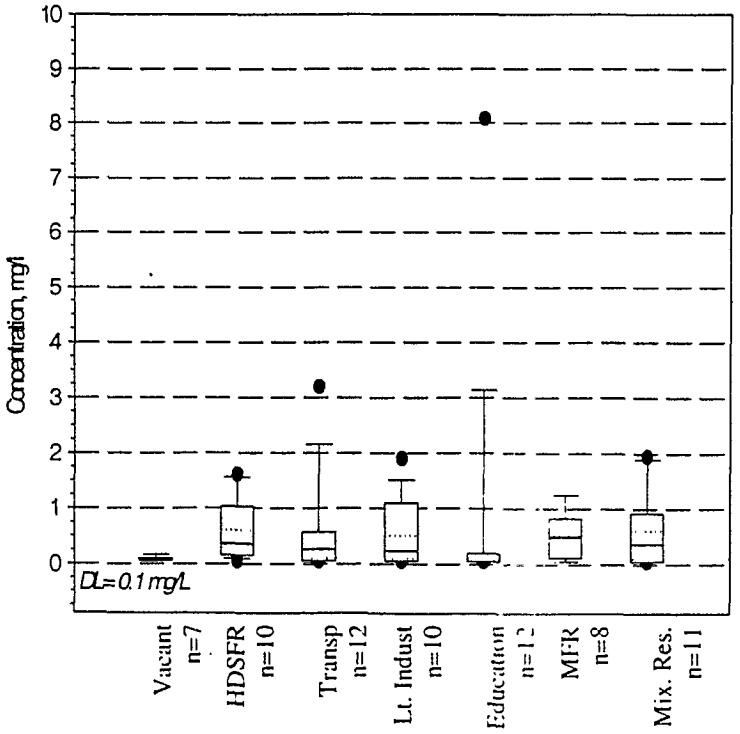


Figure 4-17j **NH3-N**



Common Objectives
Ocean Plan: 2.4 mg/L
Basin Plan: 2.7 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

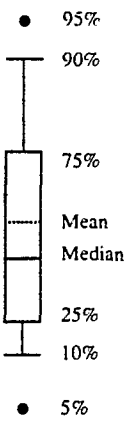


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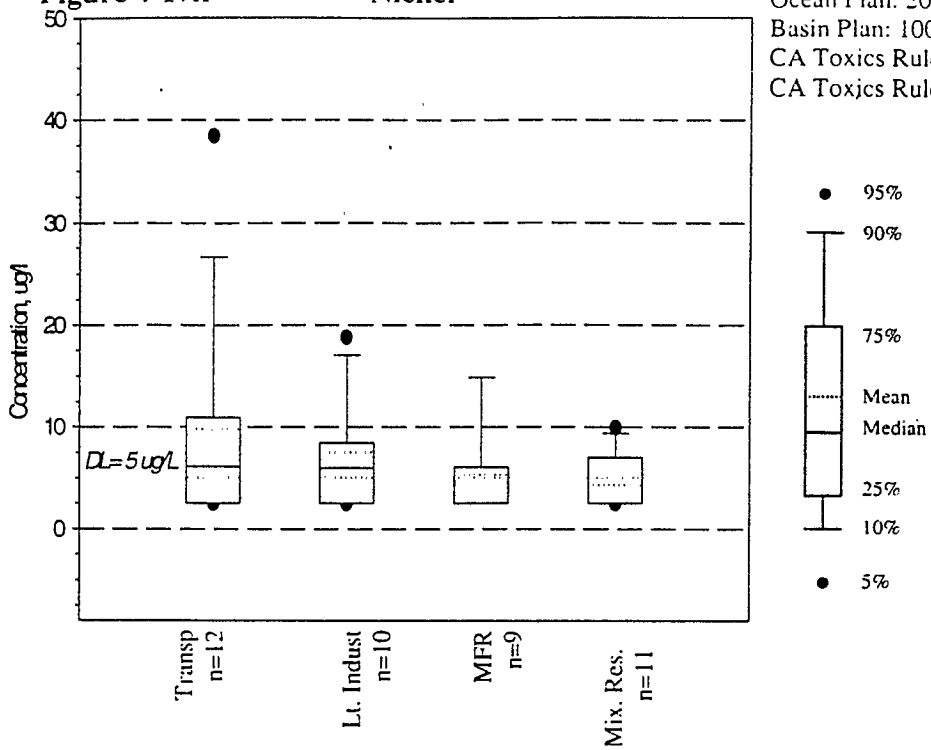
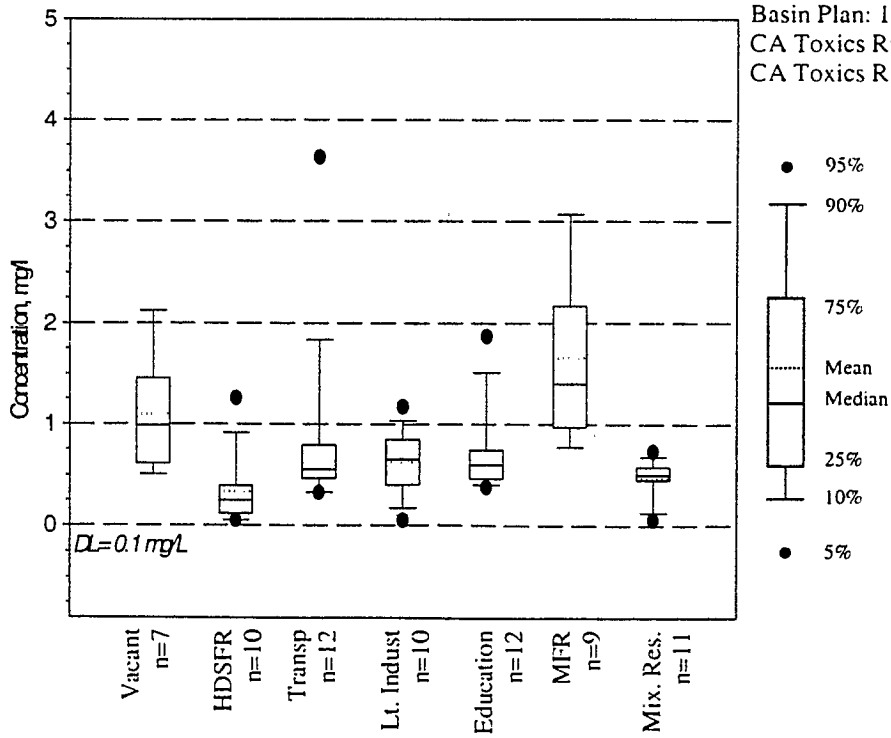
Figure 4-17k **Nickel**



Common Objectives
Ocean Plan: 20 ug/L
Basin Plan: 100 ug/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

Figure 4-17l **Nitrate-N**



Common Objectives
Ocean Plan: N/A
Basin Plan: 10 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

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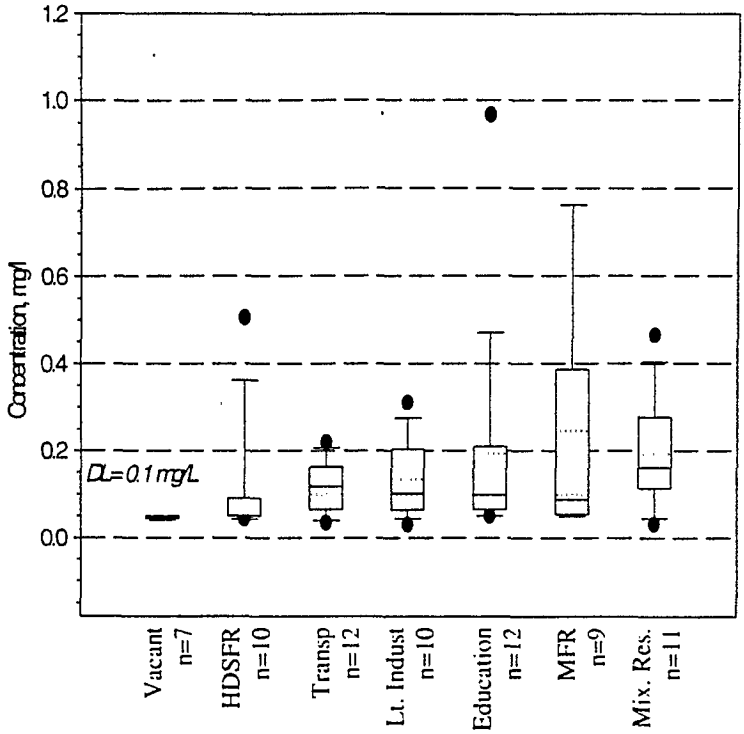
Figure 4-17m **Nitrite-N**



Common Objectives
Ocean Plan: N/A
Basin Plan: 1 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

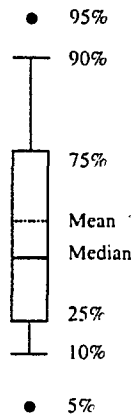
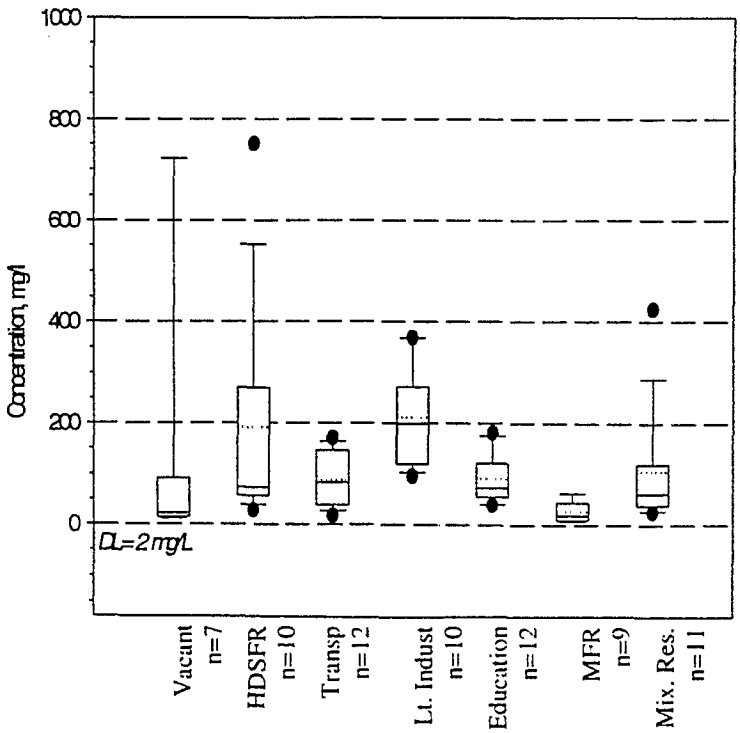


Figure 4-17n **Suspended Solids**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

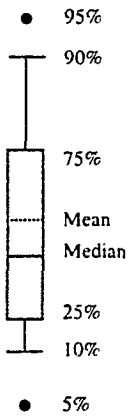


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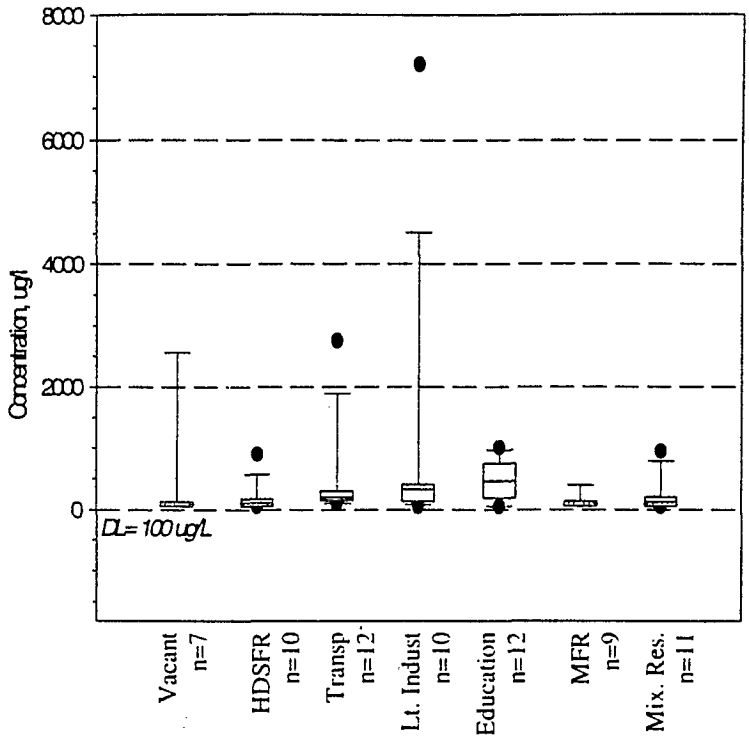
Figure 4-17o **Total Aluminum**



Common Objectives
Ocean Plan: N/A
Basin Plan: 1000 ug/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

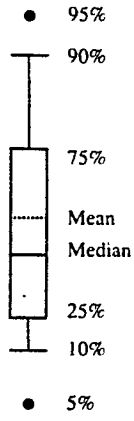
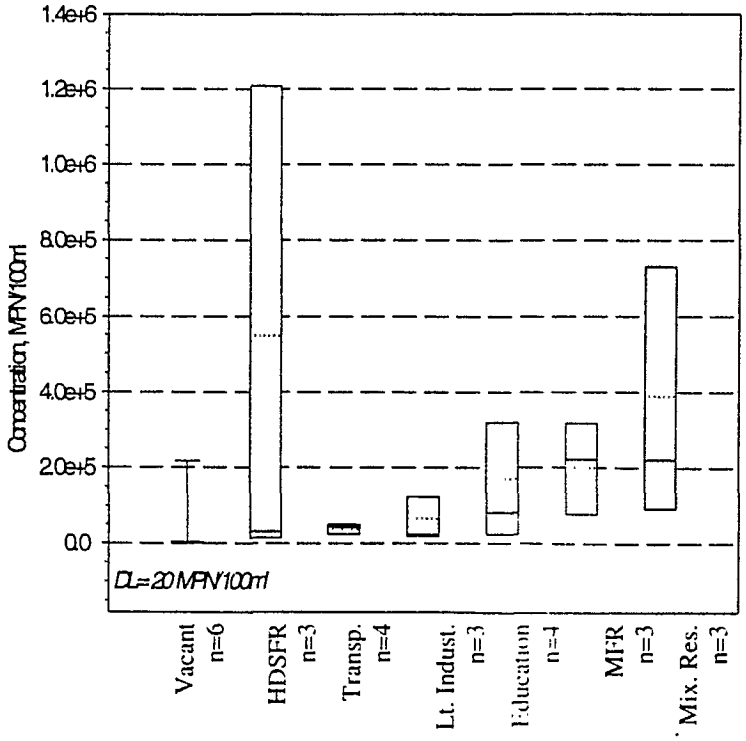


Figure 4-17p **Total Coliform**



Common Objectives
Ocean Plan: 1000 MPN/100ml
Basin Plan: 70 MPN/100ml
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

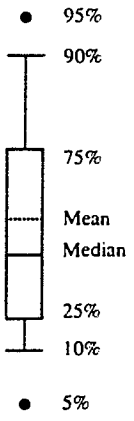
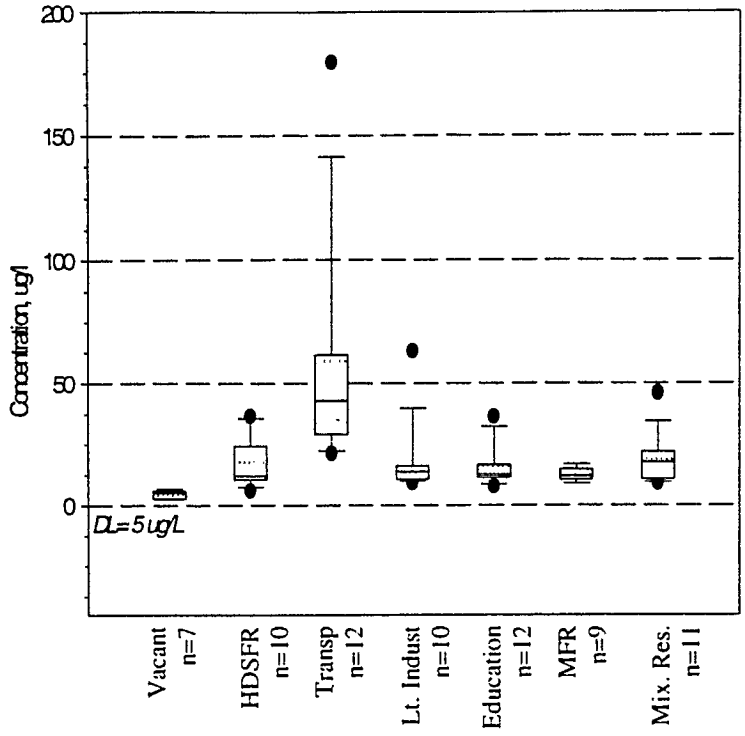
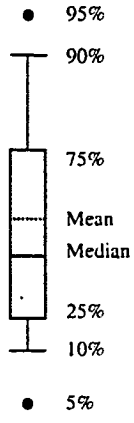


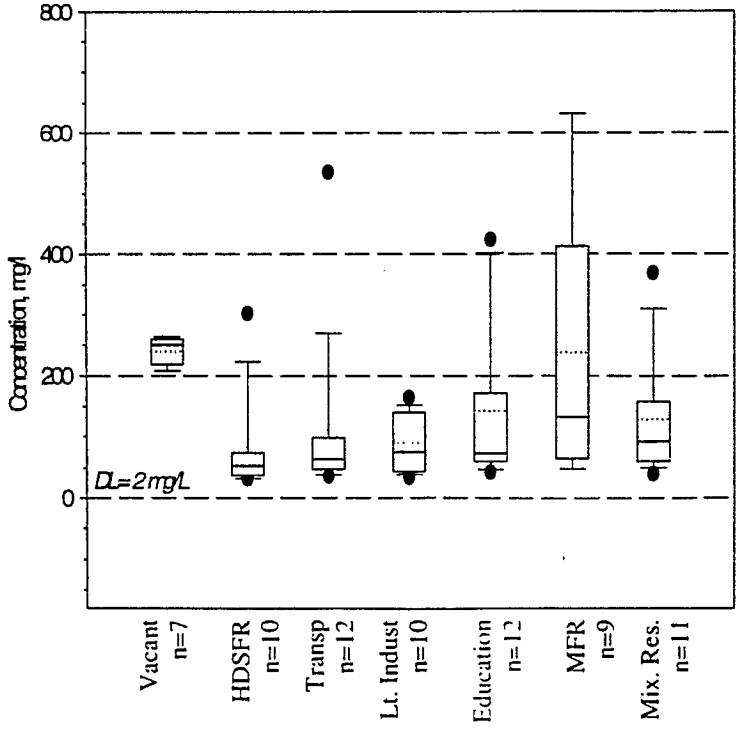
Figure 4-17q **Total Copper**

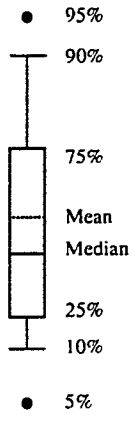




Common Objectives
Ocean Plan: 12 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

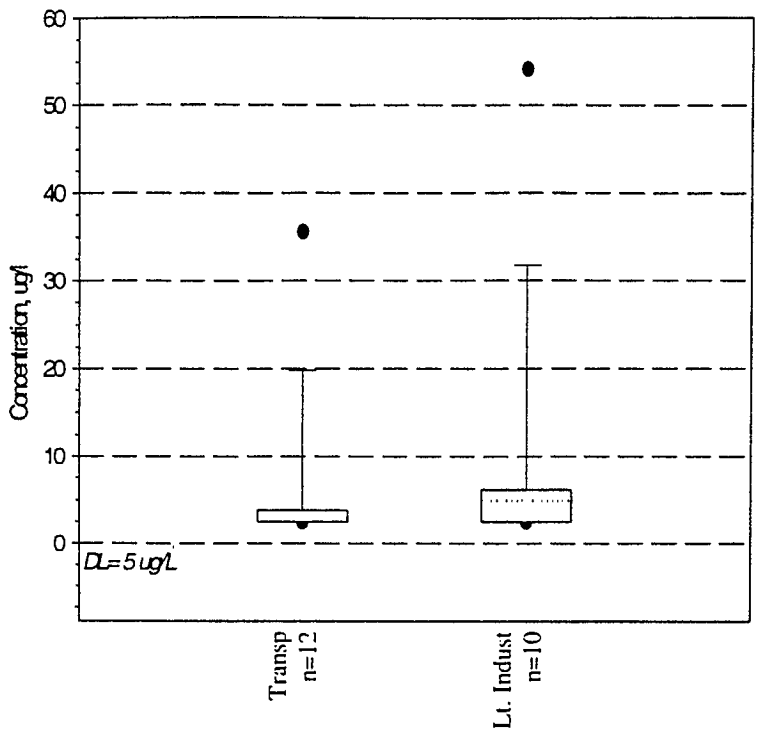
Figure 4-17r **Total Dissolved Solids**





Common Objectives
Ocean Plan: N/A
Basin Plan: 250 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

Figure 4-17s **Total Lead**



Common Objectives
Ocean Plan: 8 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

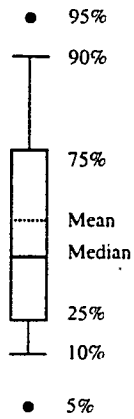
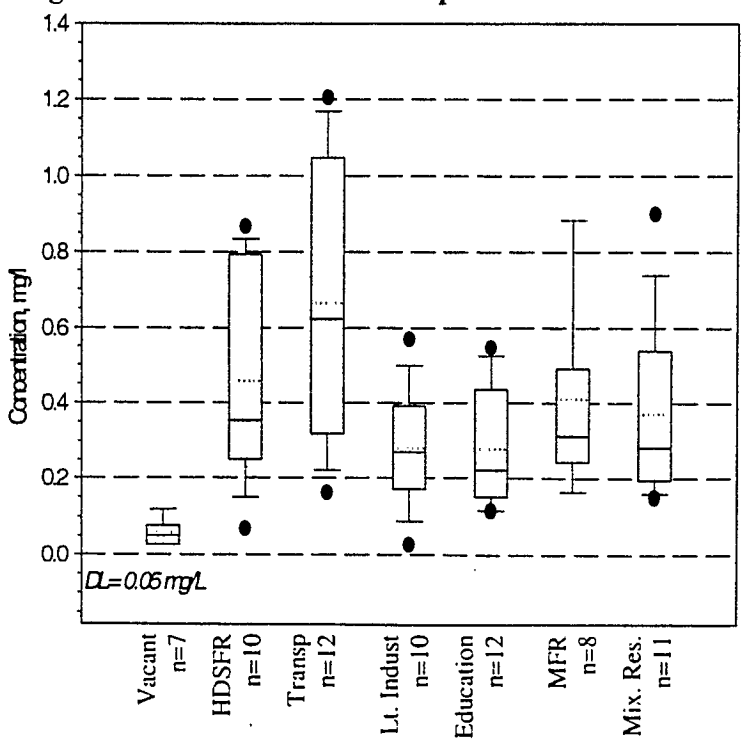


Figure 4-17t **Total Phosphorus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

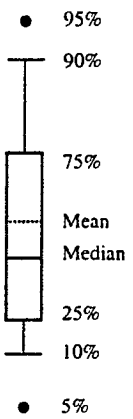


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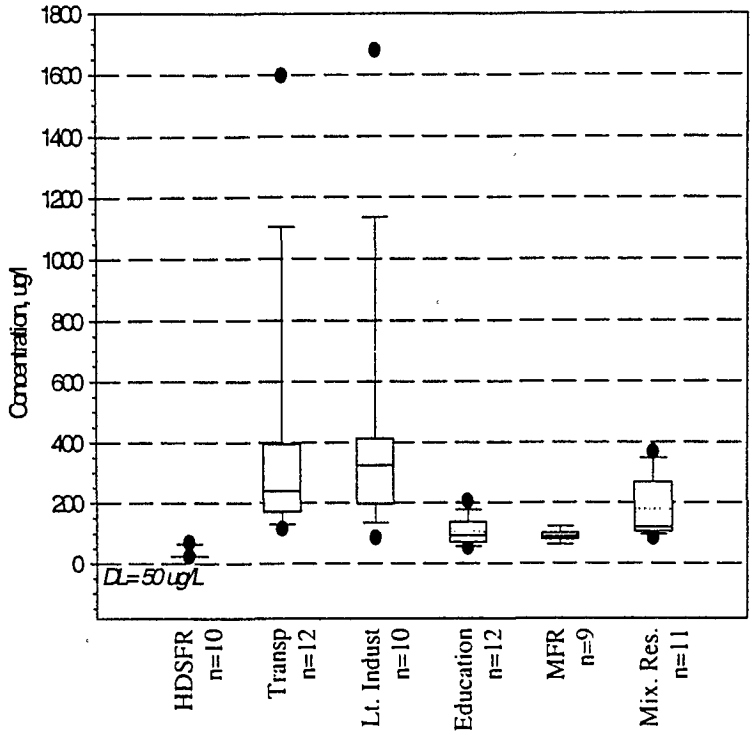
Figure 4-17u **Total Zinc**



Common Objectives
Ocean Plan: 80 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

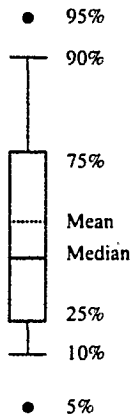
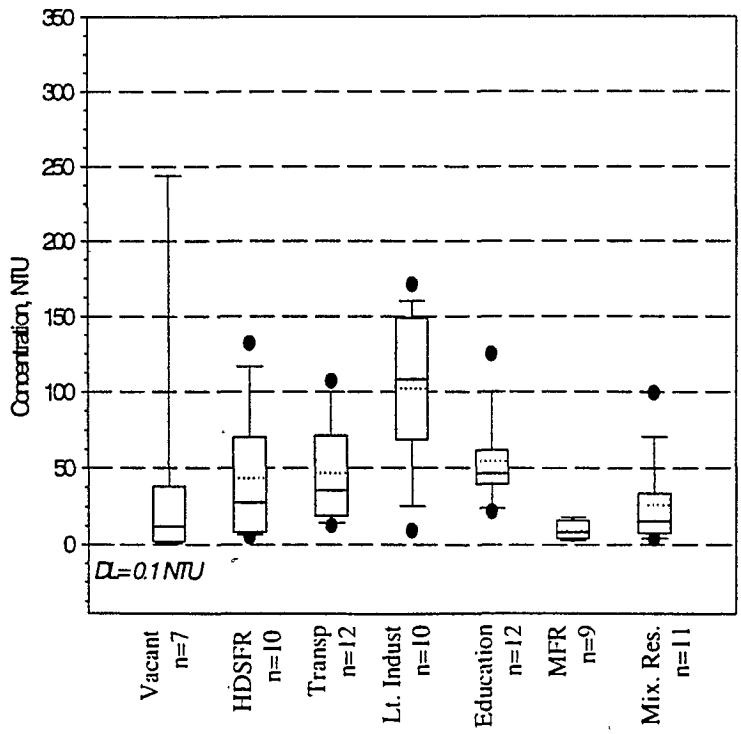


Figure 4-17v **Turbidity**



Common Objectives
Ocean Plan: 75 NTU
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

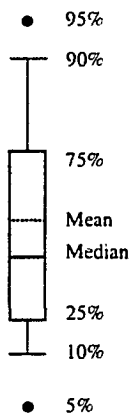


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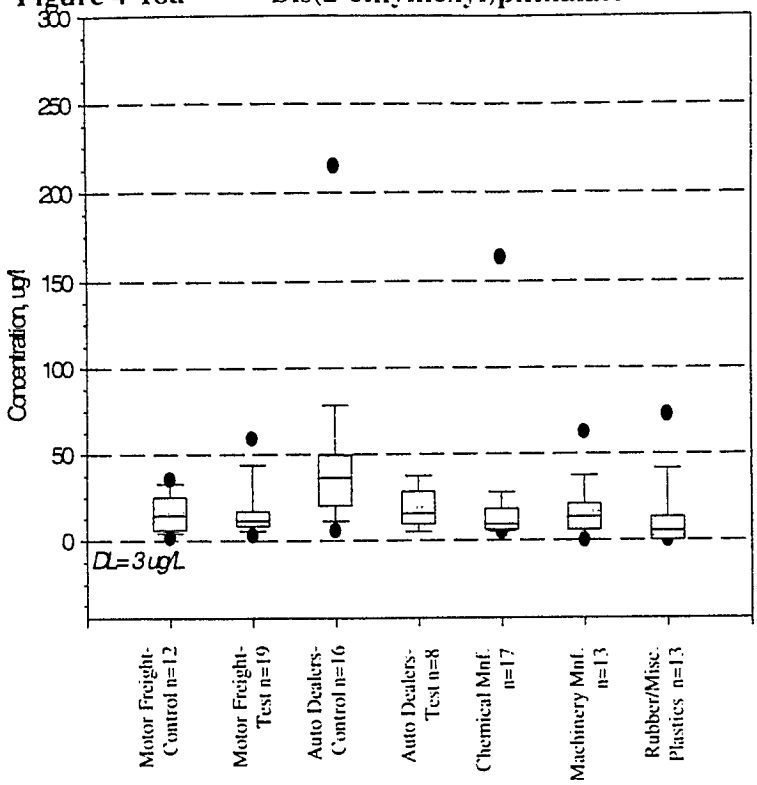
Figure 4-18a **Bis(2-ethylhexyl)phthalate**



Common Objectives
Ocean Plan: 3.5 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

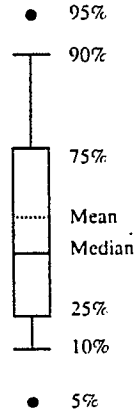
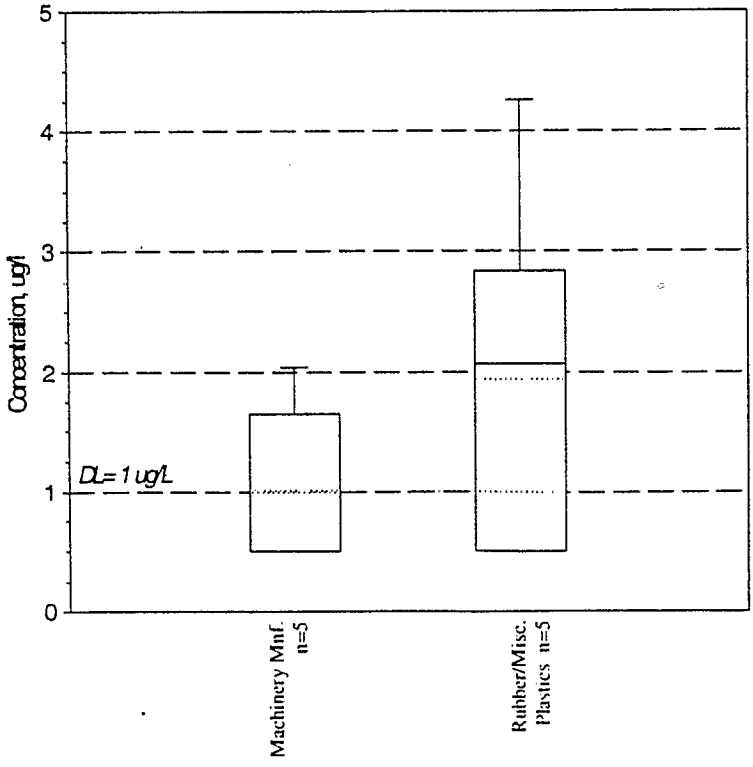


Figure 4-18b **Dissolved Cadmium**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 2.2 ug/L
CA Toxics Rule (Saltwater): 9.3 ug/L

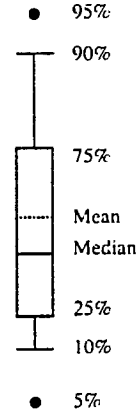


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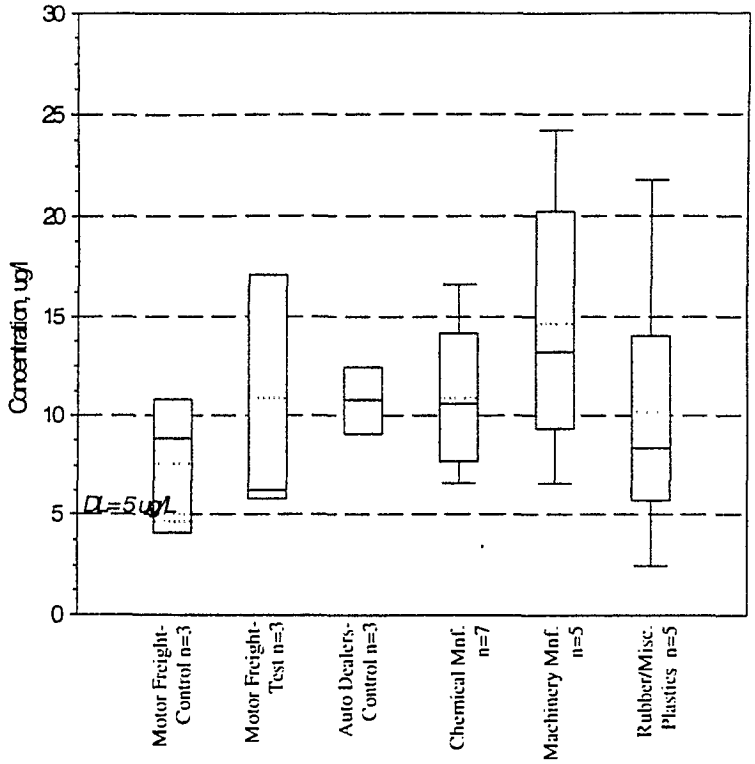
Figure 4-18c **Dissolved Copper**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 9 ug/L
CA Toxics Rule (Saltwater): 3.1 ug/L

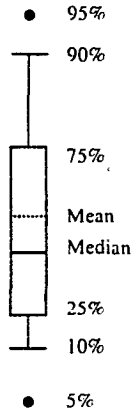
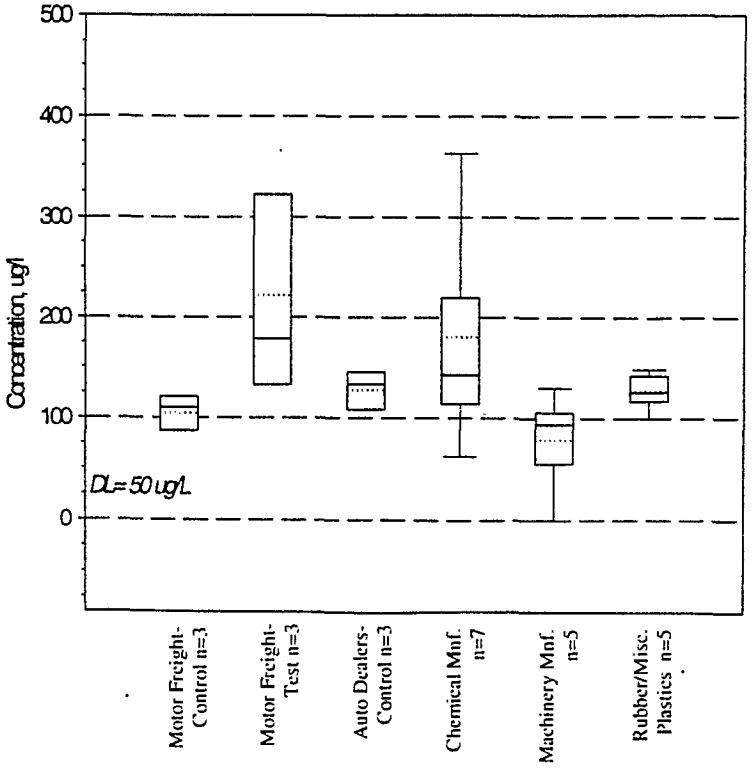


Figure 4-18d **Dissolved Zinc**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 120 ug/L
CA Toxics Rule (Saltwater): 81 ug/L

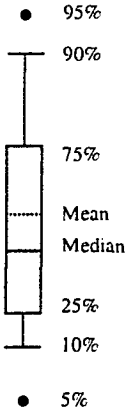
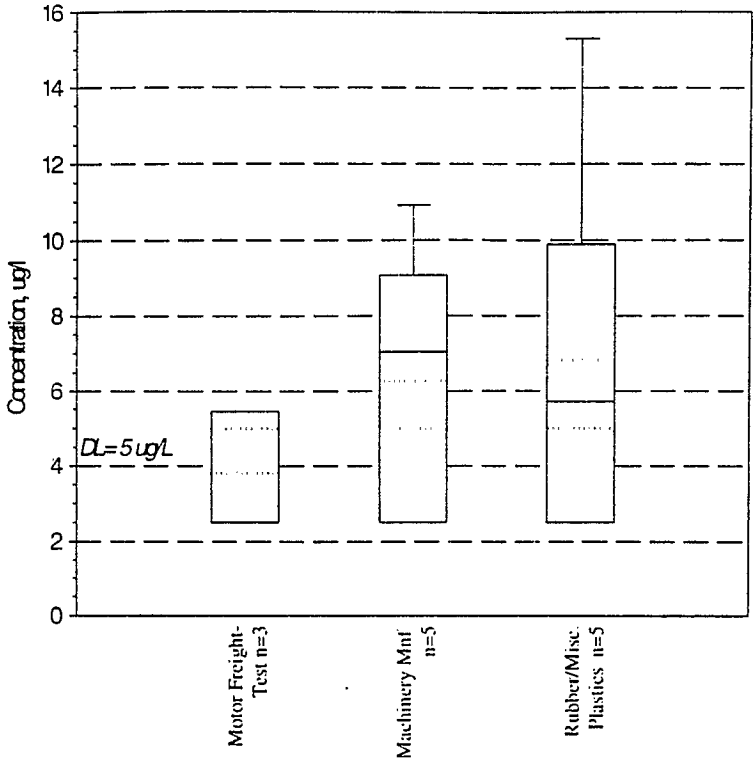


Figure 4-18e **Dissolved Nickel**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 52 ug/L
CA Toxics Rule (Saltwater): 8.2 ug/L

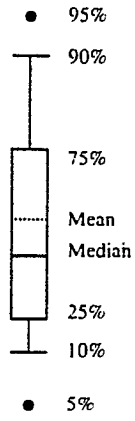
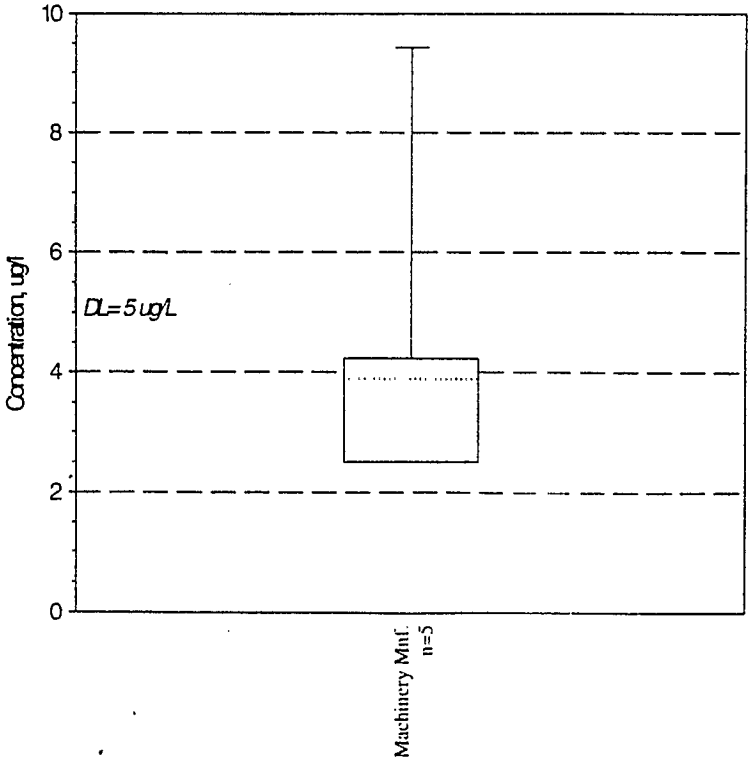


Figure 4-18f **Dissolved Lead**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): 2.5 ug/L
CA Toxics Rule (Saltwater): 8.1 ug/L

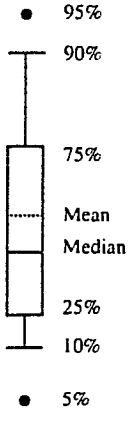


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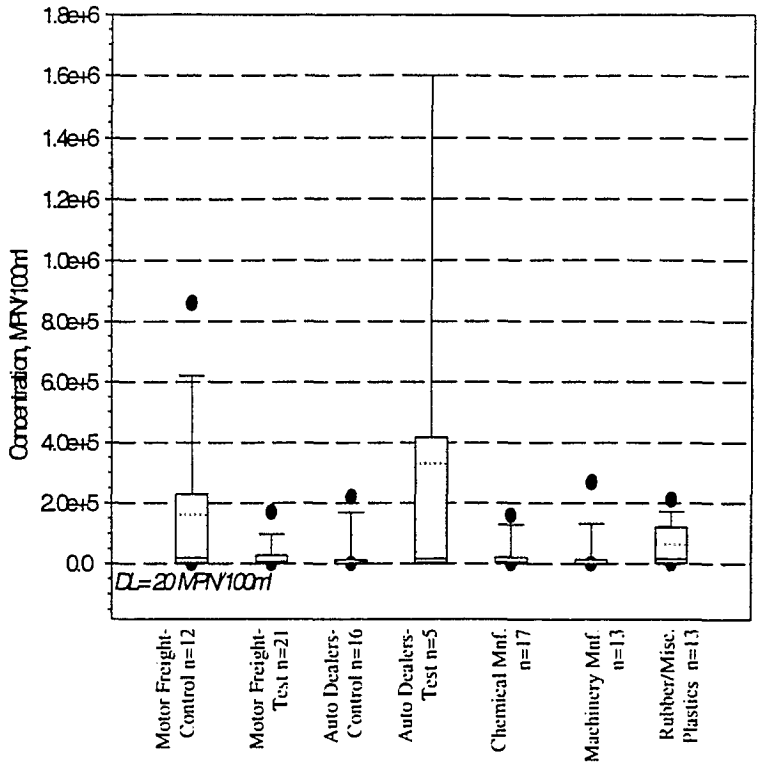
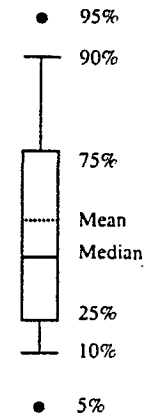
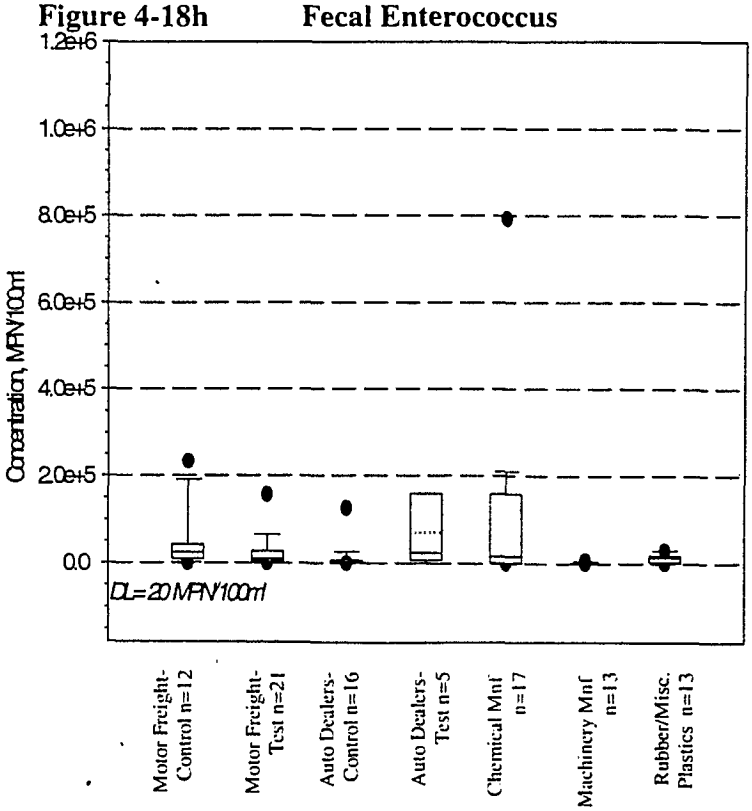
Figure 4-18g **Fecal Coliform**

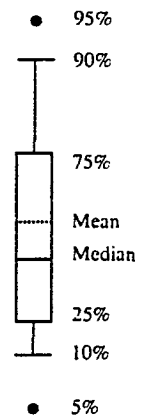




Common Objectives
Ocean Plan: 200 MPN/100ml
Basin Plan: 200 MPN/100ml
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

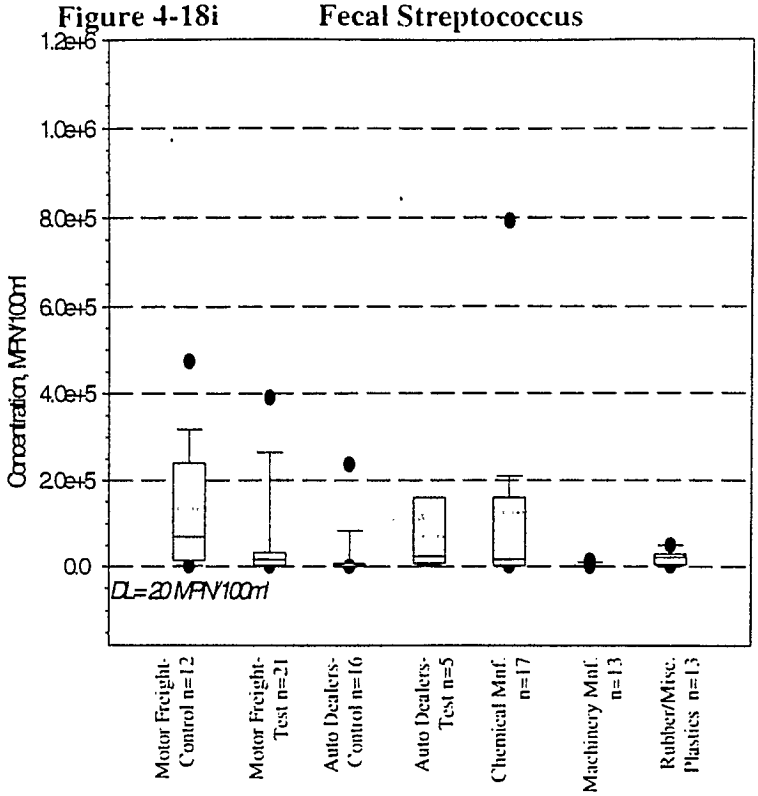
Figure 4-18h **Fecal Enterococcus**





Common Objectives
Ocean Plan: 24 MPN/100ml
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

Figure 4-18i **Fecal Streptococcus**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

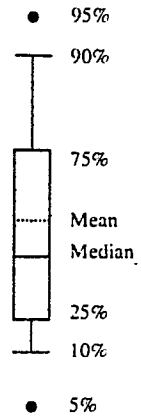
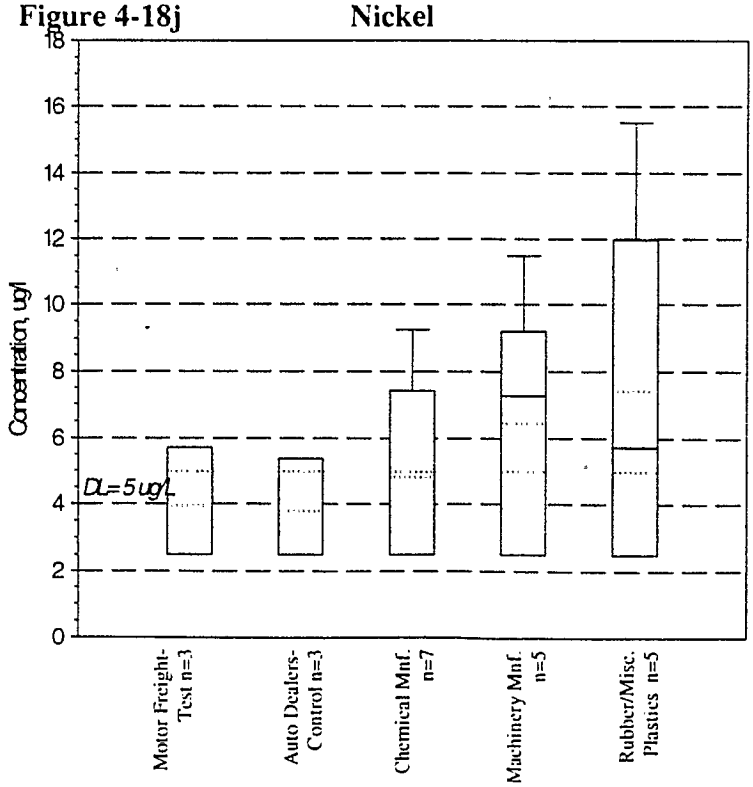


Figure 4-18j **Nickel**



Common Objectives
Ocean Plan: 20 ug/L
Basin Plan: 100 ug/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

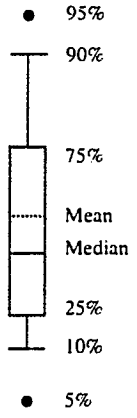


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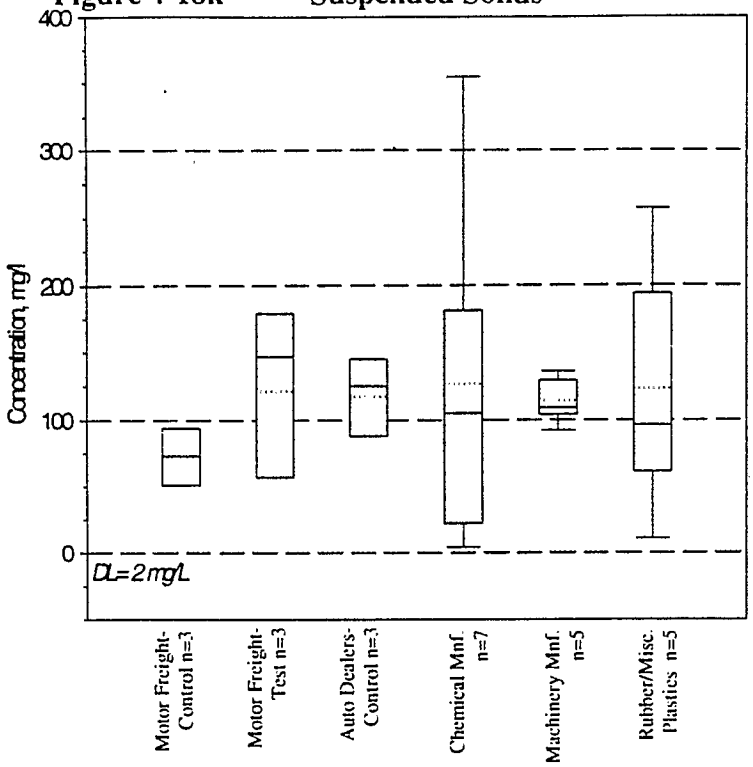
Figure 4-18k **Suspended Solids**



Common Objectives
Ocean Plan: N/A
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

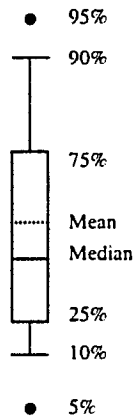
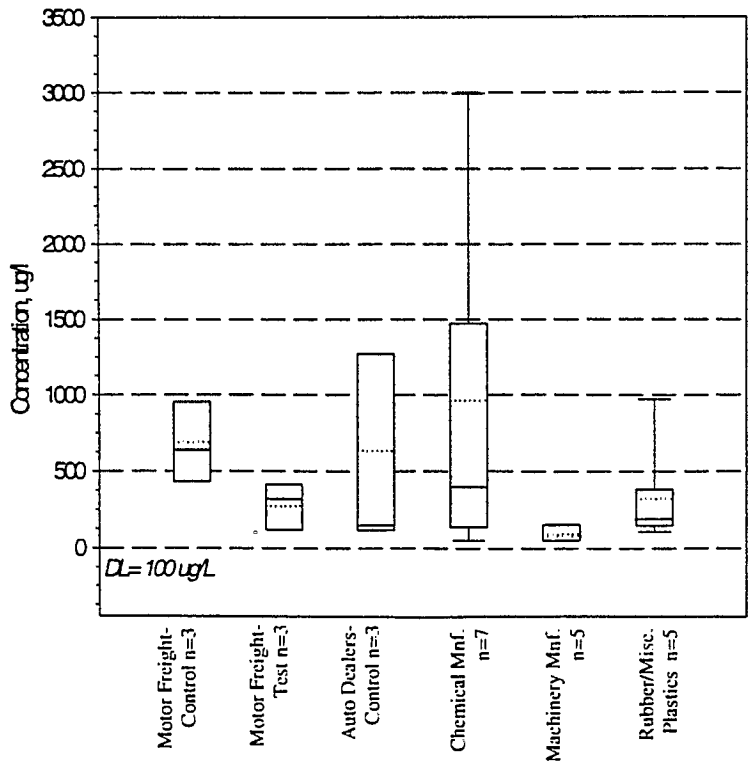


Figure 4-18l **Total Aluminum**



Common Objectives
Ocean Plan: N/A
Basin Plan: 1000 ug/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

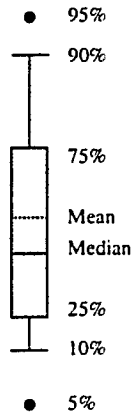


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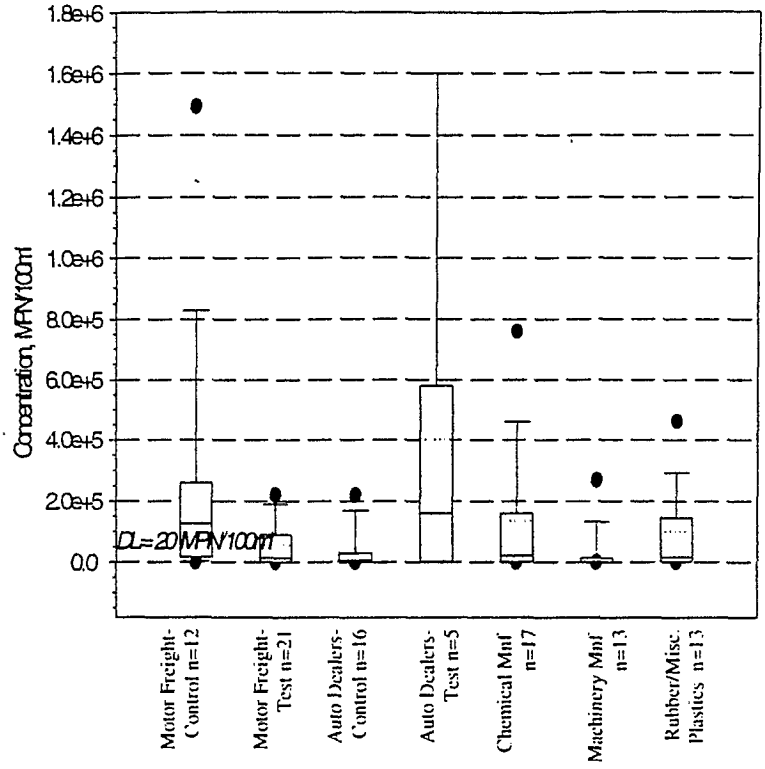
Figure 4-18m **Total Coliform**



Common Objectives
Ocean Plan: 1000 MPN/100ml
Basin Plan: 70 MPN/100ml
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

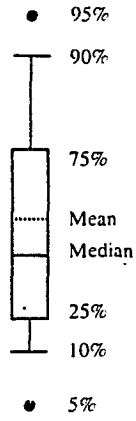
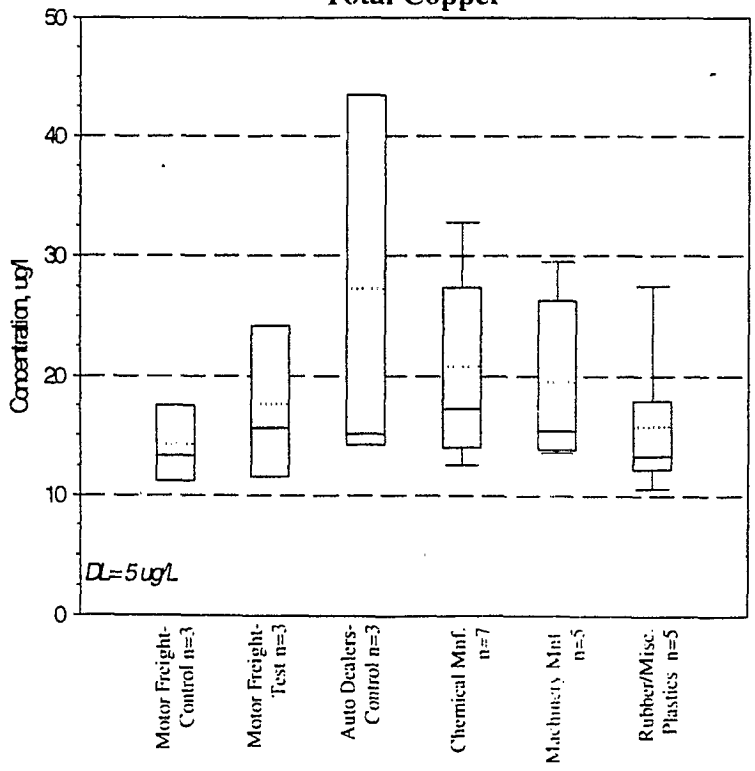


Figure 4-18n **Total Copper**



Common Objectives
Ocean Plan: 12 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

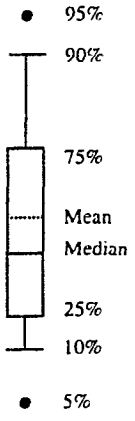


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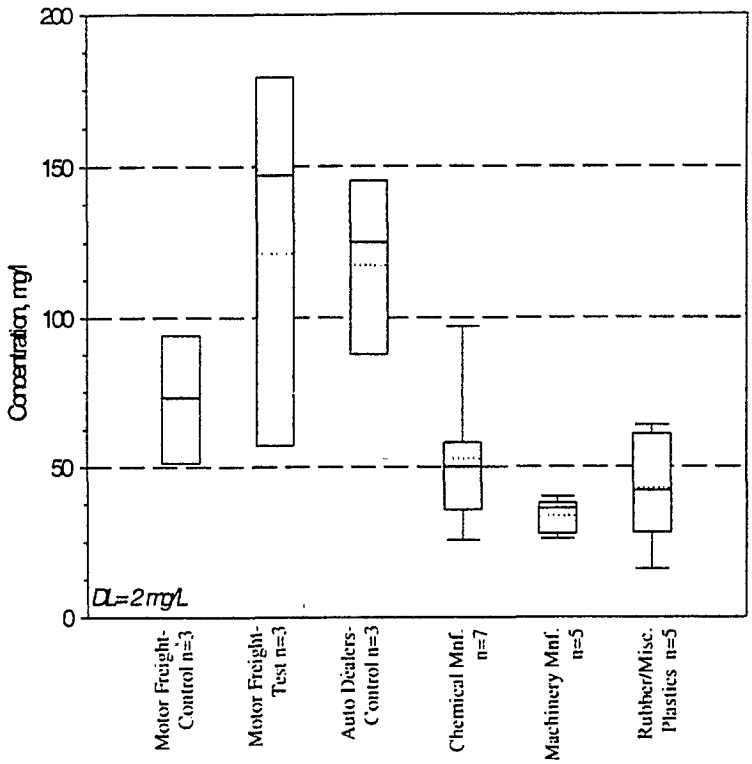
Figure 4-18o **Total Dissolved Solids**



Common Objectives
Ocean Plan: N/A
Basin Plan: 250 mg/L
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

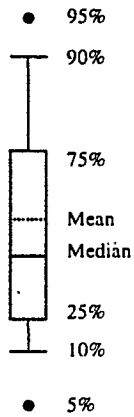
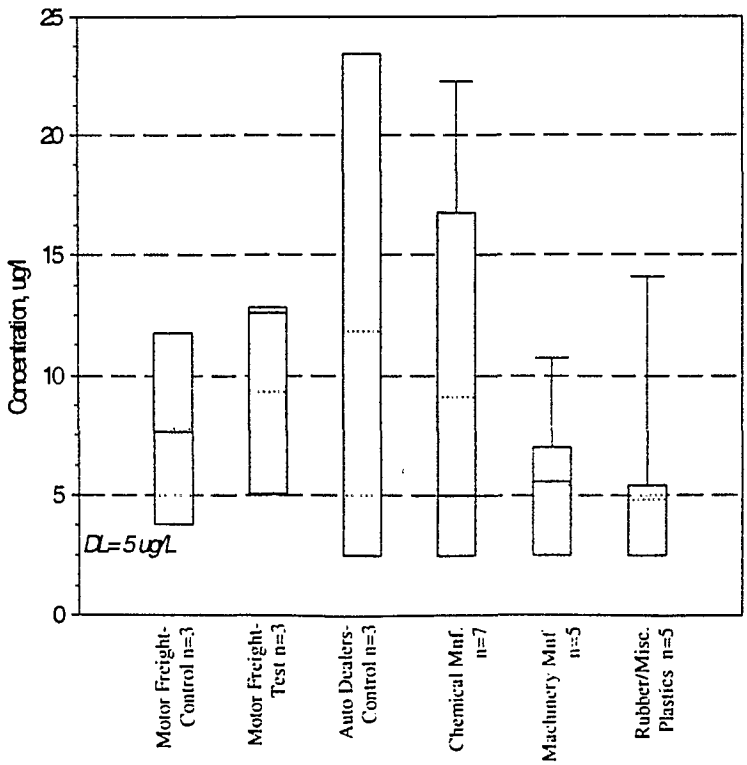


Figure 4-18p **Total Lead**



Common Objectives
Ocean Plan: 8 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

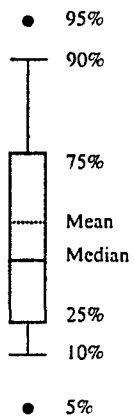


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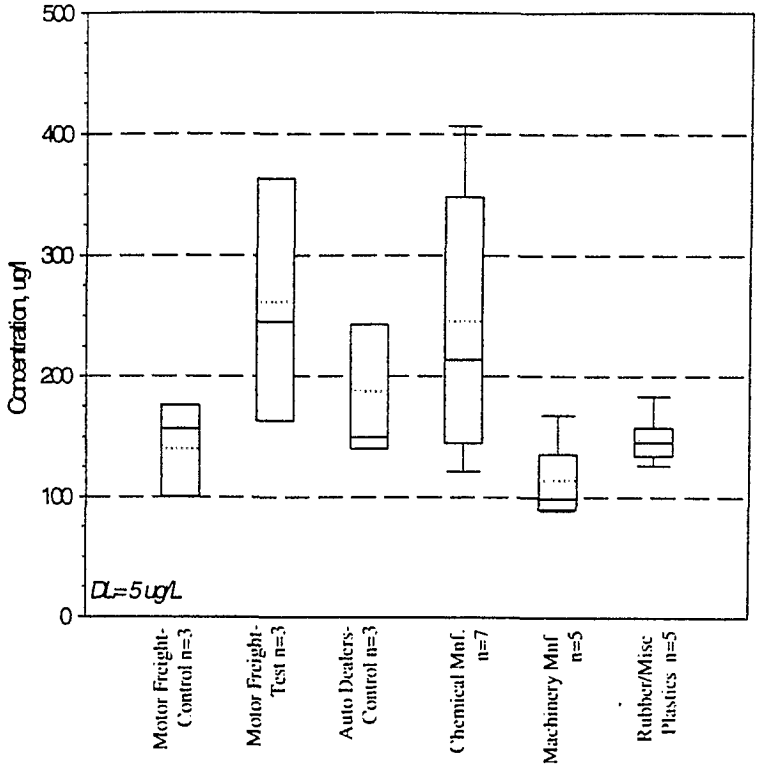
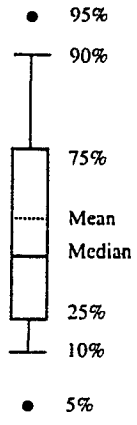
Figure 4-18q **Total Zinc**





Common Objectives
Ocean Plan: 80 ug/L
Basin Plan: N/A
CA Toxics Rule (Freshwater): N/A
CA Toxics Rule (Saltwater): N/A

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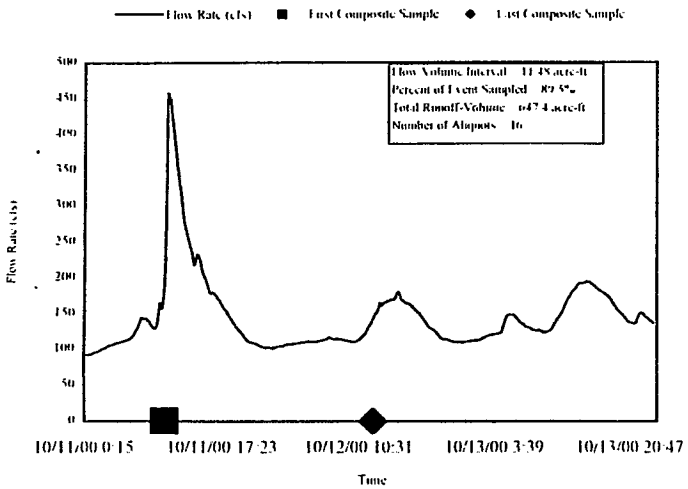
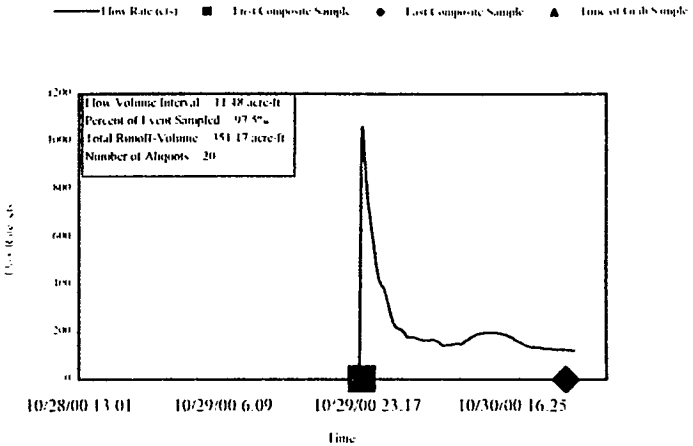
Appendix A

Hydrographs Of Monitored Stations And Rainfall Contour Maps

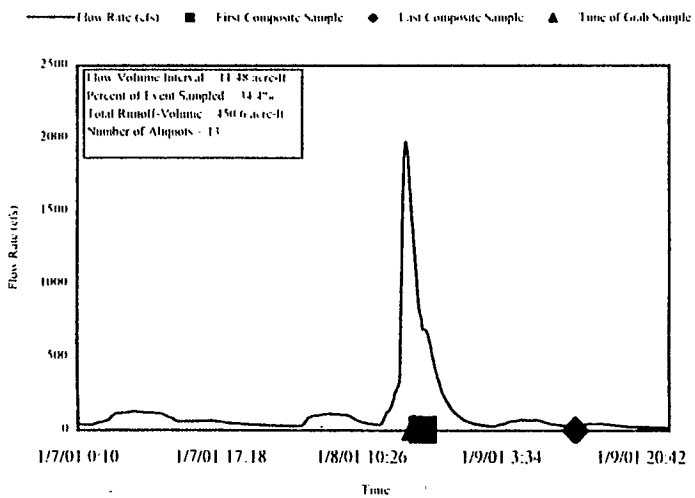
Ballona Creek, Storm 1 (10/12/2000)



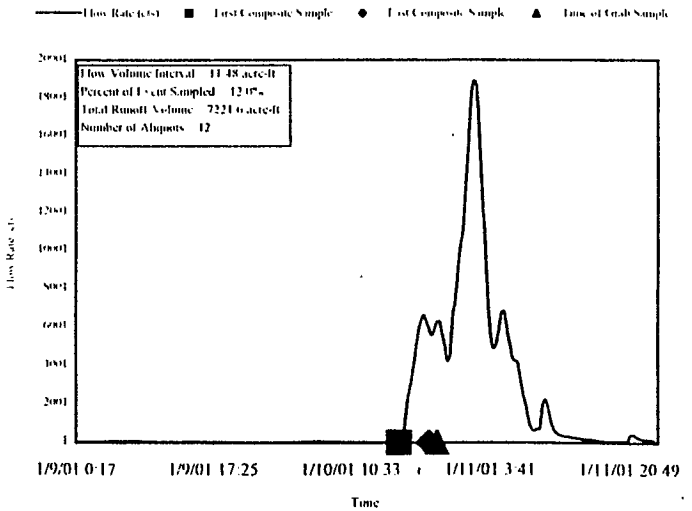
Ballona Creek, Storm 3 (10/29/2000)



Ballona Creek, Storm 4 (1/8/2001)

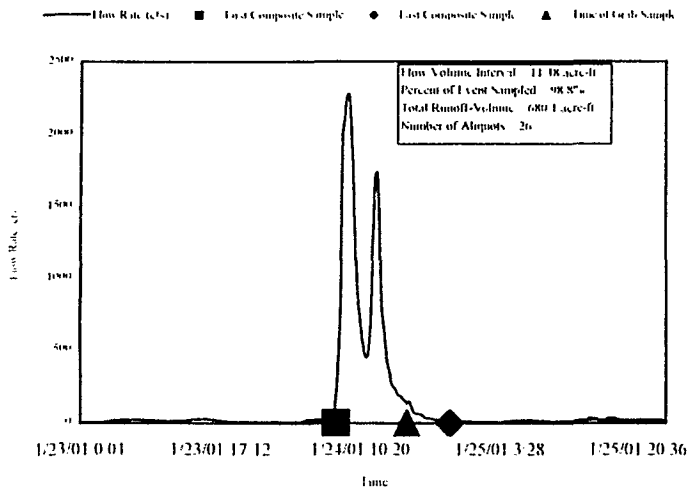


Ballona Creek, Storm 5 (1/10/2001)

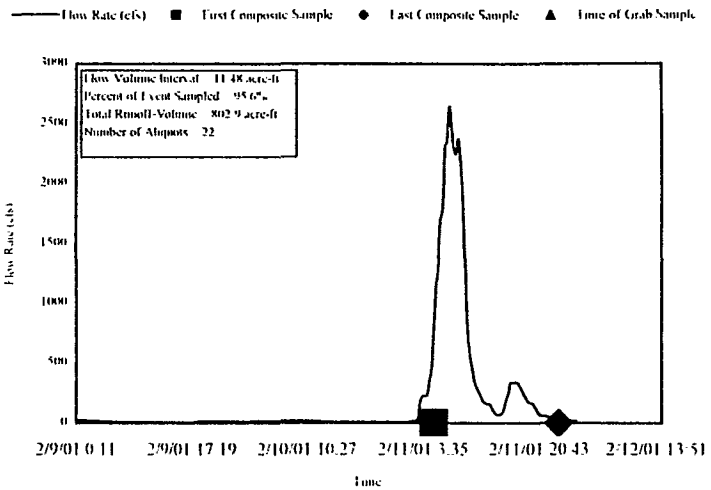


R0012513

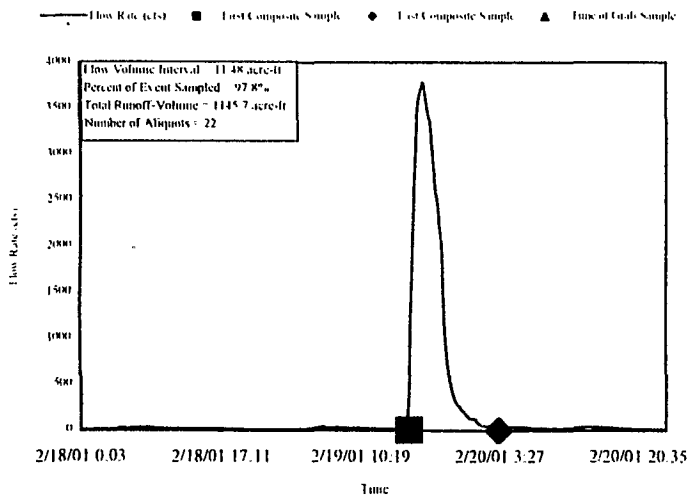
Ballona Creek, Storm 6 (1/24/2001)



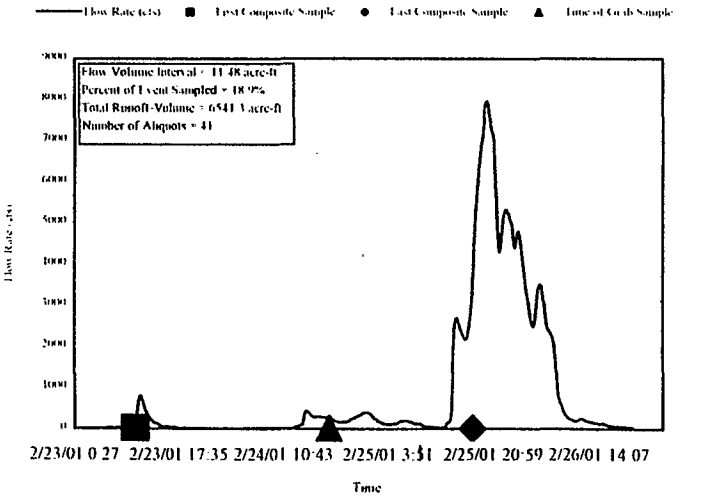
Ballona Creek, Storm 8 (2/10/2001)



Ballona Creek, Storm 9 (2/19/2001)



Ballona Creek, Storm 10 (2/24/2001)



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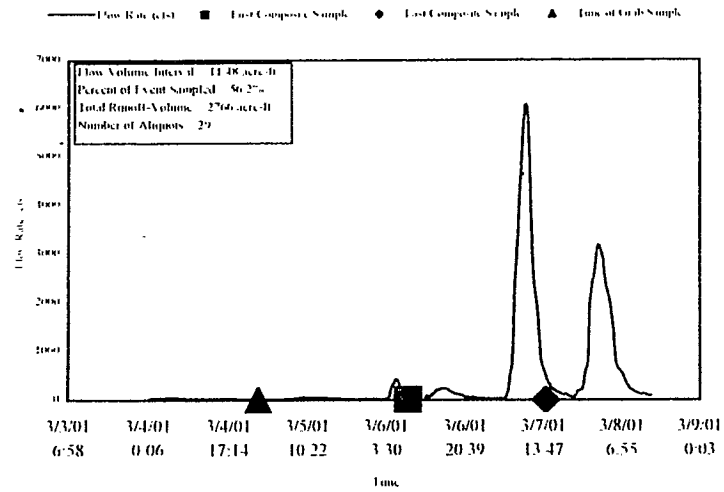
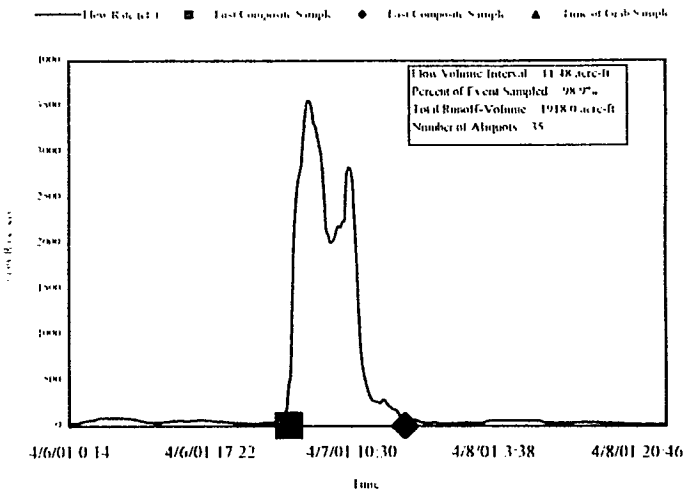
Ballona Creek, Storm 11 (03/04/2001)

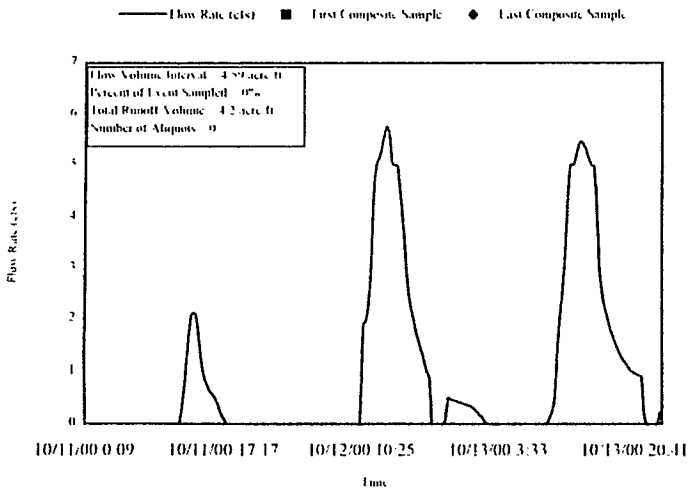


Ballona Creek, Storm 12 (04/07/2001)

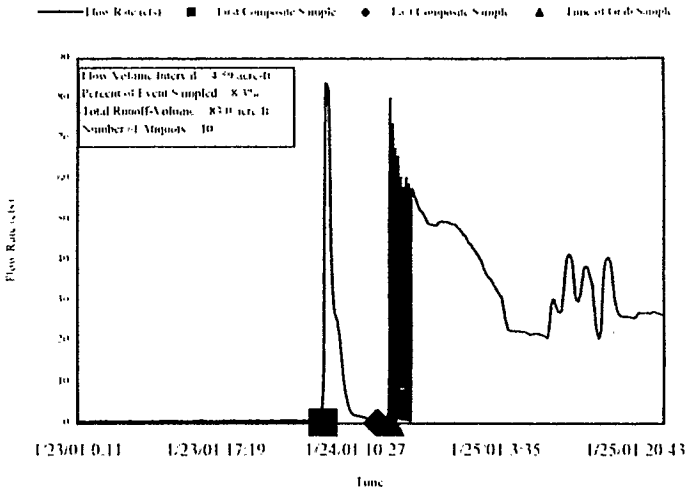


R0012515

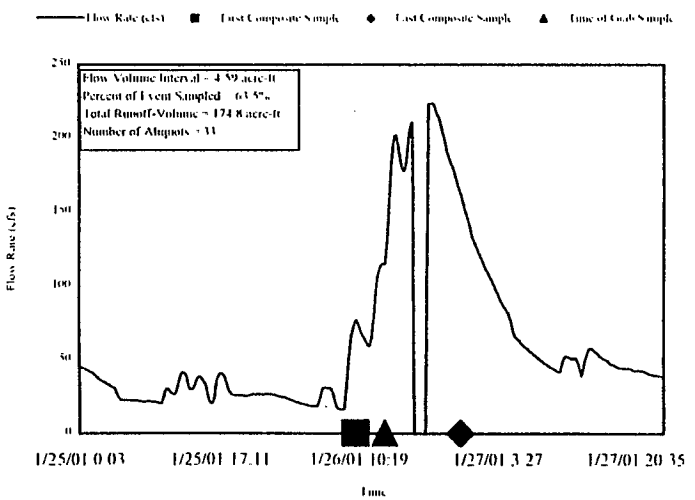
Malibu Creek, Storm 1 (10/12/2000)



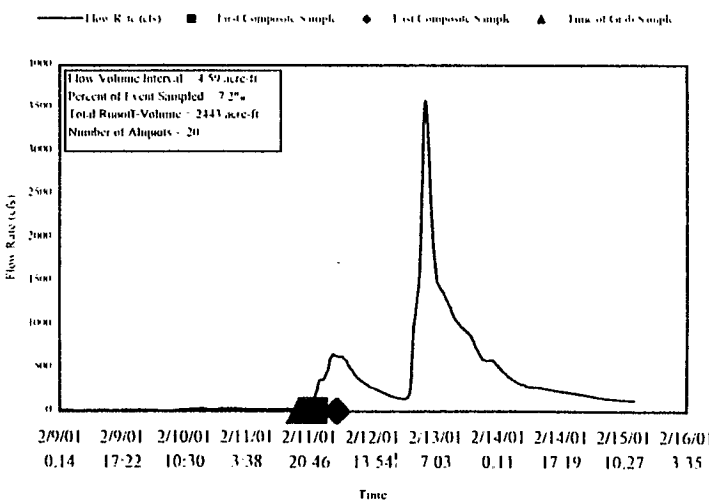
Malibu Creek, Storm 6 (1/24/2001)



Malibu Creek, Storm 7 (1/26/2001)

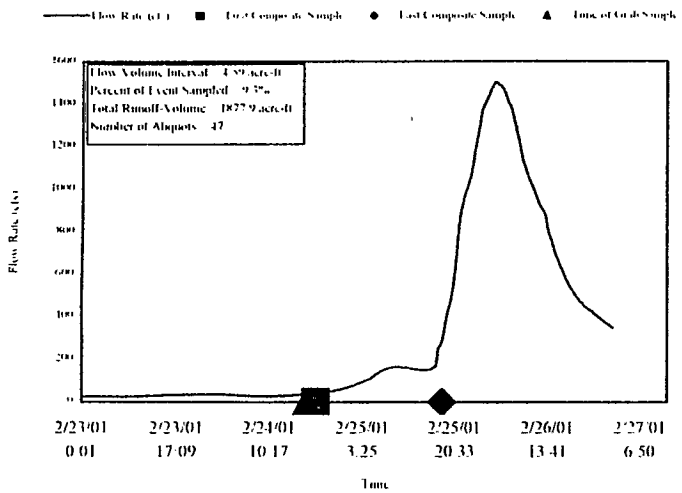


Malibu Creek, Storm 8 (2/10/2001)

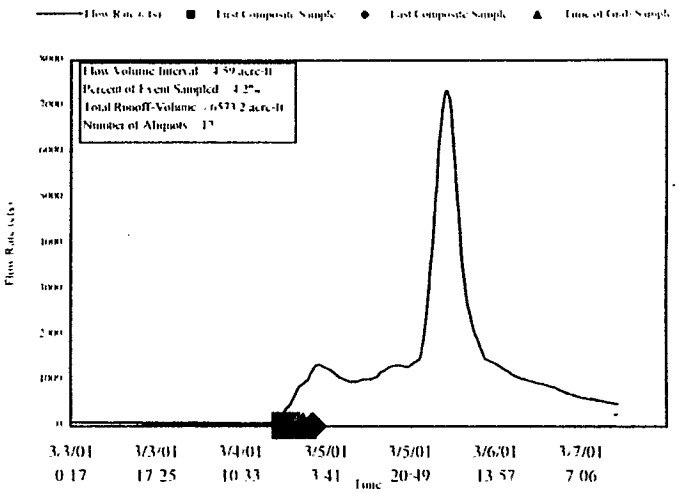


R0012516

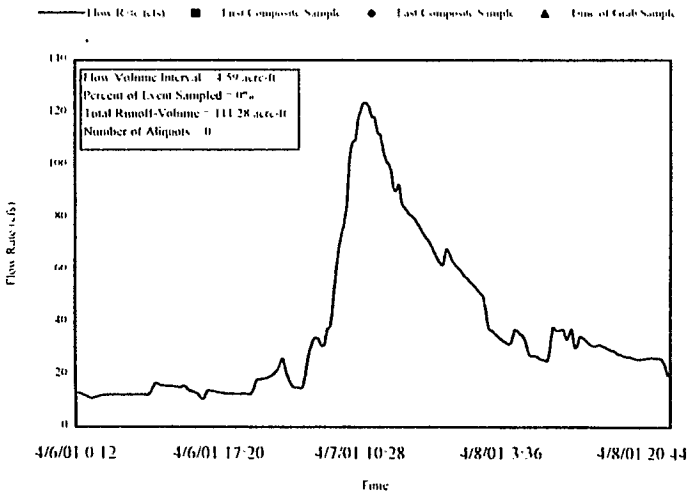
Malibú Creek, Storm 10 (2/24/2001)



Malibu Creek, Storm 11 (03/04/2001)

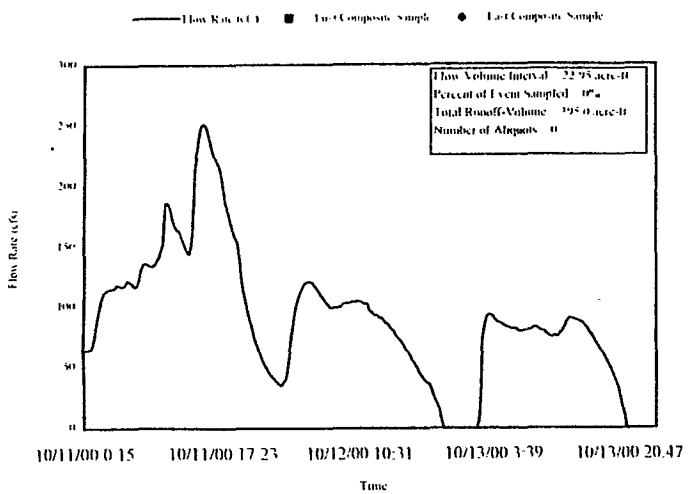


Malibu Creek, Storm 12 (04/07/2001)

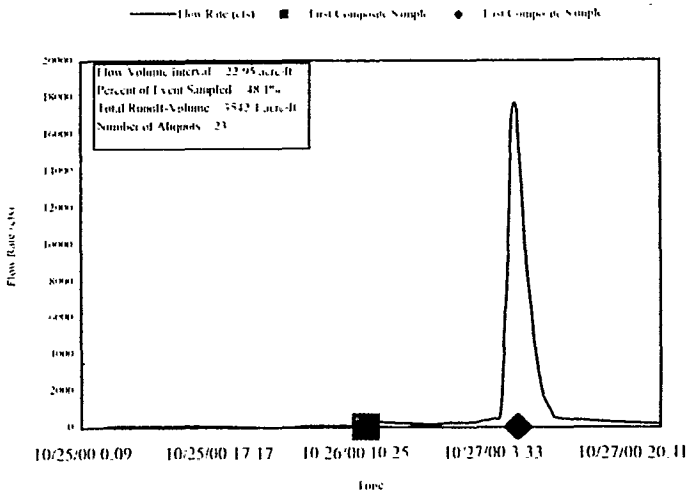


R0012517

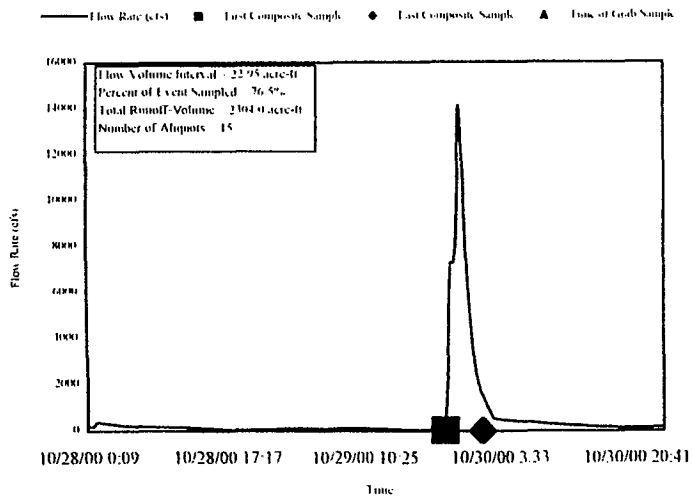
Los Angeles River, Storm 1 (10/12/2000)



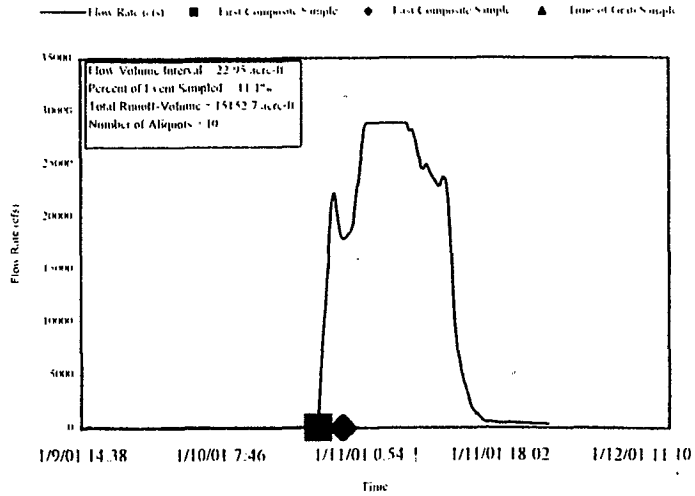
Los Angeles River, Storm 2 (10/26/2000)



Los Angeles River, Storm 3 (10/29/2000)

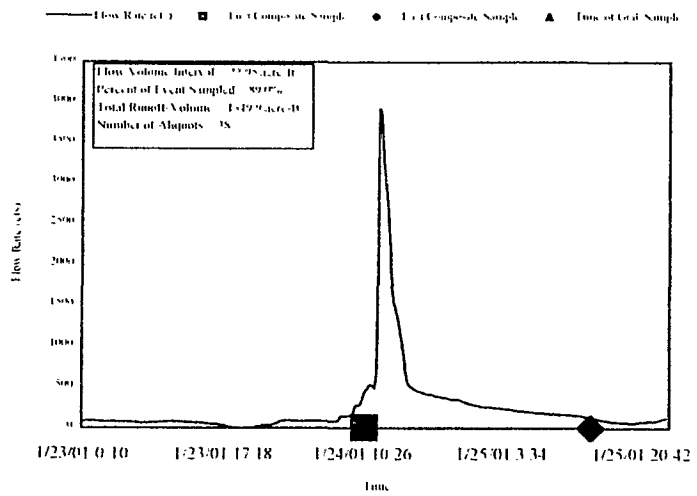


Los Angeles River, Storm 5 (1/10/2001)

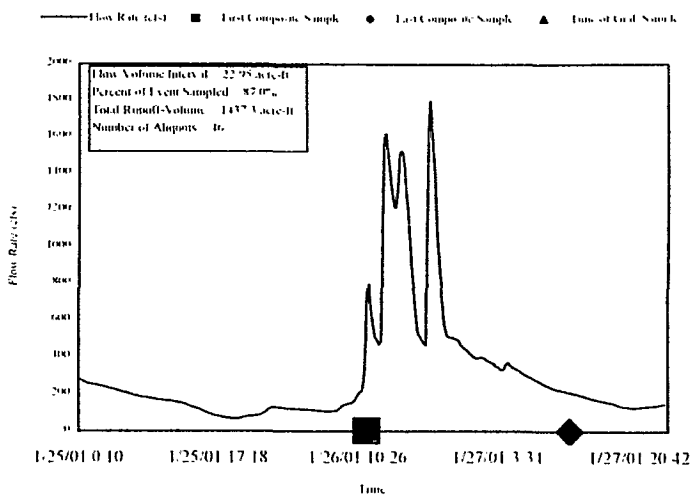


R0012518

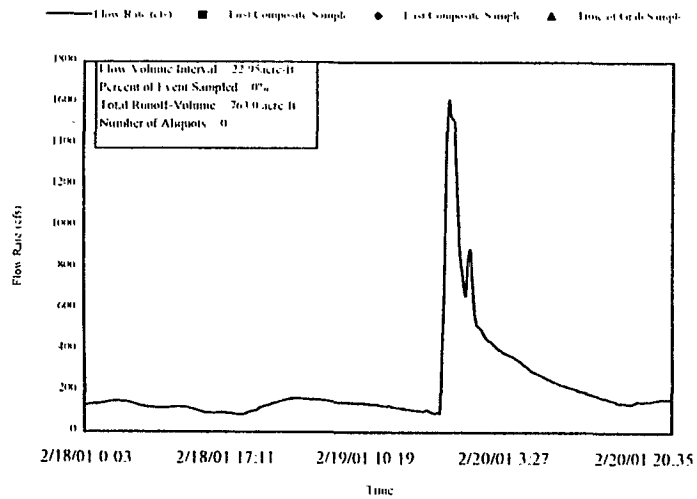
Los Angeles River, Storm 6 (1/24/2001)



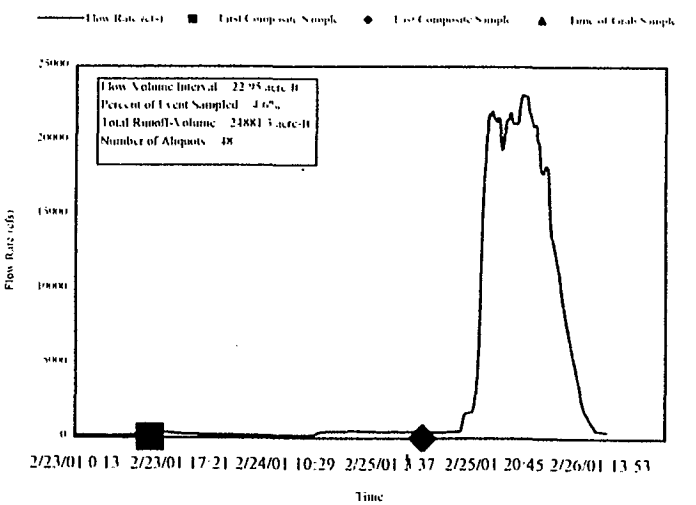
Los Angeles River, Storm 7 (1/26/2001)



Los Angeles River, Storm 9 (2/19/2001)



Los Angeles River, Storm 10 (2/24/2001)



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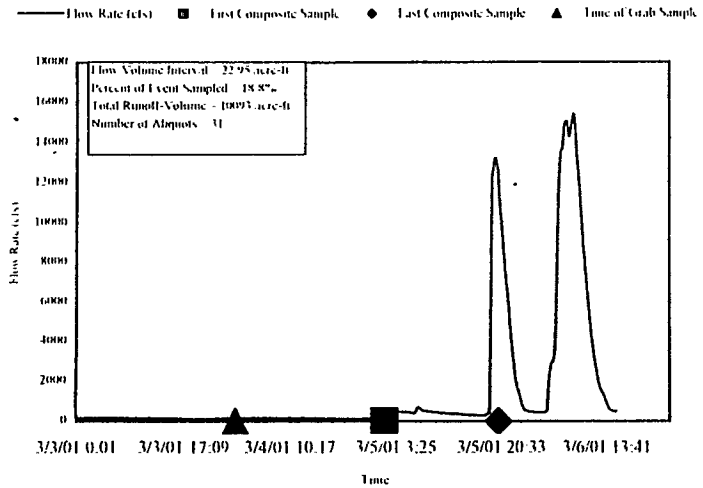
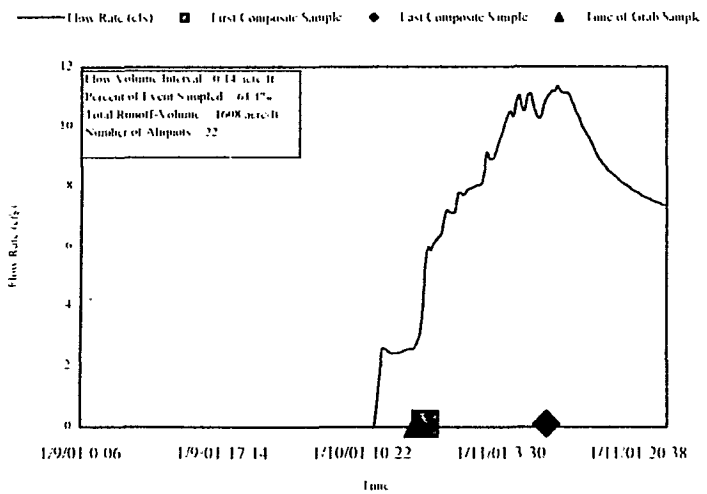
Los Angeles River, Storm 11 (03/04/2001)

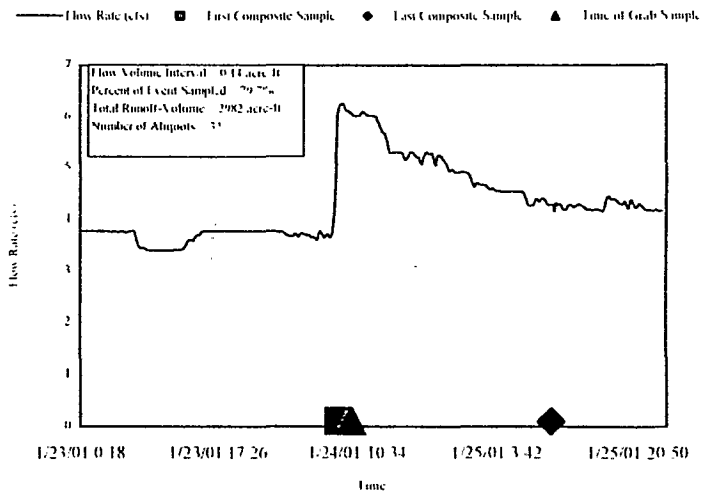


R0012520

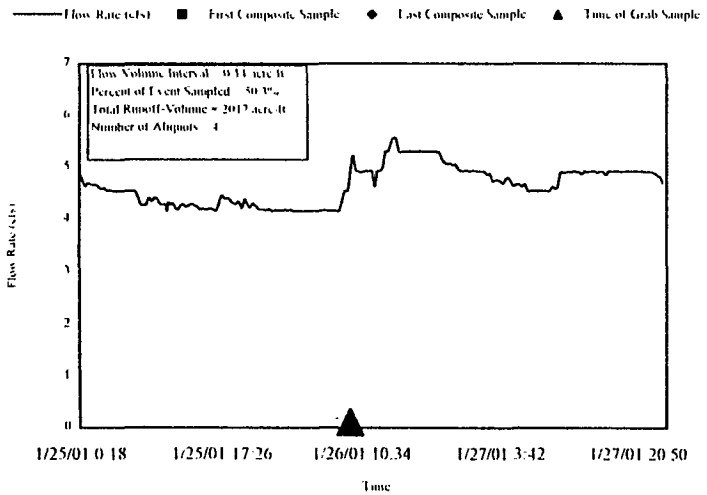
Sawpit Creek, Storm 5 (1/10/2001)



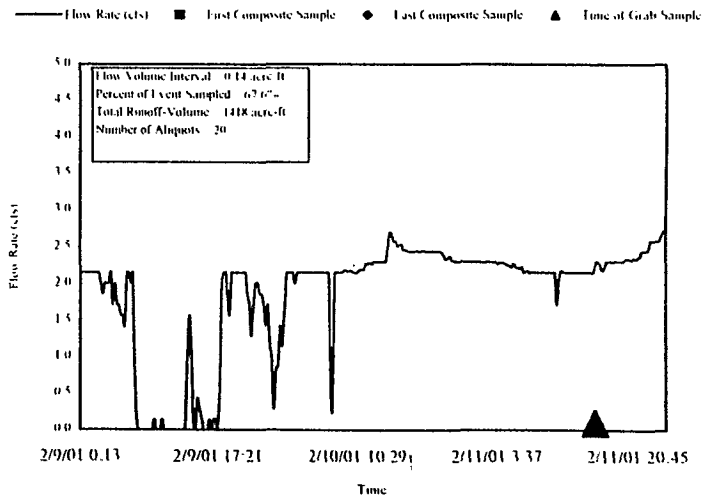
Sawpit Creek, Storm 6 (1/24/2001)



Sawpit Creek, Storm 7 (1/26/2001)

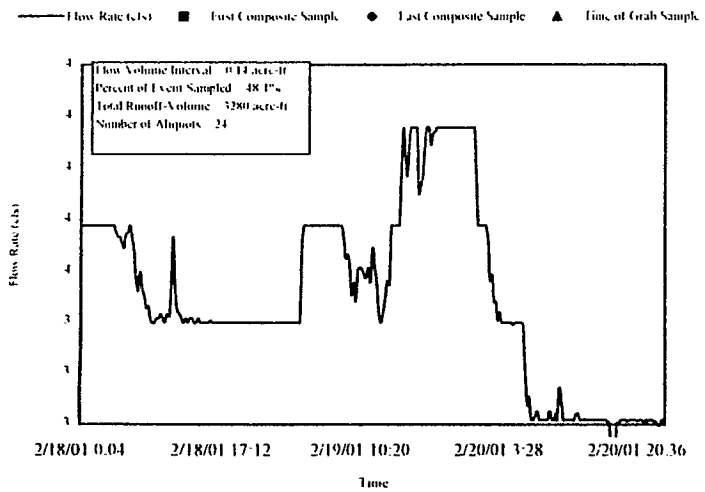


Sawpit Creek, Storm 8 (2/10/2001)

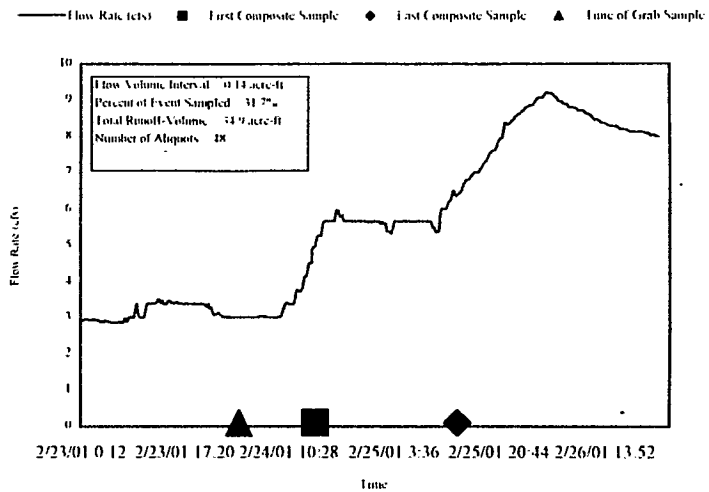


R0012521

Sawpit Creek, Storm 9 (2/19/2001)

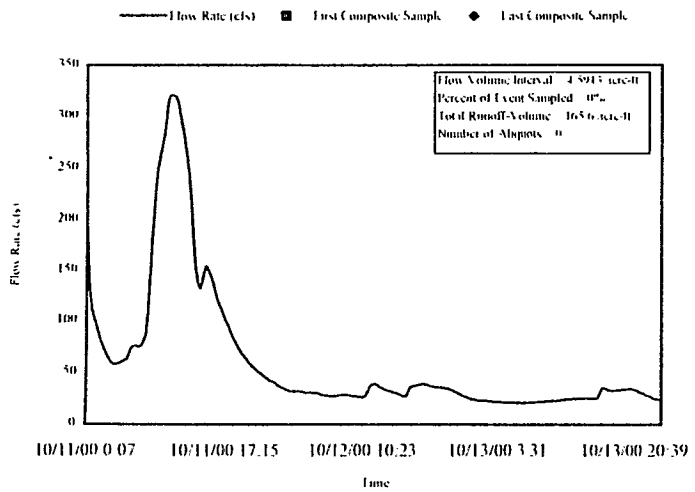


Sawpit Creek, Storm 10 (2/24/2001)

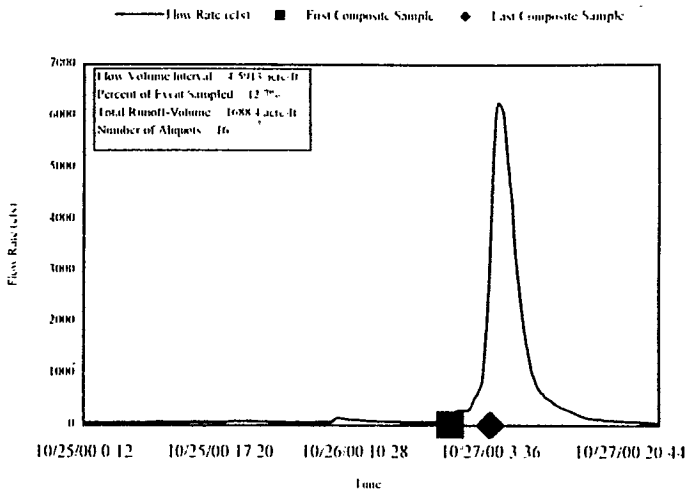


R0012522

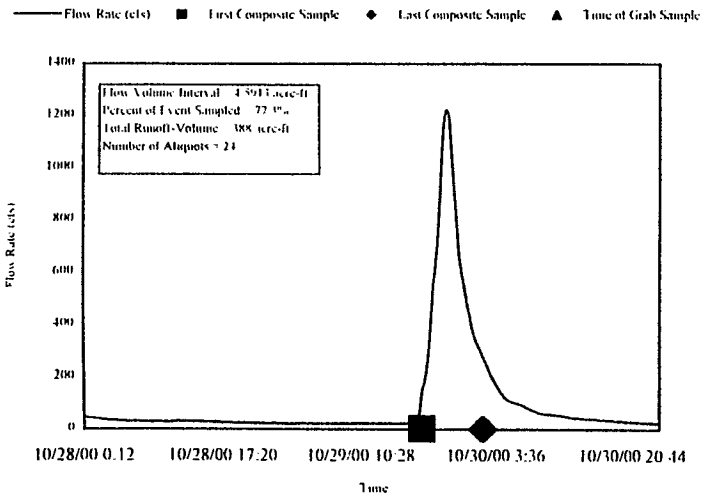
Coyote Creek, Storm 1 (10/12/2000)



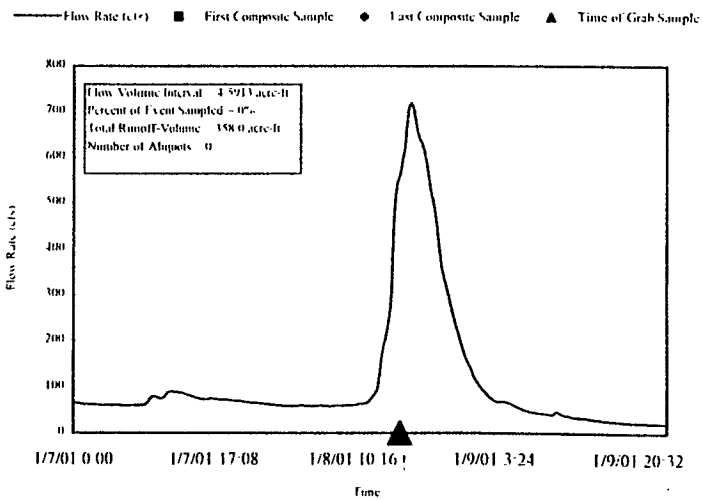
Coyote Creek, Storm 2 (10/26/2000)



Coyote Creek, Storm 3 (10/29/2000)

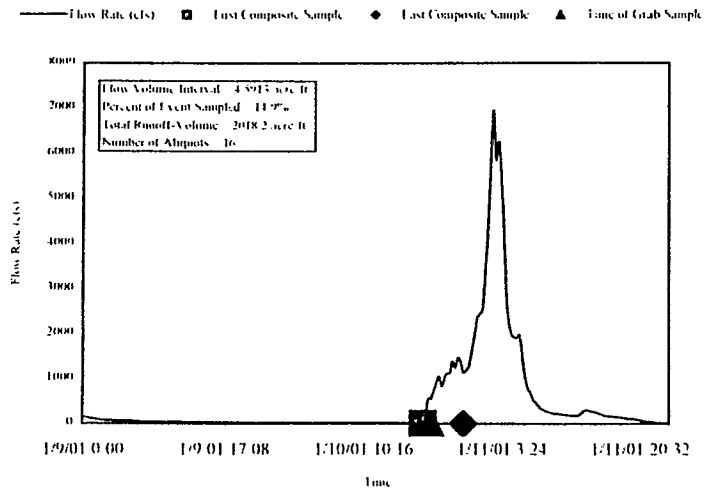


Coyote Creek, Storm 4 (1/8/2001)

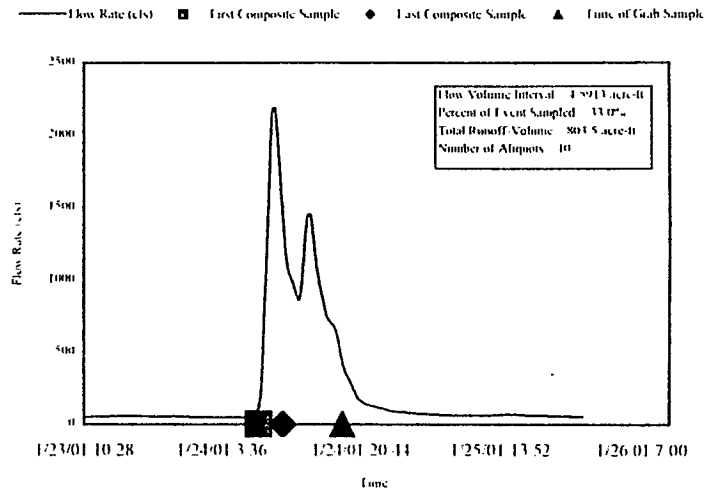


R0012523

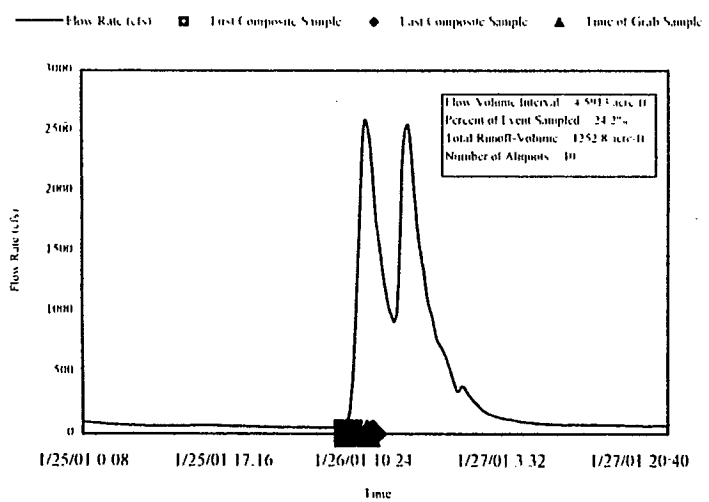
Coyote Creek, Storm 5 (1/10/2001)



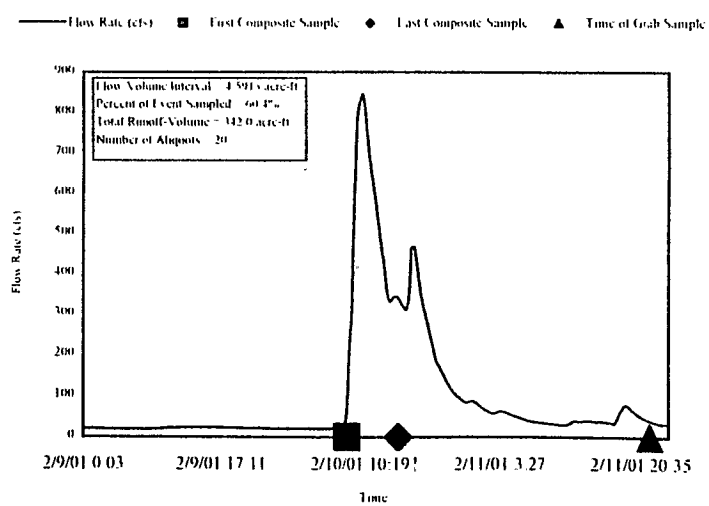
Coyote Creek, Storm 6 (1/24/2001)



Coyote Creek, Storm 7 (1/26/2001)

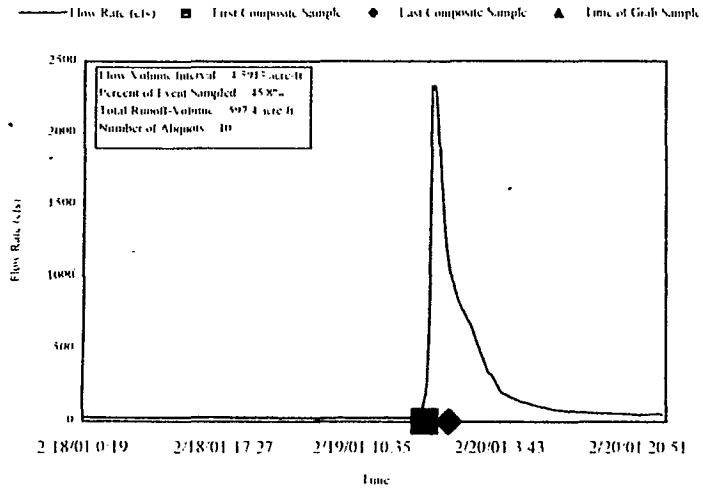


Coyote Creek, Storm 8 (2/10/2001)

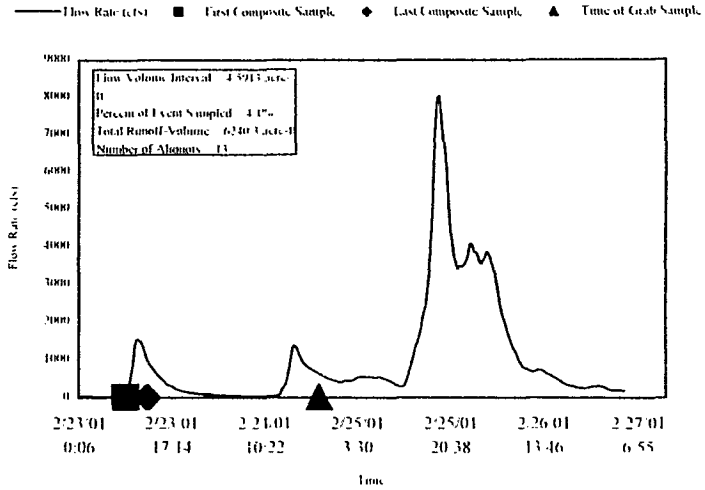


R0012524

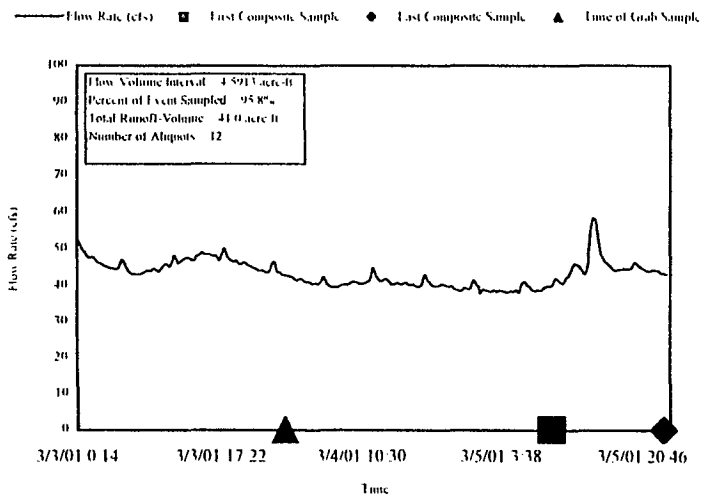
Coyote Creek, Storm 9 (2/19/2001)



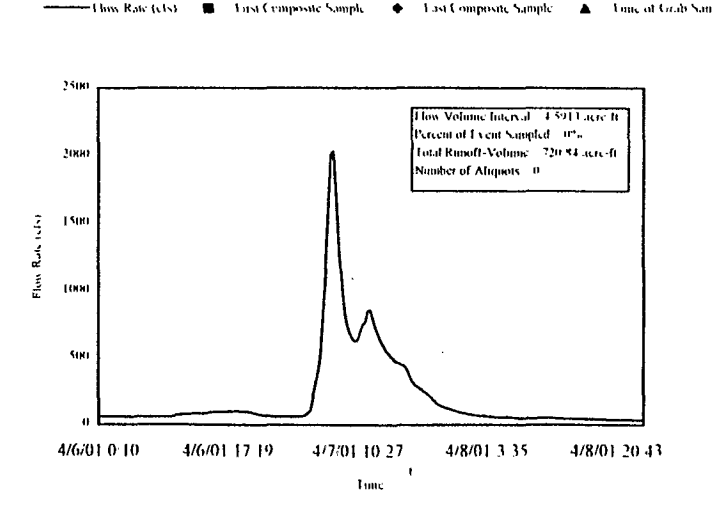
Coyote Creek, Storm 10 (2/24/2001)



Coyote Creek, Storm 11 (03/04/2001)

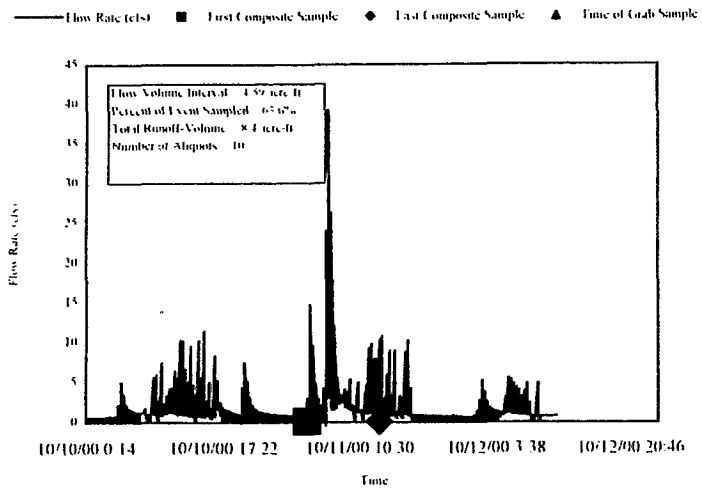


Coyote Creek, Storm 12 (04/07/2001)

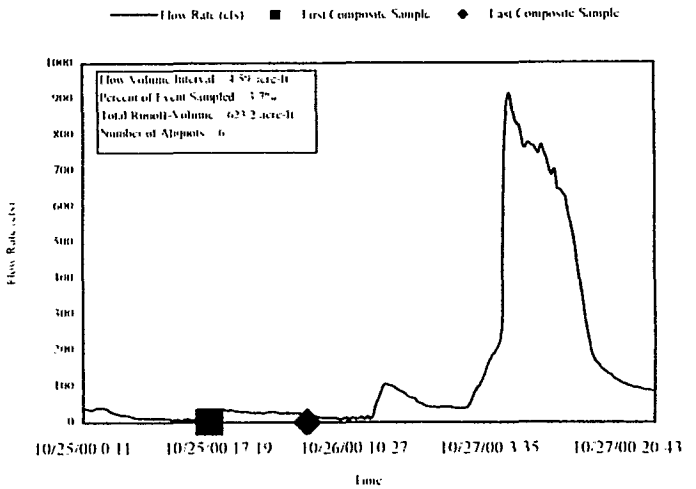


R0012525

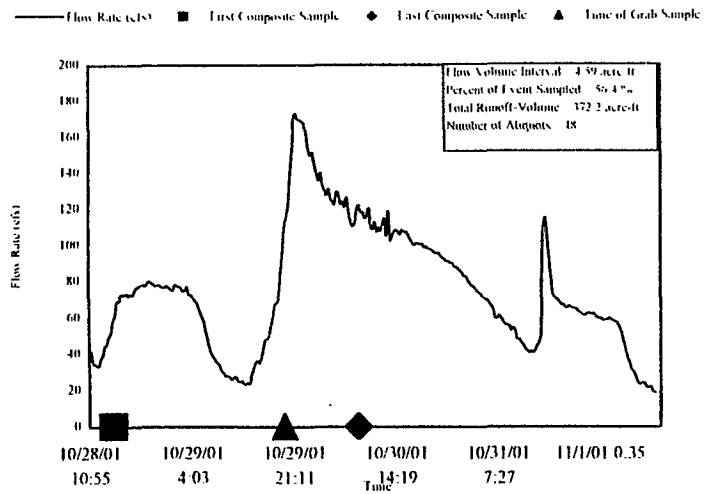
S.G.R, Storm 1 (10/12/2000)



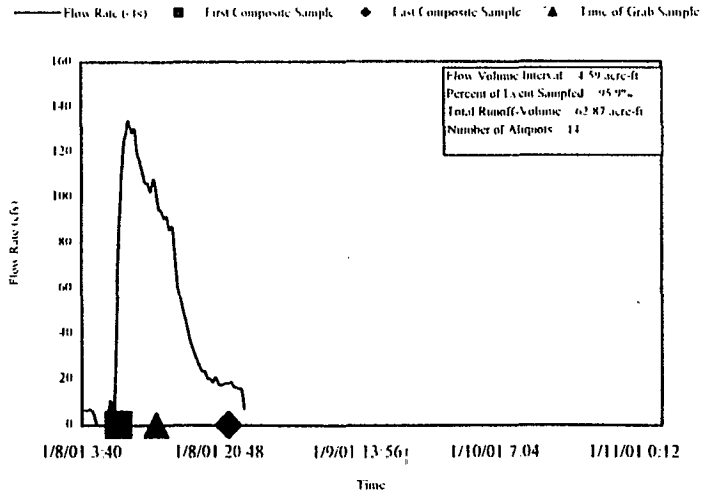
S.G.R, Storm 2 (10/26/2000)



S.G.R, Storm 3 (10/29/2000)

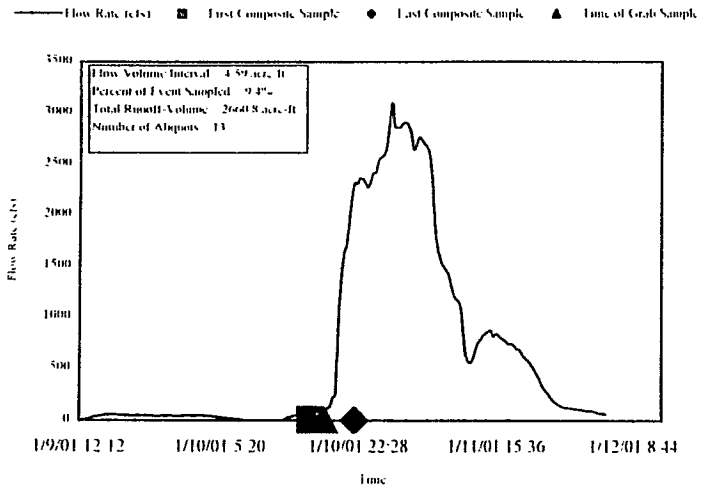


S.G.R, Storm 4 (1/8/2001)

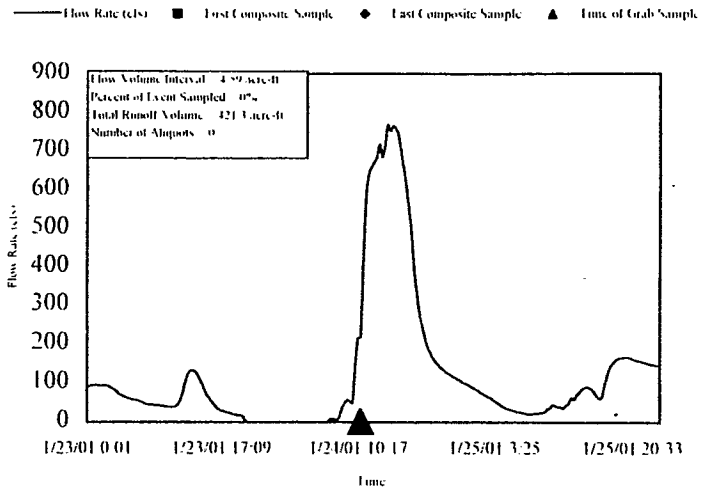


R0012526

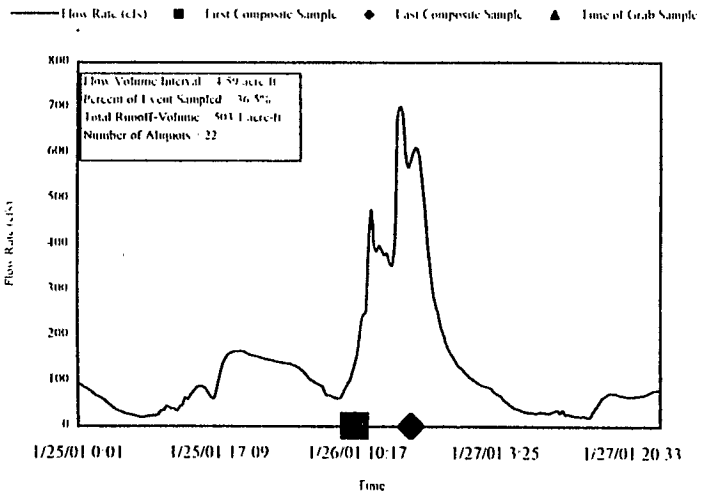
S.G.R, Storm 5 (1/10/2001)



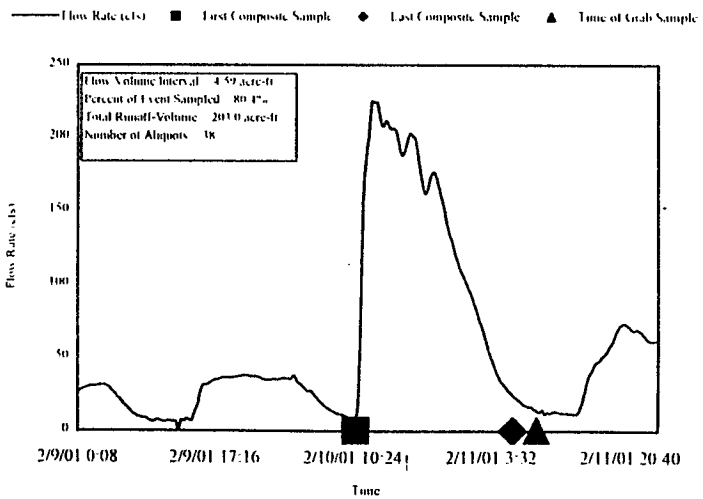
S.G.R, Storm 6 (1/24/2001)



S.G.R, Storm 7 (1/26/2001)

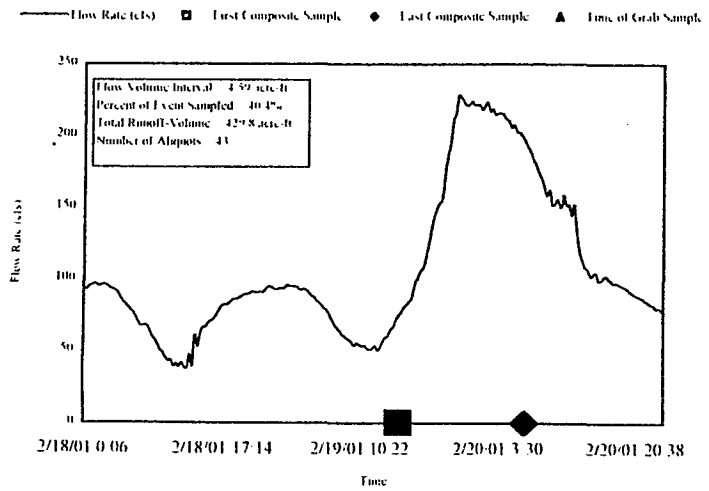


S.G.R, Storm 8 (2/10/2001)

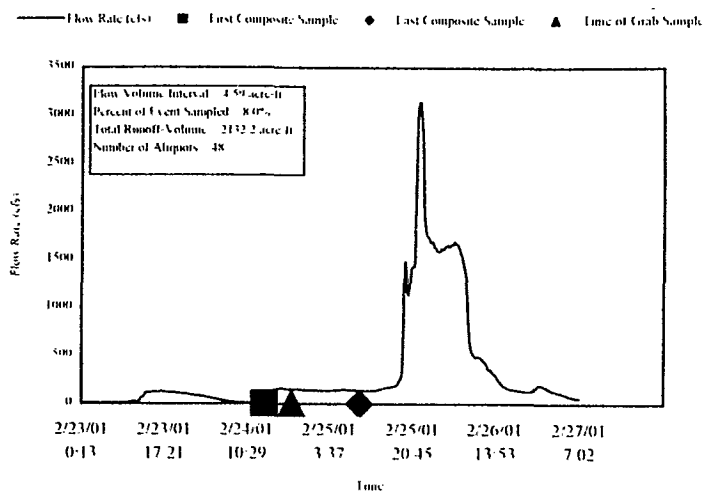


R0012527

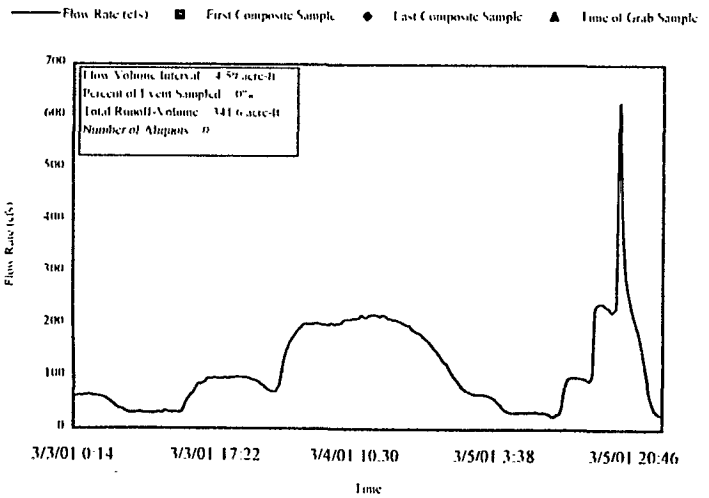
S.G.R, Storm 9 (2/19/2001)



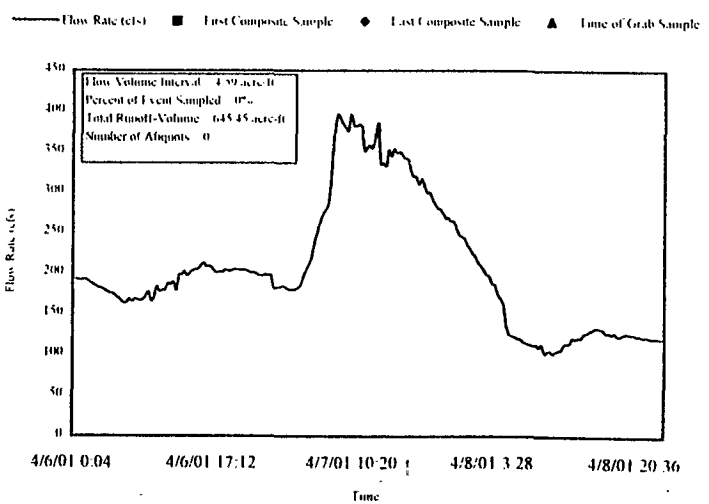
S.G.R, Storm 10 (2/24/2001)



S.G.R, Storm 11 (03/04/2001)

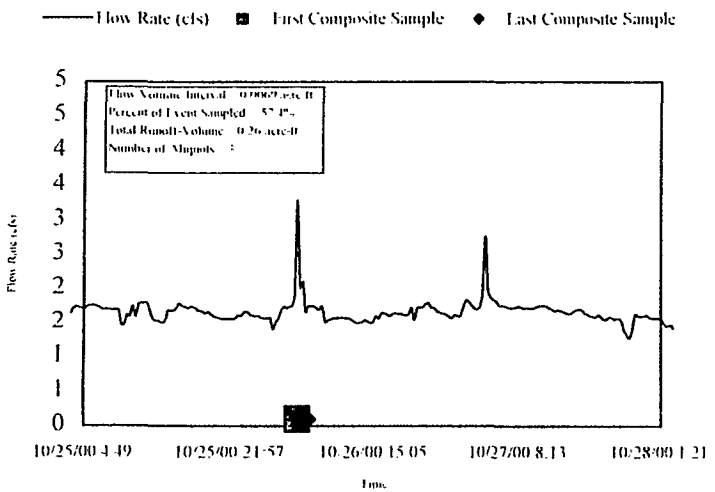


S.G.R, Storm 12 (04/07/2001)

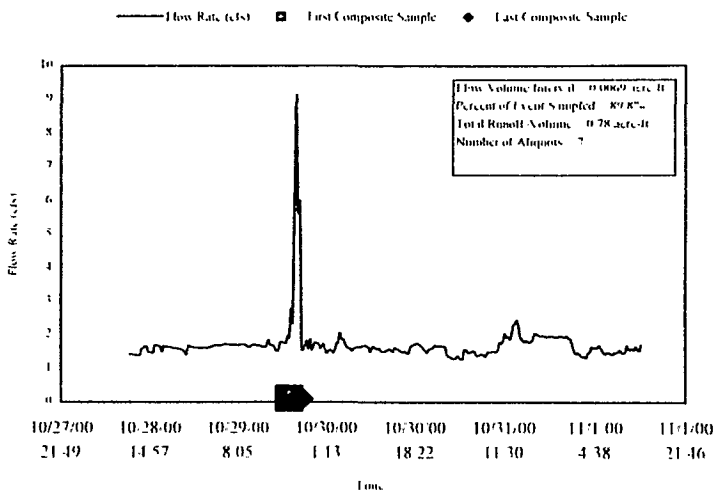


R0012528

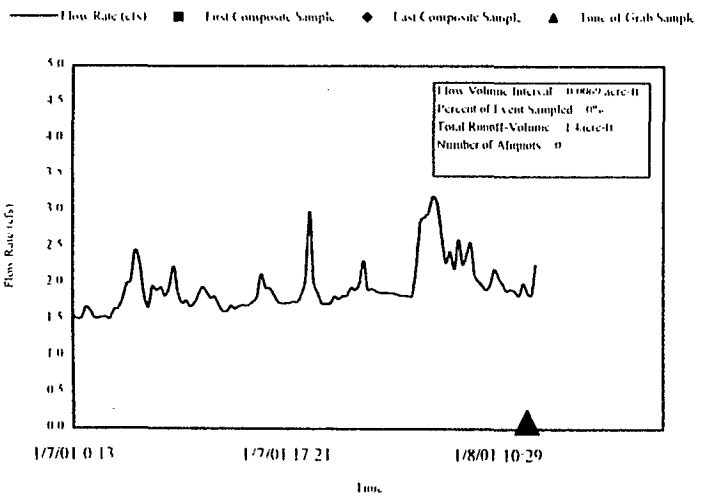
Station 18, Storm 2 (10/26/2000)



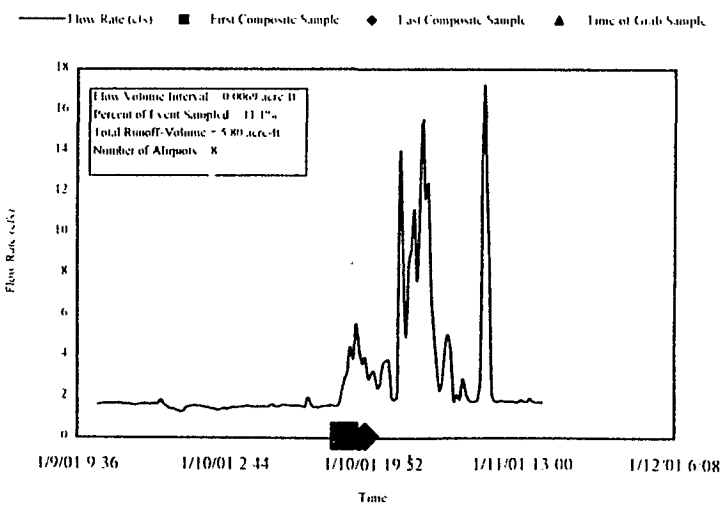
Station 18, Storm 3 (10/29/2000)



Station 18, Storm 4 (1/8/2001)

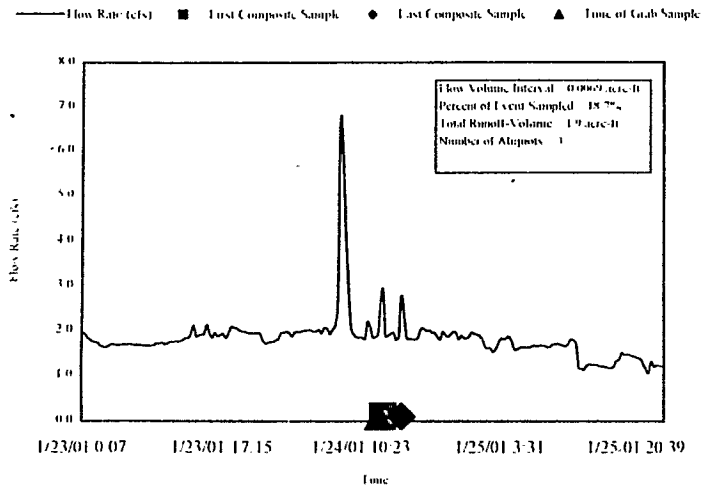


Station 18, Storm 5 (1/10/2001)

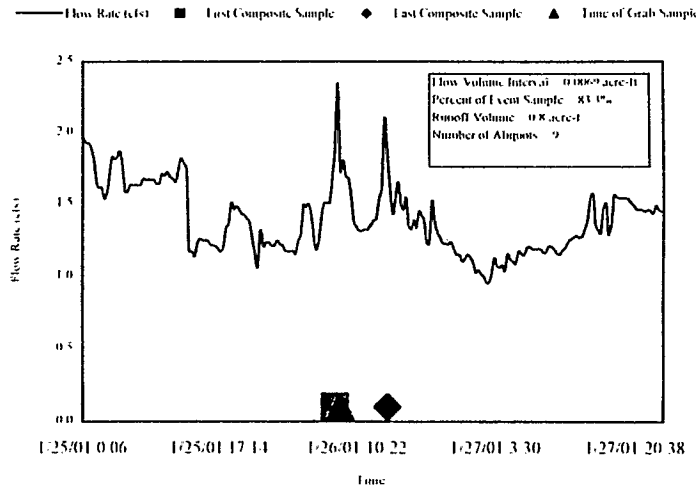


R0012529

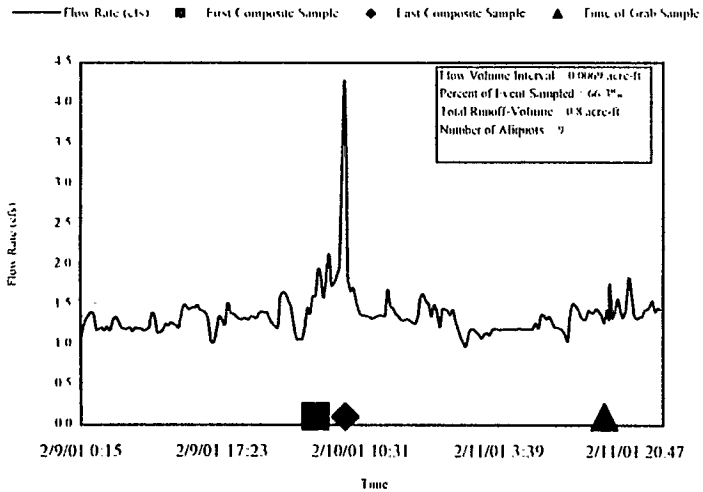
Station 18, Storm 6 (1/24/2001)



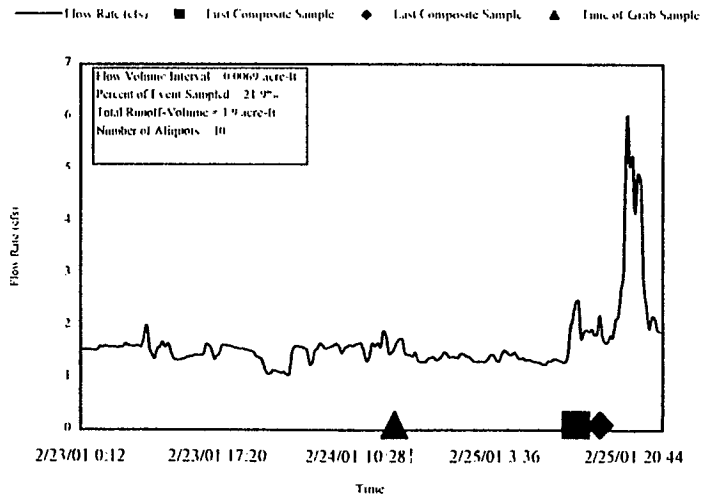
Station 18, Storm 7 (1/26/2001)



Station 18, Storm 8 (2/10/2001)

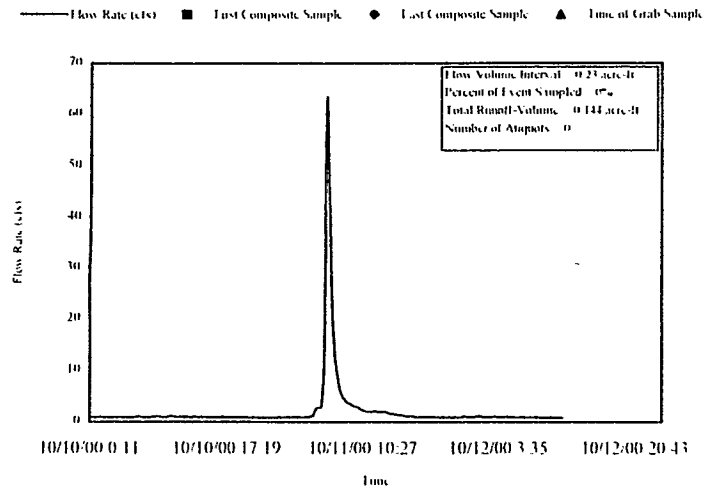


Station 18, Storm 10 (2/24/2001)

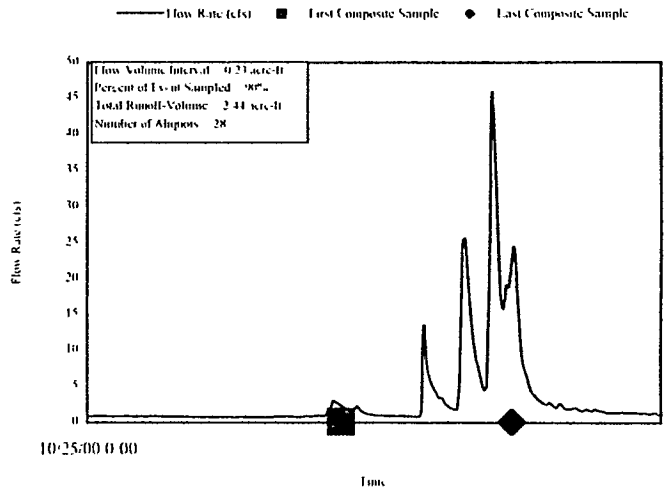


R0012530

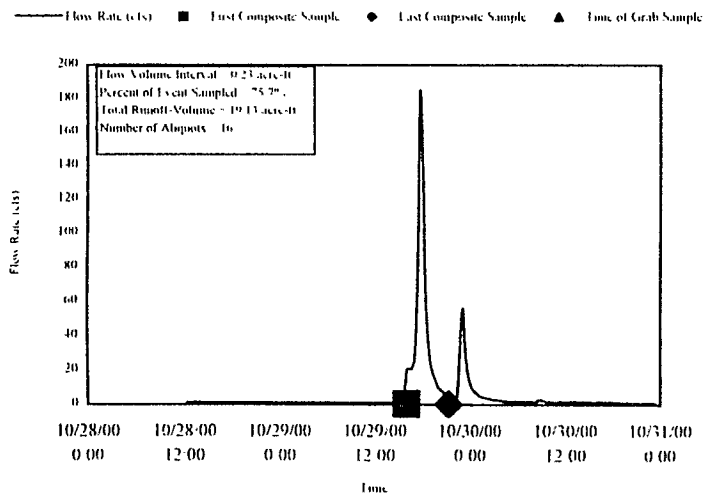
Dominguez Channel, Storm 1 (10/12/2000)



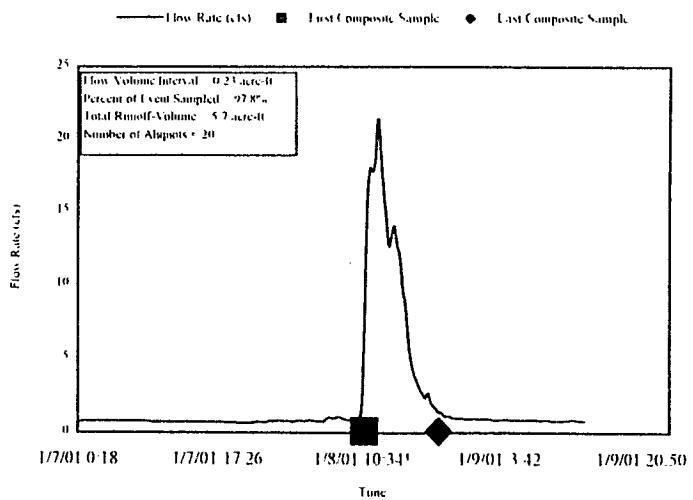
Dominguez Channel, Storm 2 (10/26/2000)



Dominguez Channel, Storm 3 (10/29/2000)

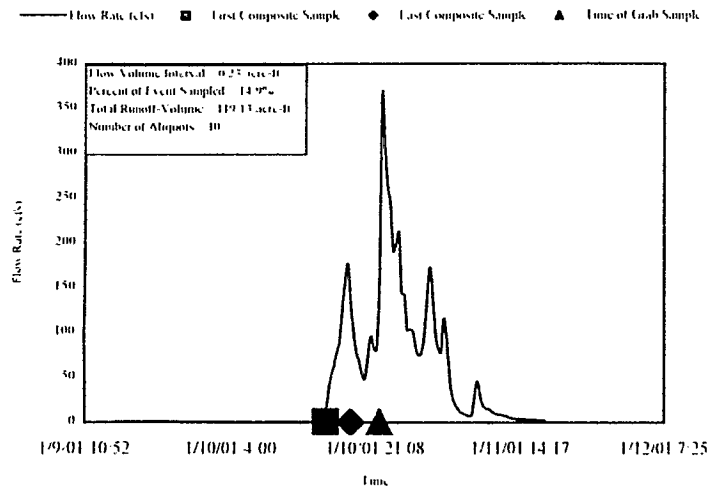


Dominguez Channel, Storm 4 (1/8/2001)

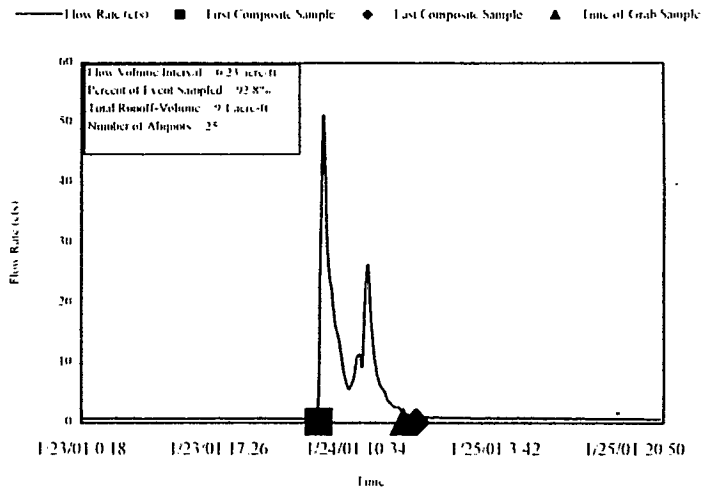


R0012531

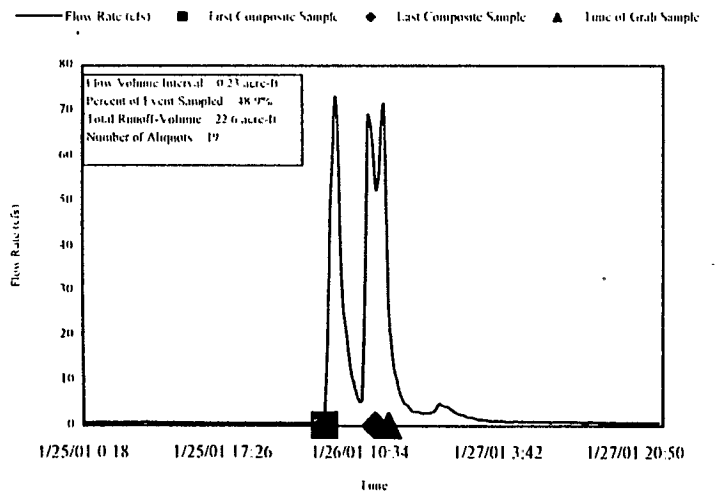
Dominguez Channel, Storm 5 (1/10/2001)



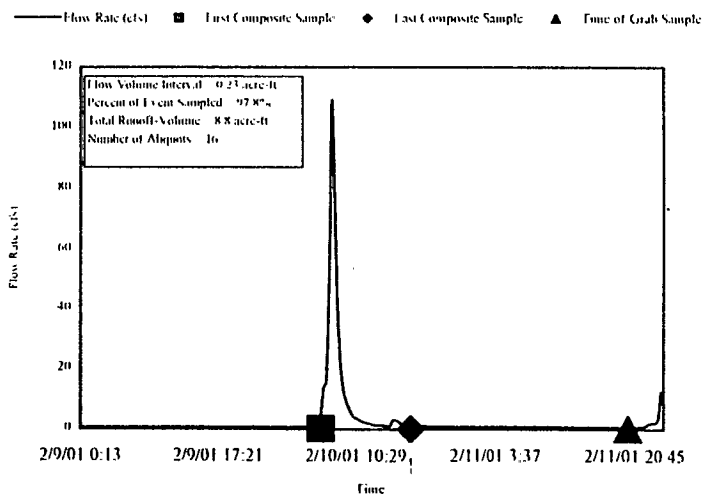
Dominguez Channel, Storm 6 (1/24/2001)



Dominguez Channel, Storm 7 (1/26/2001)

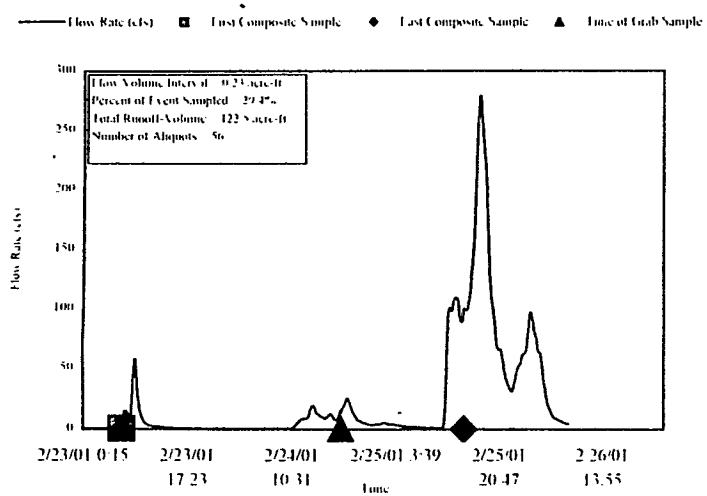


Dominguez Channel, Storm 8 (2/10/2001)

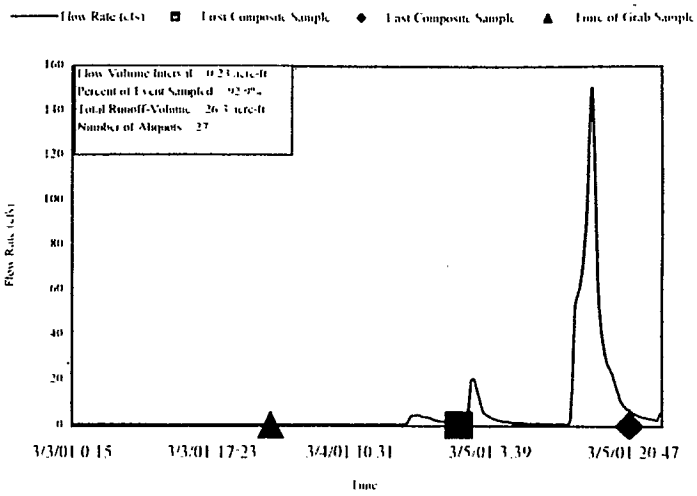


R0012532

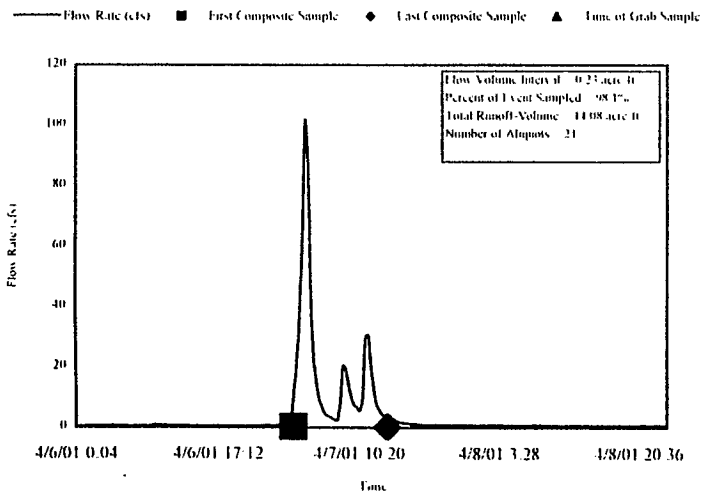
Dominguez Channel, Storm 10 (2/24/2001)



Dominguez Channel, Storm 11 (03/04/2001)

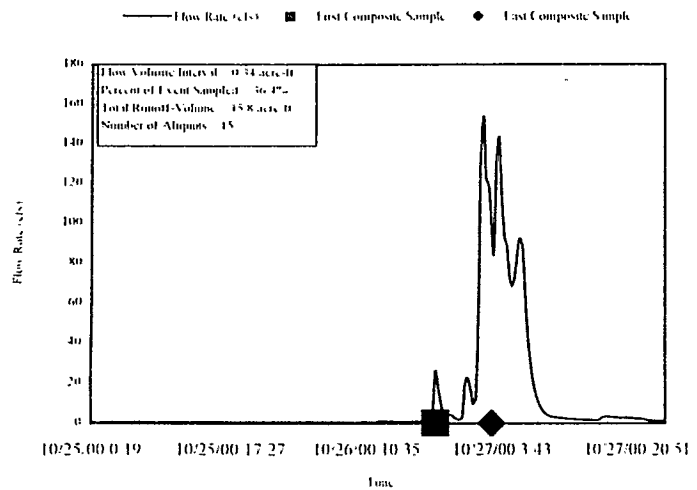


Dominguez Channel, Storm 12 (04/07/2001)

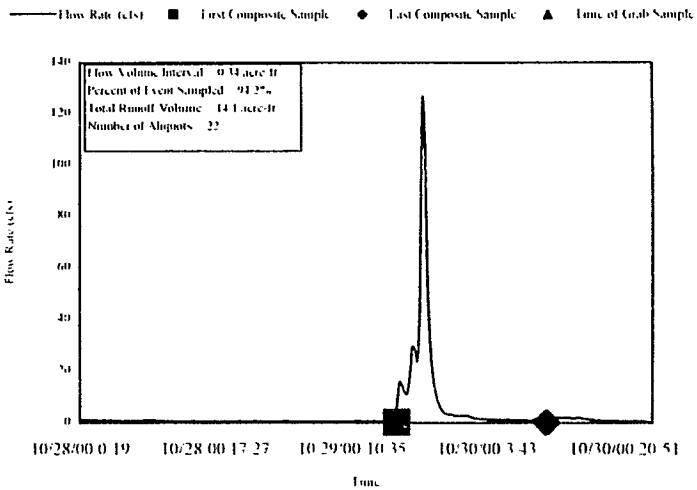


R0012533

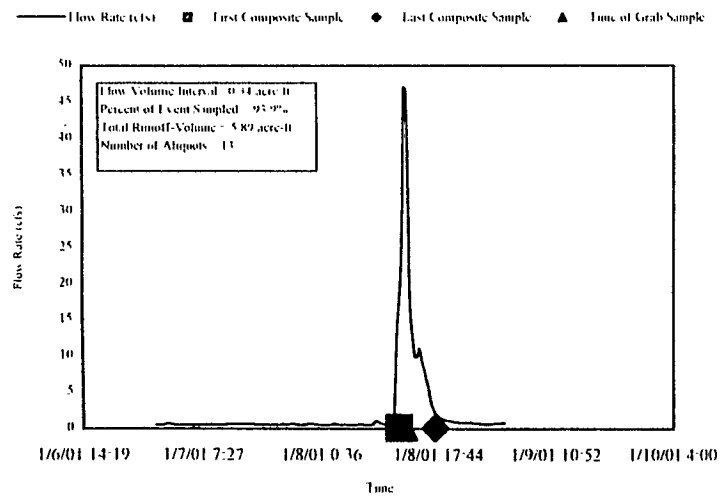
Station 24, Storm 2 (10/26/2000)



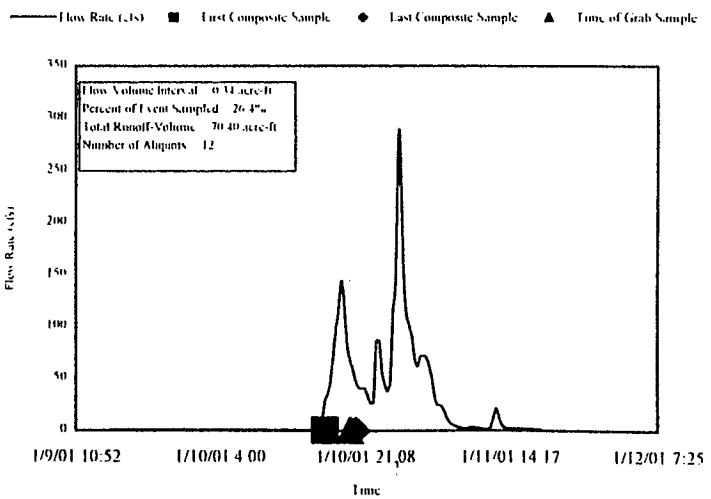
Station 24, Storm 3 (10/29/2000)



Station 24, Storm 4 (1/8/2001)

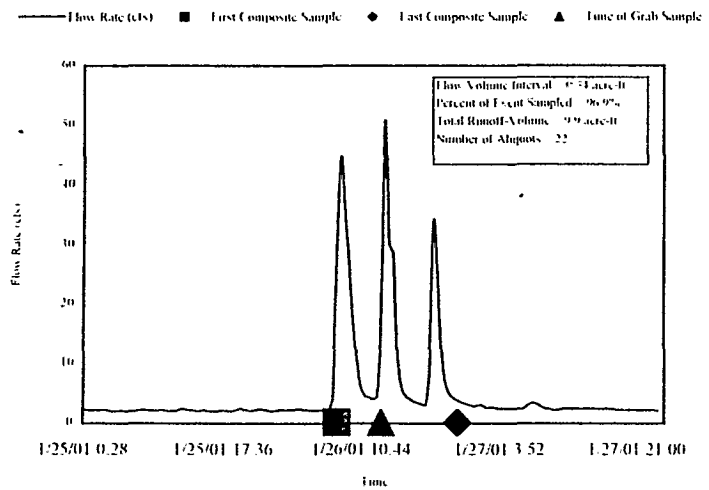


Station 24, Storm 5 (1/10/2001)

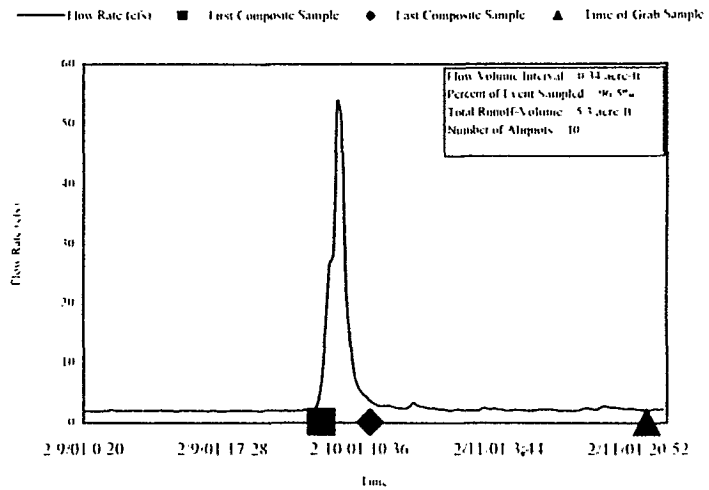


R0012534

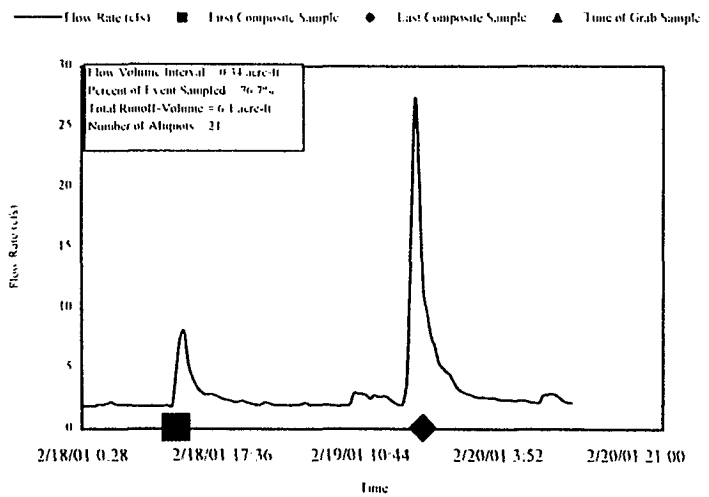
Station 24, Storm 7 (1/26/2001)



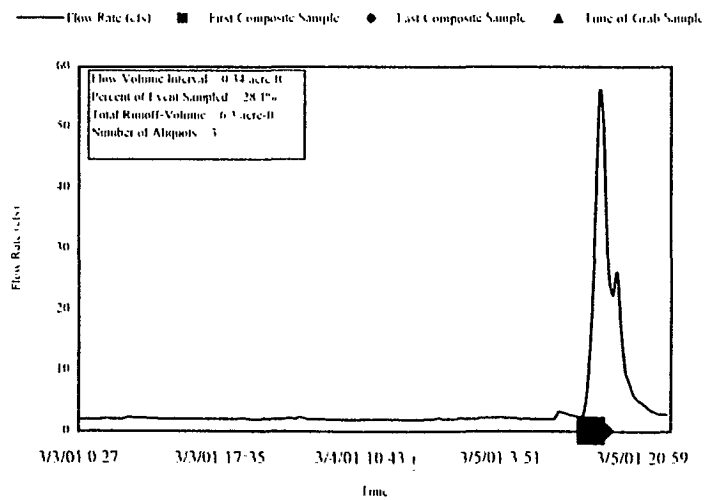
Station 24, Storm 8 (2/10/2001)



Station 24, Storm 9 (2/19/2001)

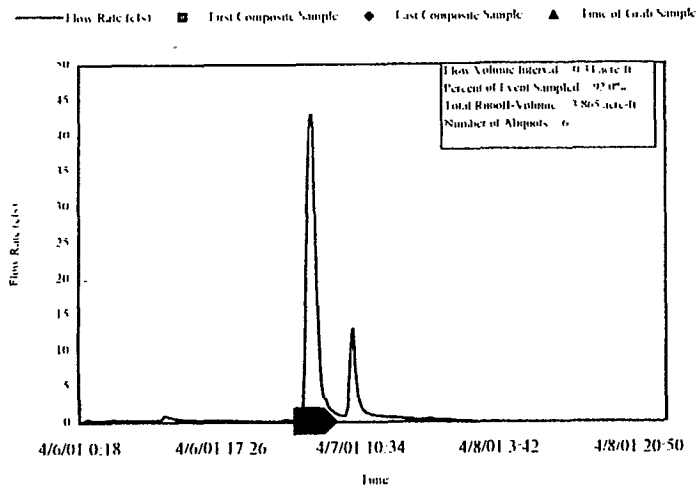


Station 24, Storm 11 (03/04/2001)



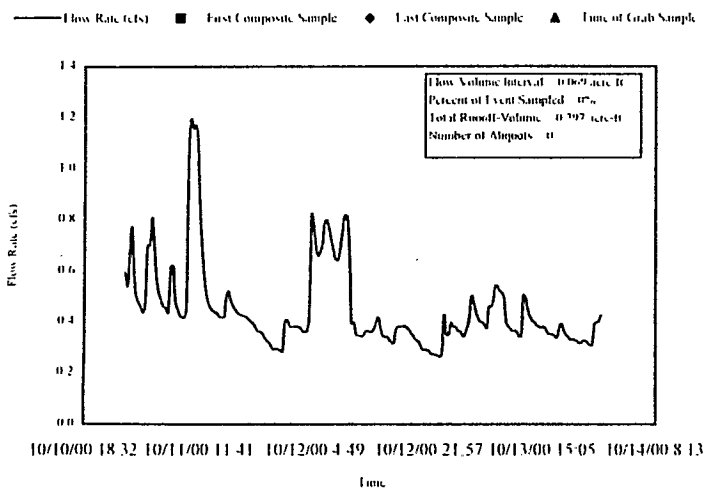
R0012535

Station 24, Storm 12 (04/07/2001)

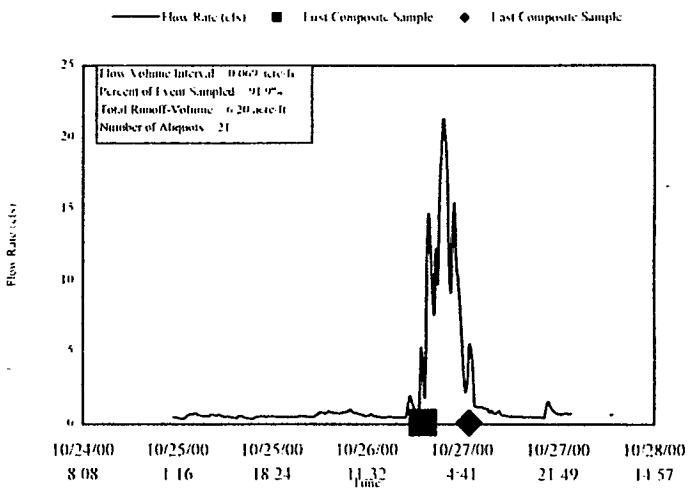


R0012526

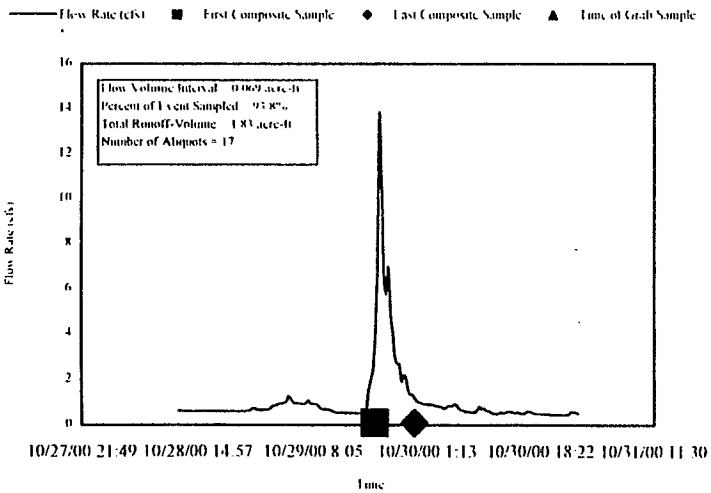
Station 25, Storm 1 (10/12/2000)



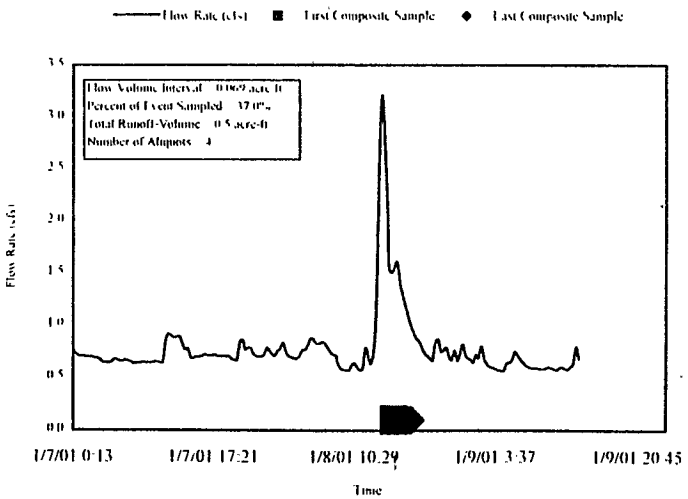
Station 25, Storm 2 (10/26/2000)



Station 25, Storm 3 (10/29/2000)

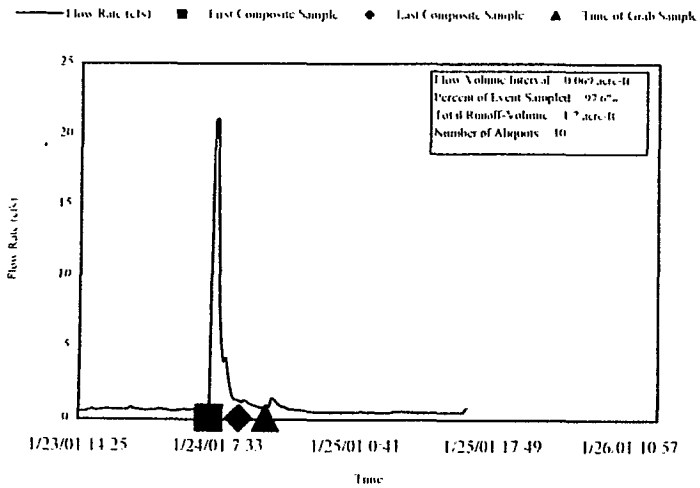


Station 25, Storm 4 (1/8/2001)

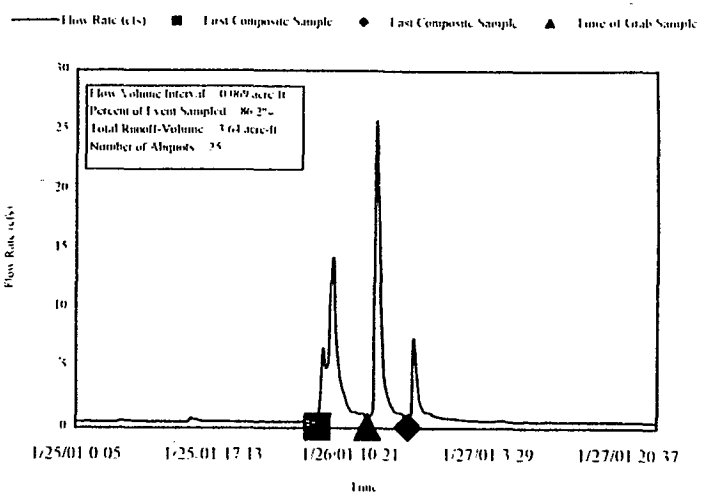


R0012537

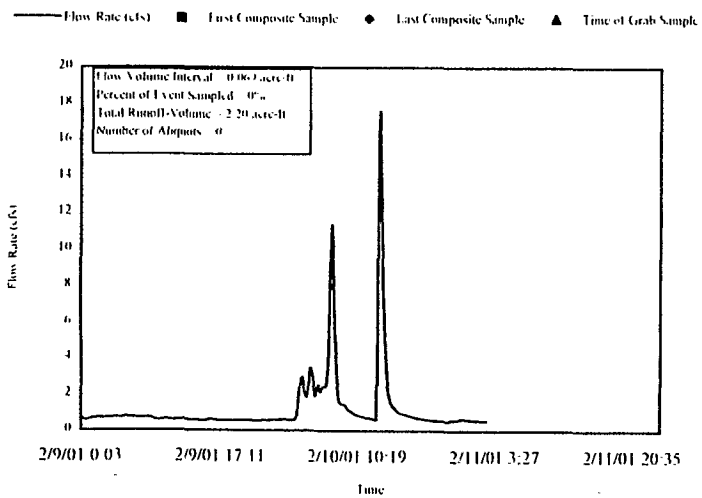
Station 25, Storm 6 (1/24/2001)



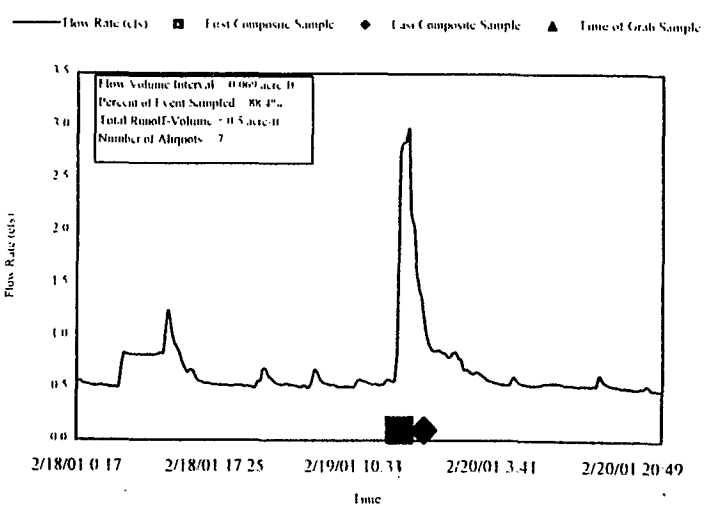
Station 25, Storm 7 (1/26/2001)



Station 25, Storm 8 (2/10/2001)

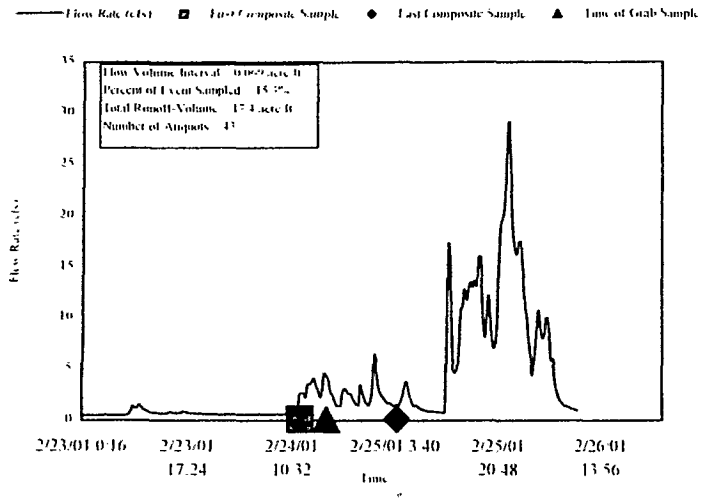


Station 25, Storm 9 (2/19/2001)

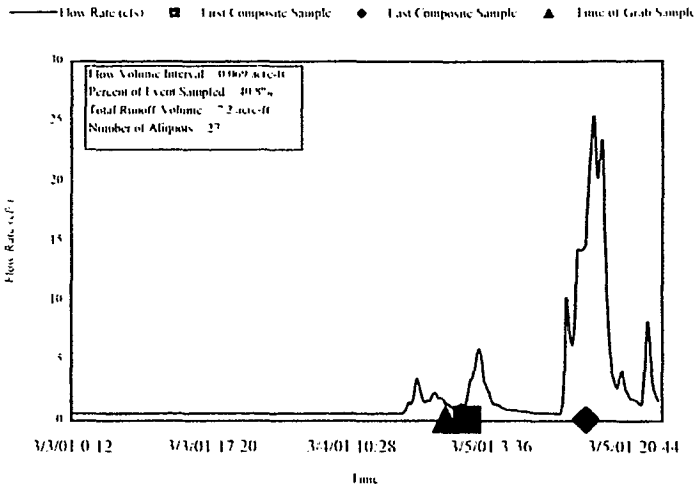


R0012538

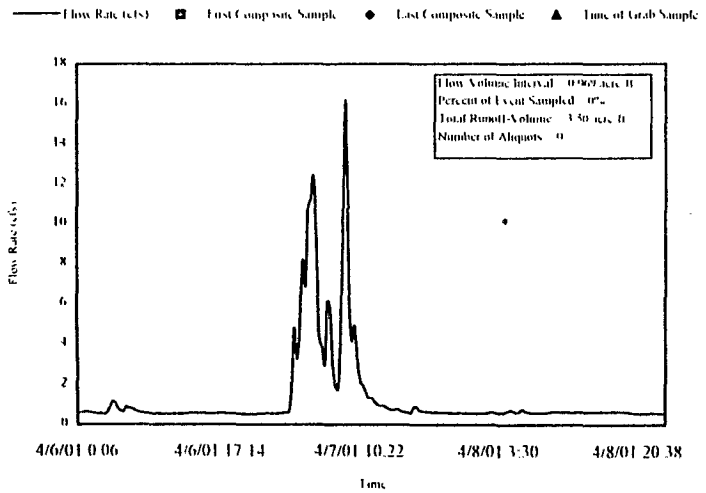
Station 25, Storm 10 (2/24/2001)



Station 25, Storm 11 (03/04/2001)

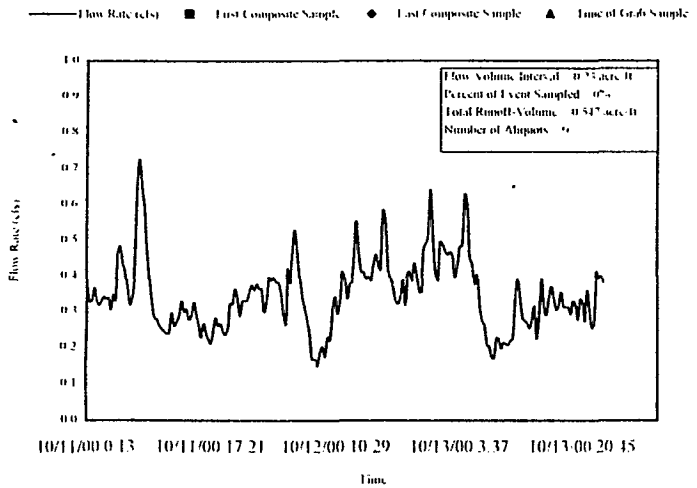


Station 25, Storm 12 (04/07/2001)

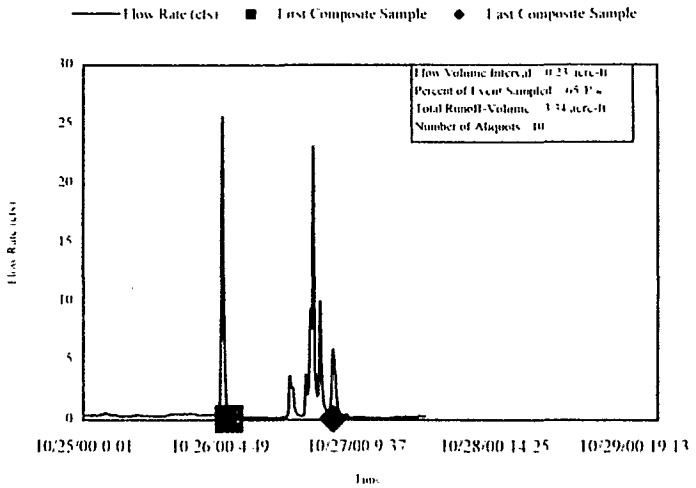


R0012539

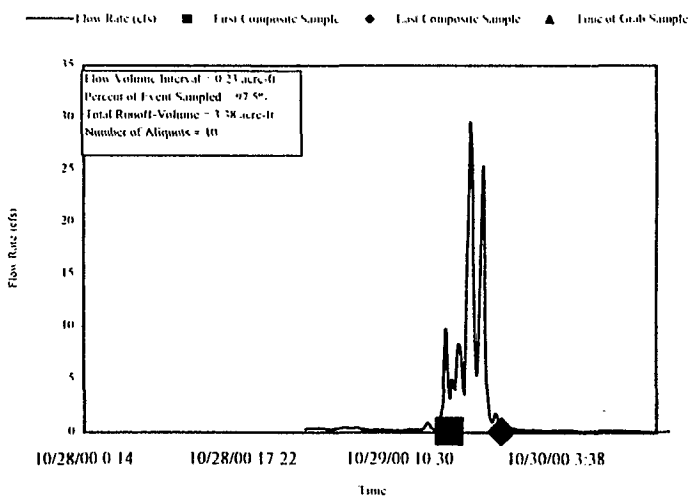
Station 26, Storm 1 (10/12/2000)



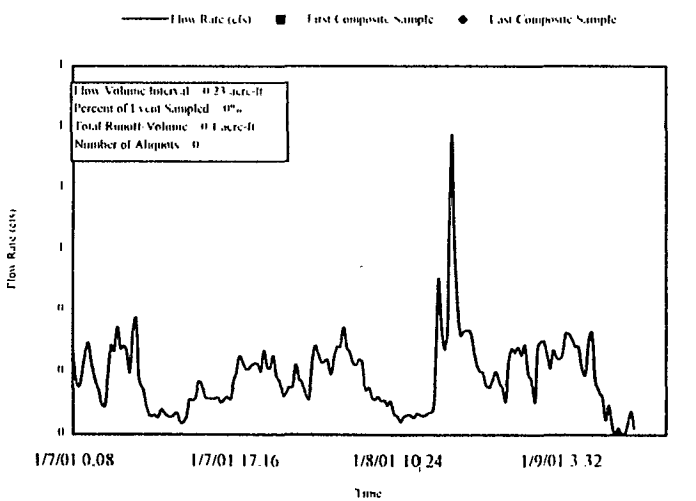
Station 26, Storm 2 (10/26/2000)



Station 26, Storm 3 (10/29/2000)

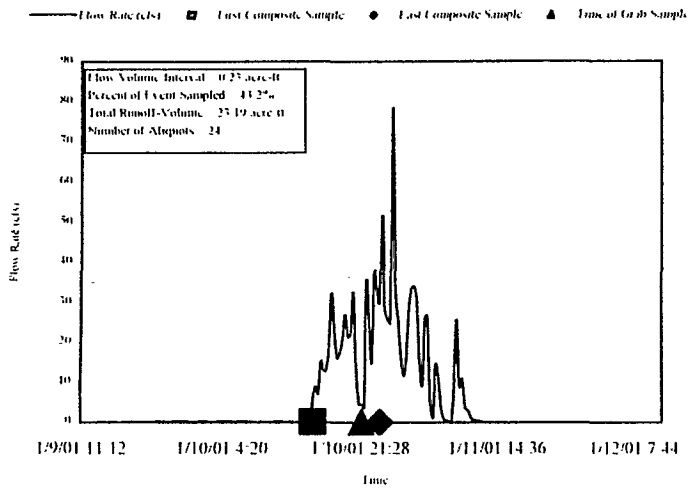


Station 26, Storm 4 (1/8/2001)

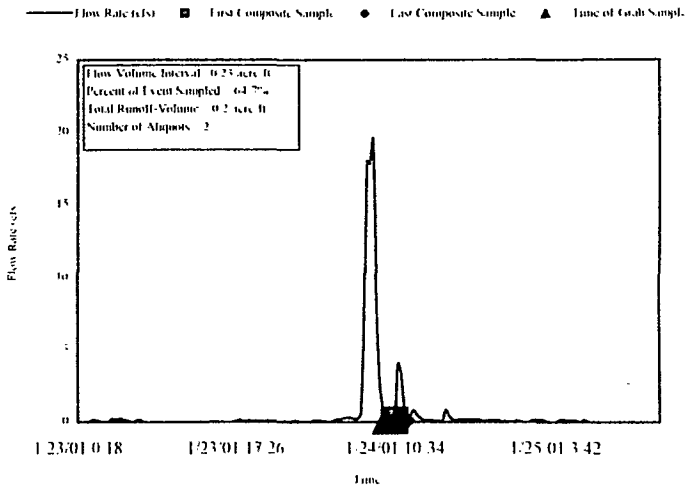


R0012540

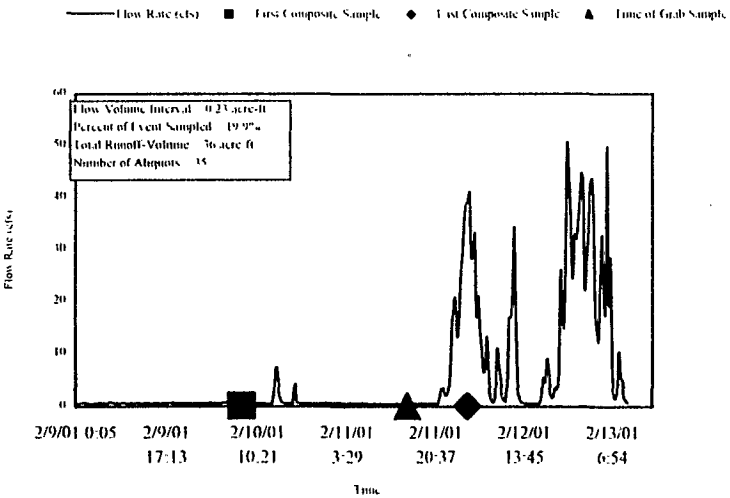
Station 26, Storm 5 (1/10/2001)



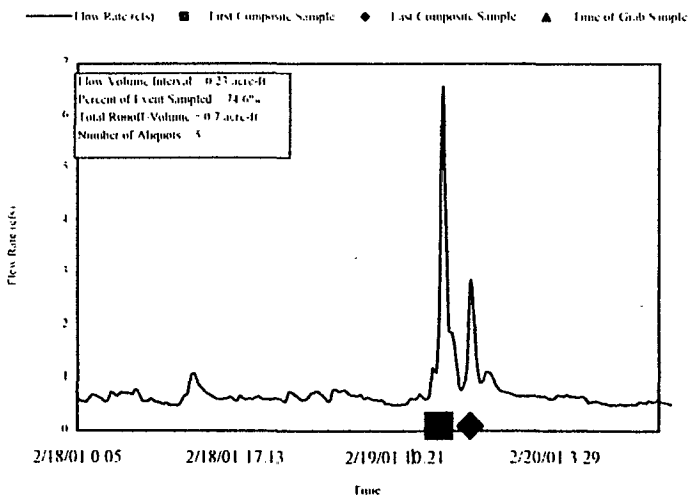
Station 26, Storm 6 (1/24/2001)



Station 26, Storm 8 (2/10/2001)

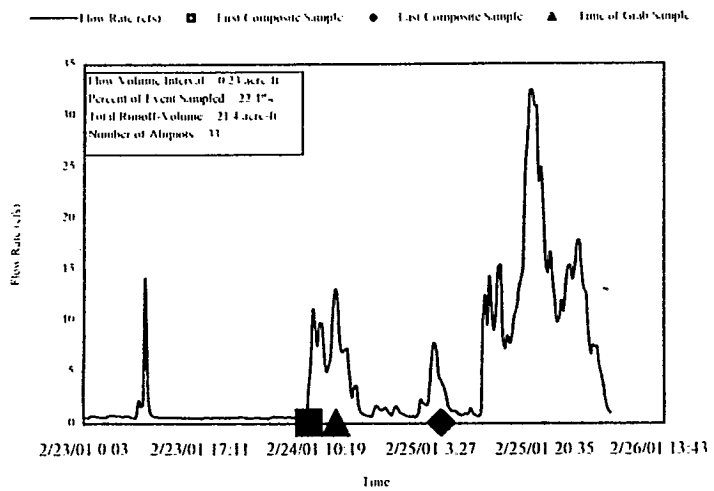


Station 26, Storm 9 (2/19/2001)

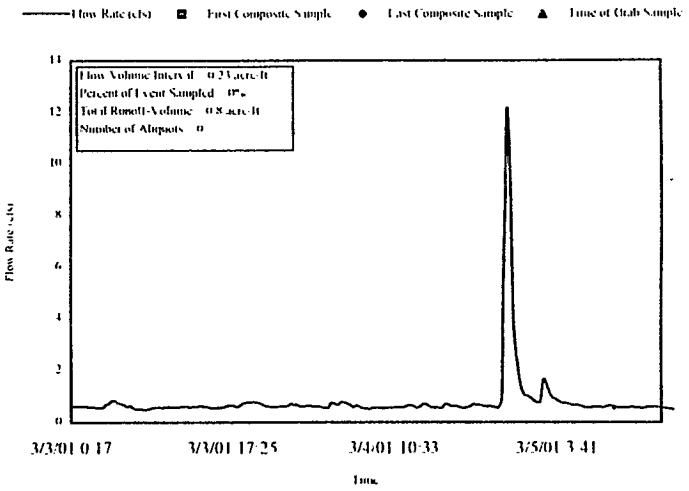


R0012541

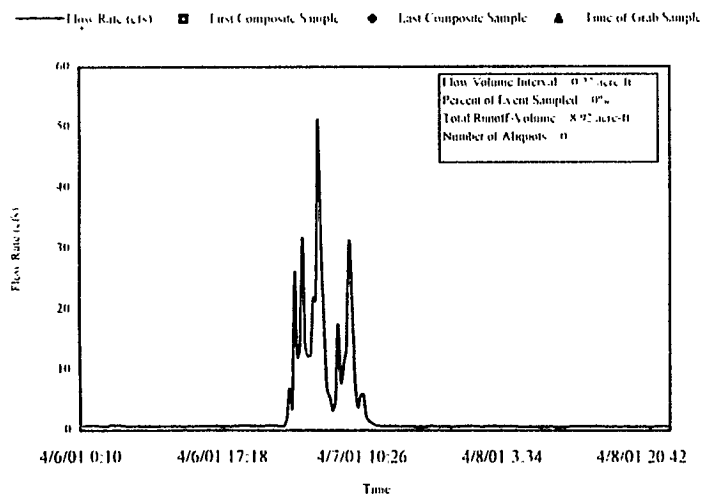
Station 26, Storm 10 (2/24/2001)



Station 26, Storm 11 (03/04/2001)

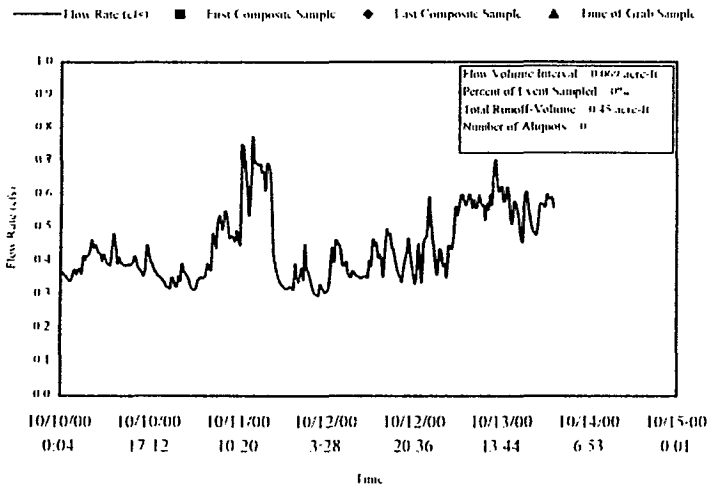


Station 26, Storm 12 (04/07/2001)

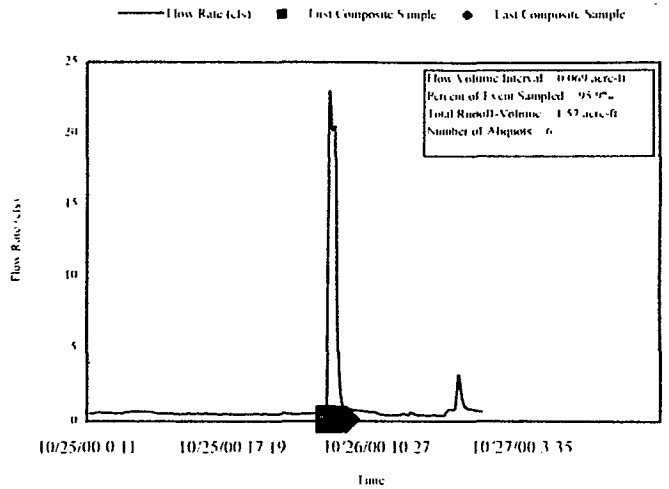


R0012542

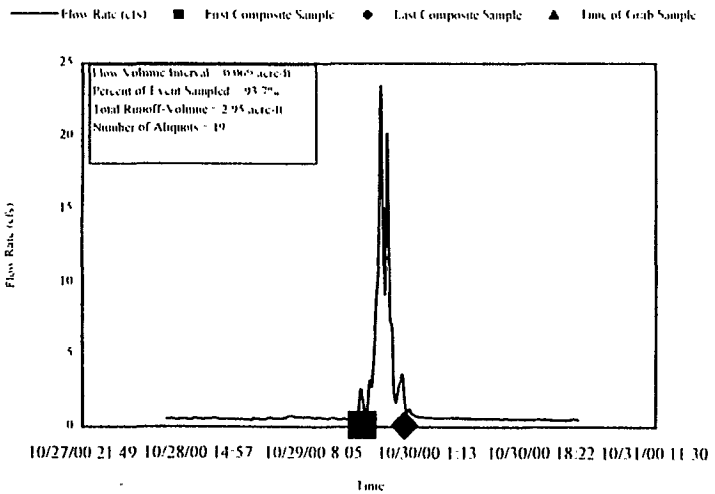
Station 27, Storm 1 (10/12/2000)



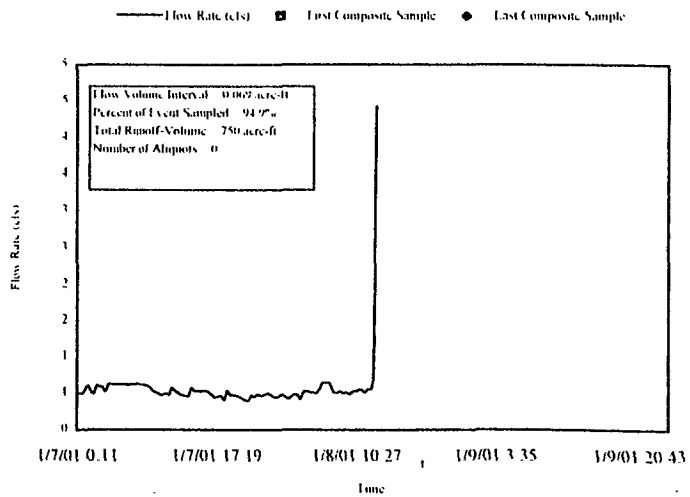
Station 27, Storm 2 (10/26/2000)



Station 27, Storm 3 (10/29/2000)

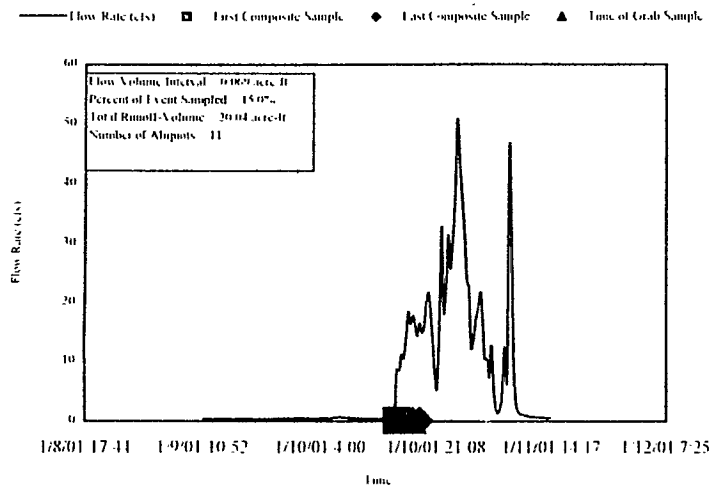


Station 27, Storm 4 (1/8/2001)

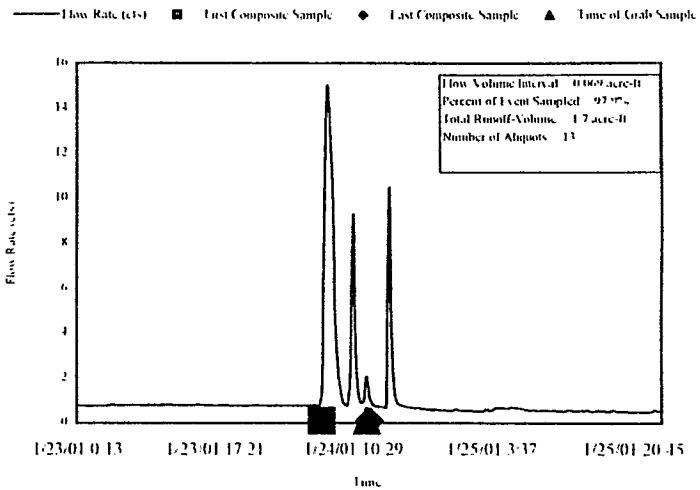


R0012543

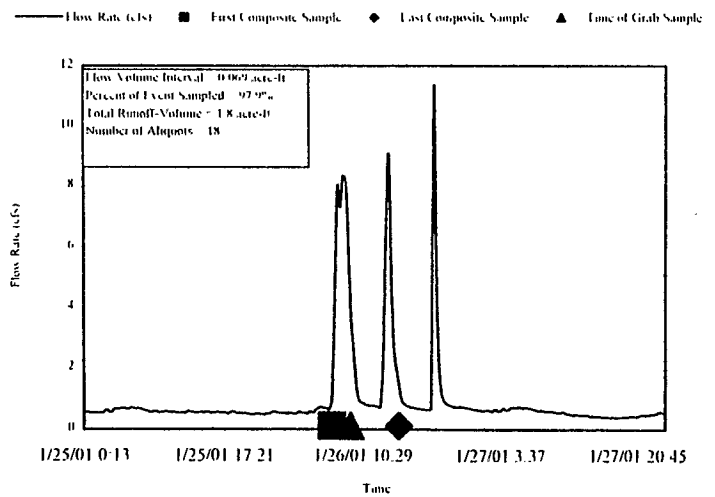
Station 27, Storm 5 (1/10/2001)



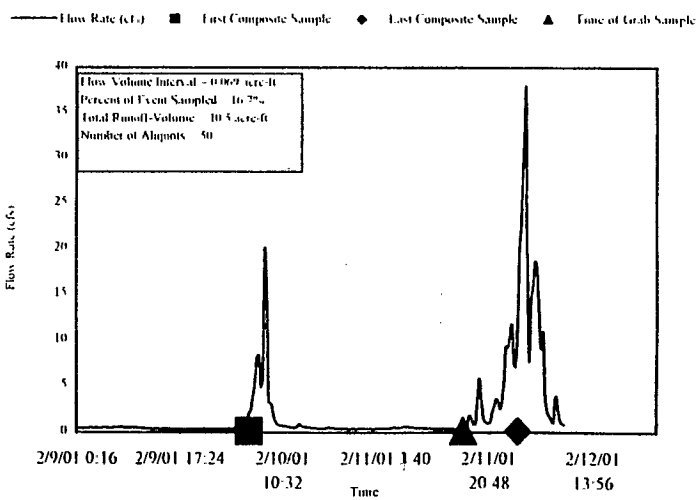
Station 27, Storm 6 (1/24/2001)



Station 27, Storm 7 (1/26/2001)



Station 27, Storm 8 (2/10/2001)



R0012544

Table B-1. Summary of Results for the 2000-2001 Routine Monitoring at Ballona Creek

STATION NO					S01	S01	S01	S01	S01	S01	S01	S01	S01	S01
STATION NAME					Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek
STORM NO.					0001-01	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/31/2000	01/04/2001	01/17/2001	01/25/2001	01/30/2001	02/15/2001	02/20/2001	02/28/2001	03/07/2001
	Sample Type	EPA Method	DL	Units										
Conventional														
Cyanide	Grab	A335.2	0 01	mg/L	0		0 0232	0	0	0	0		0	.0 018
TPH	Grab	A418 1	1	mg/L	2		8 2	6 85	0	1 9	1.5		2	3 1
Oil and Grease	Grab	A413.1	1	mg/L	0		7.5	9 2	3.1	0	0		1 4	3 6
Total Phenols	Grab	A420.1	0.1	mg/L	0		0	0	0	0	0		0	0
Indicator Bacteria														
Total Coliform	Grab	C9221B	20	MPN/100ml	9000000		16000000	21000	240000	90000	500000		1700000	500000
Fecal Coliform	Grab	C9221C	20	MPN/100ml	1700000		16000000	7000	240000	90000	70000		1700000	500000
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml	5000000		1600000	90000	240000	240000	170000		500000	160000
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml	3000000		900000	50000	240000	240000	160000		170000	160000
General														
Ammonia	Comp	A350 3	0.1	mg/L	0 85	0	1.47	1 004	0.387	0 45	0 74	0		0
Calcium	Comp	A215 2	1	mg/L	66.5	52 1	39 2	20	11	20	16.03	12	18 04	16
Magnesium	Comp	C3500MgD	1	mg/L	27 7	24 3	17.9	2 43	9 42	6 69	4.86	9 72	9.72	4 86
Potassium	Comp	A258.1	1	mg/L	10 9	4.21	5 36	3 54	2 53	2 88	2 41	1 89	2.1	1 85
Sodium	Comp	A273.1	1	mg/L	52 7	47 1	38 8	11.5	18 4	22 4	12	12.2	17.5	12 1
Bicarbonate	Comp	A310 1	2	mg/L	196	147	142	62.1	29 7	38.7	45 26	51.72	71 12	45 26
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	72 8	48 8	46 5	8 62	8 56	15.1	12 9	11 5	17 2	9 21
Flouride	Comp	B429	0 1	mg/L	0.52	0 27	0 43	0 15	0 11	0.12	0.1	0	0.12	0.1
Nitrate	Comp	B429	0 1	mg/L	7 68	5 31	0 36	0 95	2.87	2 11	2.23	2.16	4.85	1 85
Sulfate	Comp	B429	0.1	mg/L	130	90 5	62.4	10 8	12.2	25	16.6	19.1	28 3	17.4
Alakalinity	Comp	A310 1	4	mg/L	161	121	117	50.9	24 4	31.8	37 1	42 4	58.3	37 1
Hardness	Comp	A130 2	2	mg/L	280	230	172	160	66.2	77 5	60	70	85	60
Dissolved Phosphorus	Comp	A365 2	0 05	mg/L	0 312	0 213	0 42	0 18	0 24	0 16	0.16	0 134	0 108	0 076
Total Phosphorus	Comp	A365 2	0.05	mg/L	0 325	0 224	0 47	0 24	0 3	0 18	0 19	0.152	0 194	0 139
COD	Comp	A410 4	5	mg/L	70.1	77.2	72.9	70.1	87.4	23 2	34.7	48 6	33 9	12 9
pH	Comp	A150.1	na		7.69	7 87	7 62	7.01	6.62	6.87	6.96	7.12	7.36	7 4
NH3-N	Comp	A350 3	0.1	mg/L	0.701	0	1.22	0 83	0.32	0 372	0 612	0		0
Nitrate-N	Comp	C4110B	0.1	mg/L	1.73	1 2	0	0 215	0 648	0.476	0 504	0 488	1.1	0.418
Nitrite-N	Comp	C4110B	0.1	mg/L	0 965	0.079	0.26	0 18	0.11	0 103	0.164	0 073	0	0.07
Kjeldahl-N	Comp	A351 4	0.1	mg/L	1.7	0 558	3 66	3 68	2.3	2 88	2.76	0 962		1.33
Specific Conductance	Comp	A120 1	1	umhos/cm	817	629	495	188	128.7	209	178 7	161	245	168.7
Total Dissolved Solids	Comp	A160.1	2	mg/L	500	368	320	108	71.2	122	122	90	148	96
Turbidity	Comp	A180.1	0 1	NTU	13.5	44.3	62.7	137	24 3	61.3	15 4	35.7	53.5	22 6
Suspended Solids	Comp	A160.2	2	mg/L	61	141	175	460	124	249	78	45	172	144
Volatile Suspended Solids	Comp	160 4	1	mg/L	26	33	53	107	37	81	17	17	63	32
MBAS	Comp	A425 1	0 05	mg/L	0 107	0 05	0 328	0.092	0.149	0 112	0.078	0	0.096	0.069
Total Organic Carbon	Comp	A415.1	1	mg/L	18.8	6 6	16 9	12.16	10.9	5.9	7 13	5 79	6.7	4 4
BOD	Comp	A405 1	2	mg/L	6.7	7 1	6 6	15.9	18.6	6.1	13	0	11.05	8 4
Metals														
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	206	0	0	0	0	0	106
Total Aluminum	Comp	A202 2	1000	ug/l	0	500	1680	231	750	236	109	132.1	140	180
Dissolved Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208 2	10	ug/l	38.3	43 5	53 9	28	18 2	25 3	26 3	19 9	18 8	22 5
Total Barium	Comp	A208 2	10	ug/l	52 8	43.5	94 2	28	27.4	28 4	26.7	25.5	19	22.5
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0

R0012545

Table B-1. Summary of Results for the 2000-2001 Routine Monitoring at Ballona Creek

STATION NO.					S01	S01	S01	S01	S01	S01	S01	S01	S01	S01
STATION NAME					Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek	Ballona Creek
STORM NO					0001-01	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/31/2000	01/04/2001	01/17/2001	01/25/2001	01/30/2001	02/15/2001	02/20/2001	02/28/2001	03/07/2001
	Sample Type	EPA Method	DL	Units										
Metals (cont)														
Dissolved Boron	Comp	A212 3	100	ug/l	333	130	287	0	0	121	0	0	148	112
Total Boron	Comp	A212.3	100	ug/l	346	236	312	0	102	147	0	0	150	127
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218.2	5	ug/l	0	0	7.07	0	0	0	0	0	0	0
Total Chromium	Comp	A218 2	5	ug/l	0	0	7 07	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	10.1	5.28	12.1	8 12	8 52	7 34	0	6 39	6.28	0
Total Copper	Comp	A220.1	5	ug/l	10 3	12 8	50 1	16 6	14 8	10 2	6 89	9 47	9.56	6 9
Dissolved Iron	Comp	A236.1	100	ug/l	0	170	100	440	210	0	0	0	0	120
Total Iron	Comp	A236 1	100	ug/l	0	630	4060	840	1160	360	110	300	230	230
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239 2	5	ug/l	0	0	34 5	0	6 52	0	0	0	0	0
Dissolved Manganese	Comp	A243 1	100	ug/l	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	0	0	124	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249 1	5	ug/l	5 4	0	8 42	5	0	0	0	0	0	0
Total Nickel	Comp	A249 1	5	ug/l	6 92	0	10 8	5 15	5 82	0	0	0	0	0
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289 1	50	ug/l	0	0	50 5	0	260	57 8	0	51.6	0	0
Total Zinc	Comp	A289 1	50	ug/l	0	0	203	54.2	371	60	0	56.4	0	0
Semi-Volatiles Organics														
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l										
All other SVOCs	Comp	625M	0.5-5 0	ug/l										
Pesticides														
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531 1	5	ug/l										
2,4-D	Comp	515	10	ug/l										
2,4,5-TP	Comp	515	1	ug/l										
Bentazon	Comp	515	2	ug/l										
Glyphosate	Comp	547	25	ug/l										
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012546

Table B-2. Summary of Results for the 2000-2001 Routine Monitoring at Malibu Creek

STATION NO					S02	S02	S02	S02	S02	S02	S02	S02	S02	S02
STATION NAME					Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek
STORM NO.					0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/28/2000	10/31/2000	01/04/2001	01/10/2001	01/25/2001	01/29/2001	02/15/2001	02/20/2001	02/28/2001	03/08/2001
	Sample Type	EPA Method	DL	Units										
Conventional														
Cyanide	Grab	A335 2	0 01	mg/L										
TPH	Grab	A418 1	1	mg/L		0	0	0	2 6	0	0		0	0
Oil and Grease	Grab	A413 1	1	mg/L		0	0	1 5	4 7	1 3	0		0	0
Total Phenols	Grab	A420.1	0.1	mg/L										
Indicator Bacteria														
Total Coliform	Grab	C9221B	20	MPN/100ml		900000	1100	9000	33000	22000	1300		2100	28000
Fecal Coliform	Grab	C9221C	20	MPN/100ml		140000	700	9000	28000	14000	140		2100	28000
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml		700000	80	90000	2100	7000	230		170	160000
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml		220000	40	22000	2100	5000	130		170	17000
General														
Ammonia	Comp	A350 3	0.1	mg/L		0	0.169	0.244	0.112	0.313	0.44	0	0.146	0.108
Calcium	Comp	A215.2	1	mg/L	132	148	48	108 7	132	140 3	90.18	88 2	102 2	88 2
Magnesium	Comp	C3500MgD	1	mg/L	79 3	92.4	209	58 3	71.7	65 6	52.27	46 2	54.7	49.1
Potassium	Comp	A258.1	1	mg/L	11 3	8 72	7 28	6 25	6 48	5.02	4.01	3.75	3 86	3 1
Sodium	Comp	A273.1	1	mg/L	101	144	191	109	116	22.2	74	76 5	92	65 5
Bicarbonate	Comp	A310 1	2	mg/L	209	263	311	178	237	229	181	232	232.77	193 98
Carbonate	Comp	A310 1	2	mg/L	0	0	28.1	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	144	132	194	90 8	103	114	65.8	75 2	71 3	53
Flouride	Comp	B429	0 1	mg/L	0 18	0 21	0.24	0 2	0.23	0 23	0.17	0.16	0 2	0 17
Nitrate	Comp	B429	0 1	mg/L	19 8	6 54	10 6	11 5	13.7	8 21	4.06	7 75	5 82	4 32
Sulfate	Comp	B429	0 1	mg/L	533	542	937	368	369	497	326	293	354	275
Alakalinity	Comp	A310 1	4	mg/L	171	215	278	146	194	188	148 4	190 8	190 8	159
Hardness	Comp	A130 2	2	mg/L	656	750	980	510	625	620	440	410	480	422
Dissolved Phosphorus	Comp	A365 2	0 05	mg/L	1 12	0 935	0.7	0 7	0 72	0.41	0 213	0 31	0 21	0 1925
Total Phosphorus	Comp	A365.2	0 05	mg/L	1.16	0 967	0 78	0 84	0 8	0.44	0 239	0.334	0 346	0 2268
COD	Comp	A410.4	5	mg/L	90.6	139	160	60 5	96 8	116	33 5	35.7	68.3	30 6
pH	Comp	A150 1	na		8 08	8	8 58	7 8	8 15	8.11	8 07	8 12	8 11	8 01
NH3-N	Comp	A350 3	0 1	mg/L		0	0.14	0.202	0	0 259	0 36	0	0.121	0
Nitrate-N	Comp	C4110B	0.1	mg/L	4 47	2.15	2 394	2 6	3 09	1.85	0.917	1.75	1.31	0 975
Nitrite-N	Comp	C4110B	0 1	mg/L	0	0	0	0	0	0	0	0	0	0 119
Kjeldahl-N	Comp	A351.4	0 1	mg/L	1 37	0 936	5 56	9 34	1.17	1 4	0 974	0 585	0 984	2 46
Specific Conductance	Comp	A120 1	1	umhos/cm	2025	2290	2890	1495	1440	1469	1099	1076	1450	918
Total Dissolved Solids	Comp	A160.1	2	mg/L	1242	1356	1668	942	992	1028	740	732	940	628
Turbidity	Comp	A180.1	0 1	NTU	8.54	31.1	4.01	1000	44.1	164	360	16.1	47 9	37 9
Suspended Solids	Comp	A160.2	2	mg/L	27	71	5	1894	81	214	767	21	110	341
Volatile Suspended Solids	Comp	160 4	1	mg/L	6	15	1	210	16	33	39	9	30	39
MBAS	Comp	A425 1	0 05	mg/L	0	0	0.053	0	0	0	0.273	0	0	0
Total Organic Carbon	Comp	A415.1	1	mg/L	8.7	8 1	5 81	7	6.1	5.6	6	7.37	6 6	5 8
BOD	Comp	A405.1	2	mg/L	2 7	4.04	5	14 8	4.9	6.6	7.2	0	3 81	4 9
Metals													62832	62899
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	247	0	0	0	0	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	119	1020	0	247	174	0	178 4	241.4	237	0
Dissolved Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208.2	10	ug/l	29.9	35.4	34.6	26 8	13 1	21.7	28 3	25.1	26.6	23 6
Total Barium	Comp	A208.2	10	ug/l	32.4	43	34 6	26.8	28.9	33.7	28 4	26	26.9	24 6
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0

R0012547

Table B-2. Summary of Results for the 2000-2001 Routine Monitoring at Malibu Creek

STATION NO.					S02	S02	S02	S02	S02	S02	S02	S02	S02	S02
STATION NAME					Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek	Malibu Creek
STORM NO.					0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/28/2000	10/31/2000	01/04/2001	01/10/2001	01/25/2001	01/29/2001	02/15/2001	02/20/2001	02/28/2001	03/08/2001
	Sample Type	EPA Method	DL	Units										
Metals (cont)														
Dissolved Boron	Comp	A212 3	100	ug/l	231	111	590	329	456	360	224	247	298	0
Total Boron	Comp	A212 3	100	ug/l	321	127	611	329	458	428	291	298	328	0
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	1 39	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	1 39	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Copper	Comp	A220.1	5	ug/l	9.7	8 42	6.66	6.22	5 96	5 3	0	7.04	5.75	5 31
Dissolved Iron	Comp	A236 1	100	ug/l	0	0	0	360	110	120	0	0	0	140
Total Iron	Comp	A236.1	100	ug/l	0	230	140	950	300	600	340	0	410	340
Dissolved Lead	Comp	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243 1	100	ug/l	0	127	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249.1	5	ug/l	7 68	7.86	8 92	10 8	7 95	8.46	6 28	5 71	6.81	5 4
Total Nickel	Comp	A249.1	5	ug/l	7 68	9 72	8 92	11.7	8 24	8.67	6 75	6 5	6.88	26.3
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	7.06	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	7 06	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	0	0	0	0	0	0	0	0	0	0
Total Zinc	Comp	A289.1	50	ug/l	0	0	0	0	0	0	0	0	0	0
Semi-Volatiles Organics														
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l				1 6		5 5	0	8 7	0	6 7
All other SVOCs	Comp	625M	0 5-5.0	ug/l				0		0	0	0	0	0
Pesticides														
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l										
2,4-D	Comp	515	10	ug/l										
2,4,5-TP	Comp	515	1	ug/l										
Bentazon	Comp	515	2	ug/l										
Glyphosate	Comp	547	25	ug/l										
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012548

Table B-3. Summary of Results for the 2000-2001 Routine Monitoring at L.A. River

STATION NO.					S10	S10	S10	S10	S10	S10	S10	S10	S10	S10	S10
STATION NAME					L.A. River	L.A. River	L.A. River	L.A. River	L.A. River	L.A. River	L.A. River	L.A. River	L.A. River	L.A. River	L.A. River
STORM NO					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/28/2000	10/30/2000	01/08/2001	01/11/2001	01/25/2001	01/30/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units											
Conventional															
Cyanide	Grab	A335.2	0.01	mg/L			0	0.105	0		0	0.026		0	0.04
TPH	Grab	A418.1	1	mg/L			2.4	3.3	0		4.6	0		2.5	1.8
Oil and Grease	Grab	A413.1	1	mg/L			1.7	3	2		2.4	0		7.1	1.3
Total Phenols	Grab	A420.1	0.1	mg/L			0	0	0		0	0		0	0
Indicator Bacteria															
Total Coliform	Grab	C9221B	20	MPN/100ml			5000000	3000000	500000		2400000	700000		2200000	600000
Fecal Coliform	Grab	C9221C	20	MPN/100ml			1700000	3000000	500000		1600000	260000		2200000	300000
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml			16000000	5000000	500000		240000	22000		900000	160000
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml			1400000	1100000	90000		240000	22000		900000	160000
General															
Ammonia	Comp	A350.3	0.1	mg/L	6.56	0	0	3.17	0.44	0.146	0.319	1.8	0	0.105	0
Calcium	Comp	A215.2	1	mg/L	52.1	20.8	16	28	16.4	30.1	12	40.08	38.1	20.04	28.9
Magnesium	Comp	C3500MgD	1	mg/L	16	6.81	2.92	6.08	0	6.08	19.4	0	36.5	0	8.56
Potassium	Comp	A258.1	1	mg/L	19.2	8.04	3.61	7.5	3.27	4.38	2.97	4.72	4.98	2.69	3.29
Sodium	Comp	A273.1	1	mg/L	62	19.7	10.5	29.8	9.2	25.1	15.8	32.9	63.5	15.1	26.2
Bicarbonate	Comp	A310.1	2	mg/L	154	92.2	44.8	85.4	42.8	38.8	45.3	64.7	116	51.72	19.4
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	83.5	19	8.13	31.4	6.87	18.9	7.82	36.6	87.3	15.2	23.7
Flouride	Comp	B429	0.1	mg/L	0.41	0.41	0.12	0.35	0.11	0.13	0.12	0.21	0.2	0.1	0.14
Nitrate	Comp	B429	0.1	mg/L	3.23	4.88	1.86	0	3.16	1.26	2.73	5.25	6.89	5.84	7.29
Sulfate	Comp	B429	0.1	mg/L	97.3	26.5	9.04	40.1	11.6	26.2	12.5	47.6	77.1	15.6	56.4
Alakalinity	Comp	A310.1	4	mg/L	126	75.6	36.8	70	35	31.8	37.1	53	95.4	42.4	15.9
Hardness	Comp	A130.2	2	mg/L	196	80	52	95	41	100	110	102	140	50	107
Dissolved Phosphorus	Comp	A365.2	0.05	mg/L	0.844	0.857	0.491	0.6	0.2	0.36	0.2	0.538	0.284	0.164	0.1859
Total Phosphorus	Comp	A365.2	0.05	mg/L	0.953	0.89	0.517	0.72	0.27	0.42	0.24	0.635	0.325	0.261	0.1902
COD	Comp	A410.4	5	mg/L	172	119	62.7	119	64.1	69.9	10.9	40.2	68.3	18.8	23.2
pH	Comp	A150.1	na		7.19	7.04	7.04	7.02	6.53	6.83	6.67	6.64	7.6	6.92	6.79
NH3-N	Comp	A350.3	0.1	mg/L	5.42	0	0	2.62	0.36	0.121	0.264	1.49	0	0	0
Nitrate-N	Comp	C4110B	0.1	mg/L	0.729	1.1	0.42	0	0.7135	0.285	0.616	1.19	1.56	1.32	1.65
Nitrite-N	Comp	C4110B	0.1	mg/L	0.68	0.657	0.082	0.08	0	0.247	0.186	0.84	0.298	0	0.052
Kjeldahl-N	Comp	A351.4	0.1	mg/L	6.4	1.956	1.118	6.1	3.26	4.2	2.08	5.1	0.527	1.046	1.4
Specific Conductance	Comp	A120.1	1	umhos/cm	752	360	161	352	133	246	128.3	363	620	181.6	334
Total Dissolved Solids	Comp	A160.1	2	mg/L	490	214	92	220	78	144	74	202	344	116	198
Turbidity	Comp	A180.1	0.1	NTU	43.2	283	200	88.8	205	42.4	84.3	7.43	59.5	27.2	31.6
Suspended Solids	Comp	A160.2	2	mg/L	75	713	541	172	428	217	161	110	42	69	157
Volatile Suspended Solids	Comp	160.4	1	mg/L	31	144	64	45	86	53	40	30	20	38	41
MBAS	Comp	A425.1	0.05	mg/L	0.149	0.09	0.059	0.226	0.087	0.123	0.076	0.203	0	0.076	0.087
Total Organic Carbon	Comp	A415.1	1	mg/L	56	18.6	10.2	31.55	8.84	10.9	7.1	11.99	6.63	8.6	5.8
BOD	Comp	A405.1	2	mg/L	6	3	5.5	5.6	0	0	12.2	0	4.6	27.8	13.5
Metals															
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	0	230	0	0	0	191.5	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	855	172	355	3480	230	248	294	0	313.9	278	0
Dissolved Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208.2	10	ug/l	59.6	24.3	16.5	41.9	28.5	25.9	19.9	27.6	40.8	19.8	26.6
Total Barium	Comp	A208.2	10	ug/l	69	33.8	21.9	101	28.5	38.4	26	31.4	42.3	21.2	27.4
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0

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Table B-3. Summary of Results for the 2000-2001 Routine Monitoring at L.A. River

STATION NO					S10	S10	S10	S10	S10	S10	S10	S10	S10	S10	S10
STATION NAME					L A River	L.A. River	L A River	L.A River	L A River	L.A River	L A. River	L A. River	L A River	L A River	L A River
STORM NO					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001 11
DATE					10/12/2000	10/28/2000	10/30/2000	01/08/2001	01/11/2001	01/25/2001	01/30/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units											
Metals (cont.)															
Dissolved Boron	Comp	A212 3	100	ug/l	239	0	109	191	106	172	117	210	219	111	174
Total Boron	Comp	A212 3	100	ug/l	319	112	129	191	106	253	121	233	221	132	174
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	0	1 45	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218 2	5	ug/l	0	6 44	0	6 88	0	0	0	0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	7 88	0	19 8	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220 1	5	ug/l	14 4	5.26	7.01	12.5	6 41	11 3	8 5	7.18	7.57	7.96	0
Total Copper	Comp	A220 1	5	ug/l	26 9	10 5	13 8	48 5	9 45	18 4	13 2	9.37	10 1	11 5	8 24
Dissolved Iron	Comp	A236 1	100	ug/l	0	0	0	410	590	200	300	270	310	200	160
Total Iron	Comp	A236.1	100	ug/l	114	230	420	6840	1020	600	420	330	680	410	360
Dissolved Lead	Comp	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239 2	5	ug/l	17.1	0	6.27	56 9	5 1	8 6	5 74	0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243 1	100	ug/l	0	115	0	143	0	0	0	0	0	0	215
Dissolved Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249 1	5	ug/l	16 8	7 75	0	14 5	5 82	5 85	0	6.11	0	0	0
Total Nickel	Comp	A249 1	5	ug/l	19 7	7.75	0	17 5	6 85	6 75	5 31	8.29	6.45	0	5 82
Dissolved Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	85.9	0	0	59 1	0	105	59	0	0	53	0
Total Zinc	Comp	A289.1	50	ug/l	100	0	0	213	0	105	65 4	54.9	0	57.6	0
Semi-Volatiles Organics															
Bis(2-ethylhexyt)phthalate	Comp	625M	3	ug/l											
All other SVOCs	Comp	625M	0.5-5.0	ug/l											
Pesticides															
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l											
2,4-D	Comp	515	10	ug/l											
2,4,5-TP	Comp	515	1	ug/l											
Bentazon	Comp	515	2	ug/l											
Glyphosate	Comp	547	25	ug/l											
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012550

Table B-4. Summary of Results for the 2000-2001 Routine Monitoring at Coyote Creek

STATION NO.					S13	S13	S13	S13	S13	S13	S13	S13	S13	S13
STATION NAME					Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek
STORM NO.					0001-01	0001-02	0001-03	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/28/2000	10/30/2000	01/11/2001	01/25/2001	02/01/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units										
Conventional														
Cyanide	Grab	A335 2	0 01	mg/L										
TPH	Grab													
Oil and Grease	Grab	A413 1	1	mg/L										
Total Phenols	Grab	A420.1	0.1	mg/L										
Indicator Bacteria														
Total Coliform	Grab	C9221B	20	MPN/100ml						900000	300000		500000	28000
Fecal Coliform	Grab	C9221C	20	MPN/100ml						220000	300000		110000	900
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml						28000	17000		110000	800
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml						28000	13000		50000	800
General														
Ammonia	Comp	A350 3	0.1	mg/L	5.13	0 209	0	0 116	0 413	0 421	0 65	0 105	0	0
Calcium	Comp	A215.2	1	mg/L	64 1	40 1	14 4	19 2	26 1	17	28.05	16	20.04	64 1
Magnesium	Comp	C3500MgD	1	mg/L	17	7 29	3 7	2 91	5 47	4 25	9 72	4 86	3 65	28
Potassium	Comp	A258.1	1	mg/L	15 9	5 66	2.02	2 55	2 94	2 38	2 87	1 83	2 01	4 9
Sodium	Comp	A273.1	1	mg/L	66.2	18 1	6.3	14 9	33.8	18 8	21 1	16 4	22.4	163
Bicarbonate	Comp	A310.1	2	mg/L	179	122	44 8	53	58 2	51 7	51.72	45 26	51.72	226 31
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	83 1	22 9	16.6	12 1	21 4	15 3	24.4	14 9	21 9	113
Flouride	Comp	B429	0.1	mg/L	0 54	0 18	0 12	0.12	0.14	0 1	0 12	0.1	0 1	0 5
Nitrate	Comp	B429	0.1	mg/L	0	0	3 2	3.9	2 45	3 4	2 41	2 49	3 81	12 9
Sulfate	Comp	B429	0.1	mg/L	125	23 4	19 2	15 3	39 7	24 6	28 4	21 4	29 5	212
Alakalinity	Comp	A310.1	4	mg/L	147	99 8	36 8	43 5	47.7	42 4	42 4	37 1	42.4	185 5
Hardness	Comp	A130 2	2	mg/L	230	130	51 2	60	87 5	60	110	60	65	275
Dissolved Phosphorus	Comp	A365.2	0.05	mg/L	0 532	0 571	0 269	0 2	0 17	0 14	0 205	0 115	0 087	0 133
Total Phosphorus	Comp	A365 2	0.05	mg/L	0.71	0 592	0 465	0 24	0 2	0 17	0 232	0 141	0 176	0 152
COD	Comp	A410 4	5	mg/L	199	126	42 8	63 2	62 2	0	27 4	47.7	16.7	223 6
pH	Comp	A150 1	na		7 26	7 16	6 97	6 37	6.86	7.02	6 91	7.29	7.27	7 95
NH3-N	Comp	A350 3	0.1	mg/L	4 24	*0 173*	0	0	*0 341*	*0 348*	*0 536*	*0*	*0*	0
Nitrate-N	Comp	C4110B	0.1	mg/L	0	0	0 722	0 881	0.553	0 768	0.544	0 562	0 86	2 91
Nitrite-N	Comp	C4110B	0.1	mg/L	0	0 094	0 079	0	0.186	0.119	0 161	0 082	0 07	0 411
Kjeldahl-N	Comp	A351 4	0.1	mg/L	6.72	2.72	1 104	2.36	3 36	1 72	3.24	0 813	1 168	1 336
Specific Conductance	Comp	A120.1	1	umhos/cm	910	351	167	190	299	204	256	162.9	243	1095
Total Dissolved Solids	Comp	A160.1	2	mg/L	596	210	98	110	168	115	142	92	154	692
Turbidity	Comp	A180.1	0.1	NTU	194	305	50 1	64 3	67.9	58.6	31	61 9	24.3	16 2
Suspended Solids	Comp	A160.2	2	mg/L	843	954	109	211	262	199	175	112	123	79
Volatile Suspended Solids	Comp	160.4	1	mg/L	138	167	18	59	59	50	33	18	51	20
MBAS	Comp	A425.1	0.05	mg/L	0 089	0 106	0 096	0 109	0 084	0.092	0 169	0 056	*0 09*	0 07
Total Organic Carbon	Comp	A415.1	1	mg/L	66.9	21.5	10 5	8 04	9.8	9 3	9 62	7.3	6.4	6.4
BOD	Comp	A405.1	2	mg/L	7.1	5	4	9	0	8 9	20	7 5	26 5	6 8
Metals														
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	147	0	0	0	0	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	199	122	247	147	399	249	*0*	113 6	168	*0*
Dissolved Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	*0*	0	0	0	0
Dissolved Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208 2	10	ug/l	52.5	30.7	12 6	24.7	22.2	16.2	28.8	19 1	18.2	57 1
Total Barium	Comp	A208 2	10	ug/l	52 8	38.5	15 7	24.7	28 7	20 9	31 1	21.5	21.1	69 5
Dissolved Berylium	Comp	A210 2	1	ug/l	0	0	0	0	*0*	0	0	0	0	0
Total Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0

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Table B-4. Summary of Results for the 2000-2001 Routine Monitoring at Coyote Creek

STATION NO					S13	S13	S13	S13	S13	S13	S13	S13	S13	S13
STATION NAME					Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek	Coyote Creek
STORM NO					0001-01	0001-02	0001-03	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/28/2000	10/30/2000	01/11/2001	01/25/2001	02/01/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units										
Metals (cont)														
Dissolved Boron	Comp	A212 3	100	ug/l	201	140	112	0	116	0	0	0	0	322
Total Boron	Comp	A212 3	100	ug/l	340	160	128	0	123	200	0	123	104	322
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Total Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	6 2	0	7 43	6.27	7.72	0	0	5 07	0	0
Total Copper	Comp	A220.1	5	ug/l	8 3	11.9	10 7	8 93	13	8 45	5 73	9 78	8.18	6.53
Dissolved Iron	Comp	A236.1	100	ug/l	160	0	0	260	0	180	0	0	0	0
Total Iron	Comp	A236 1	100	ug/l	500	160	180	280	630	430	290	0	330	210
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Manganese	Comp	A243 1	100	ug/l	260	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243 1	100	ug/l	303	123	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249 1	5	ug/l	13 5	5 65	0	0	0	0	0	0	0	0
Total Nickel	Comp	A249 1	5	ug/l	13.6	5 97	0	0	5 89	0	0	0	0	0
Dissolved Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289 1	50	ug/l	0	0	0	0	68.6	0	0	0	0	0
Total Zinc	Comp	A289.1	50	ug/l	0	0	0	0	80.7	51.1	0	0	52 2	0
Semi-Volatiles Organics														
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l										
All other SVOCs	Comp	625M	0.5-5.0	ug/l										
Pesticides														
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l										
2,4,5-TP	Comp	515	1	ug/l										
Bentazon	Comp	515	2	ug/l										
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	0	0	0	0	0
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012552

Table B-5 Summary of Results for the 2000-2001 Routine Monitoring at San Gabriel River

STATION NO.					S14	S14	S14	S14	S14	S14	S14	S14	S14
STATION NAME					San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River
STORM NO					0001-02	0001-03	0001-04	0001-05	0001-06	0001-08	0001-09	0001-10	0001-11
DATE					10/28/2000	11/01/2000	01/08/2001	01/17/2001	01/26/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units									
Conventional													
Cyanide	Grab	A335.2	0.01	mg/L		0	0	0	0.042	0.026		0	
TPH	Grab	A418.1	1	mg/L									
Oil and Grease	Grab	A413.1	1	mg/L		0	3.9	1.6	0	1.4		0	
Total Phenols	Grab	A420.1	0.1	mg/L		0	0	0	0	0		0	
Indicator Bacteria													
Total Coliform	Grab	C9221B	20	MPN/100ml		9000000	5000	90000	260000	500000		500000	
Fecal Coliform	Grab	C9221C	20	MPN/100ml		140000	3000	1100	11000	30000		300000	
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml		170000	2400	16000	50000	7000		240000	
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml		14000	2400	1100	50000	7000		130000	
General													
Ammonia	Comp	A350.3	0.1	mg/L	0	0	2.49	0.152		0.89	0	0	0
Calcium	Comp	A215.2	1	mg/L	64.1	48.1	68.1	48	104	60.12	48.1	40.08	56.1
Magnesium	Comp	C3500MgD	1	mg/L	25.8	17	31.6	9.7	24.3	17.01	29.2	9.72	17
Potassium	Comp	A258.1	1	mg/L	14.7	7.1	8.2	5.54	9.2	5.4	4.54	4.67	5.34
Sodium	Comp	A273.1	1	mg/L	73.4	62.6	110	36.9	108	60	53	36.4	45
Bicarbonate	Comp	A310.1	2	mg/L	167	128	155	116	182	129	51.72	90.52	122.85
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	118	67.1	146	42.1	132	83.3	66.2	44	55
Flouride	Comp	B429	0.1	mg/L	0.25	0.21	0.34	0.2	0.28	0.23	0.2	0.14	0.18
Nitrate	Comp	B429	0.1	mg/L	30.9	10.2	32.1	9.83	38.5	22.1	15.9	15.2	13.3
Sulfate	Comp	B429	0.1	mg/L	144	94	200	64.2	146	109	102	74.4	104
Alakalinity	Comp	A310.1	4	mg/L	137	105	127	95.4	149	106	42.4	74.2	100.7
Hardness	Comp	A130.2	2	mg/L	266	190	300	160	360	220	240	140	210
Dissolved Phosphorus	Comp	A365.2	0.05	mg/L	0.423	0.343	0.41	0.2	0.25	0.179	0.134	108	0.177
Total Phosphorus	Comp	A365.2	0.05	mg/L	0.434	0.347	0.47	0.23	0.29	0.198	0.152	167	0.184
COD	Comp	A410.4	5	mg/L	64.4	147	87.7	123	158	45.9	34.8	74.5	27.1
pH	Comp	A150.1	na		7.77	7.62	7.25	7.33	7.66	7.66	7.24	7.54	7.83
NH3-N	Comp	A350.3	0.1	mg/L	0	0	2.06	0.126	0	0.733	0	0	0
Nitrate-N	Comp	C4110B	0.1	mg/L	6.98	2.3	7.25	2.22	8.69	4.99	3.59	3.43	3
Nitrite-N	Comp	C4110B	0.1	mg/L	0	0.484	1.68	0	0	0.663	0.542	0	0
Kjeldahl-N	Comp	A351.4	0.1	mg/L	0.646	0.938	4.6	5.2	2.7	4.7	0.545	1	0.142
Specific Conductance	Comp	A120.1	1	umhos/cm	1025	671	1092	498	1112	738	664	473	626
Total Dissolved Solids	Comp	A160.1	2	mg/L	604	396	670	290	676	456	378	326	412
Turbidity	Comp	A180.1	0.1	NTU	4.31	50.9	7.37	238	3.91	2.22	19.9	46.8	20
Suspended Solids	Comp	A160.2	2	mg/L	18	93	27	612	32	8	39	76	46
Volatile Suspended Solids	Comp	160.4	1	mg/L	4	14	12	129	3	0	7	32	20
MBAS	Comp	A425.1	0.05	mg/L	0	0.058	0.141	0.096	0.063	0.101	0.06	0.061	0.05
Total Organic Carbon	Comp	A415.1	1	mg/L	7.5	9	8.9	10.51	5	8.22	7.37	5.8	5
BOD	Comp	A405.1	2	mg/L	0	0	0	0	4.7	0	0	47.7	16.4
Metals													
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	144	0	0	0	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	0	1690	401	201	0	0	0	234	123
Dissolved Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208.2	10	ug/l	43.3	37.3	56.4	39.3	45.7	41	35.7	27.7	37.4
Total Barium	Comp	A208.2	10	ug/l	44.9	48.7	56.4	39.3	51.5	41.7	36	32	37.6
Dissolved Beryllium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0
Total Beryllium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0

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Table B-5 Summary of Results for the 2000-2001 Routine Monitoring at San Gabriel River

STATION NO					S14	S14	S14	S14	S14	S14	S14	S14	S14
STATION NAME					San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River	San Gabriel River
STORM NO					0001-02	0001-03	0001-04	0001-05	0001-06	0001-08	0001-09	0001-10	0001-11
DATE					10/28/2000	11/01/2000	01/08/2001	01/17/2001	01/26/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units									
Metals (cont)													
Dissolved Boron	Comp	A212 3	100	ug/l	233	113	309	205	389	239	136	0	148
Total Boron	Comp	A212 3	100	ug/l	333	135	309	205	395	263	178	151	148
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0
Total Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	0	0	6 58	0	0	0	0	0	0
Total Copper	Comp	A220 1	5	ug/l	7 69	9.76	12 8	6 62	5 61	8 85	7.39	11 5	6 81
Dissolved Iron	Comp	A236.1	100	ug/l	0	210	310	110	0	0	0	110	260
Total Iron	Comp	A236 1	100	ug/l	0	570	1150	500	0	260	110	250	350
Dissolved Lead	Comp	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	0	5 24	0	0	0	0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243 1	100	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249 1	5	ug/l	0	5.18	6.34	5 51	6 04	5 49	9.1	0	0
Total Nickel	Comp	A249 1	5	ug/l	5 07	6 13	6.34	5.51	6.06	8 75	10.7	0	5.25
Dissolved Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289 1	50	ug/l	0	0	57 8	0	0	0	0	0	0
Total Zinc	Comp	A289.1	50	ug/l	0	65 7	57 8	0	52.1	51.9	0	0	0
Semi-Volatiles Organics													
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l									
All other SVOCs	Comp	625M	0 5-5.0	ug/l									
Pesticides													
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l									
2,4-D	Comp	515	10	ug/l									
2,4,5-TP	Comp	515	1	ug/l									
Bentazon	Comp	515	2	ug/l									
Glyphosate	Comp	547	25	ug/l									
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

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Table B-6. Summary of Results for the 2000-2001 Routine Monitoring at Sawpit Creek

STATION NO.					S11	S11	S11	S11	S11	S11	S11	S11
STATION NAME					Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek
STORM NO.					0001-03	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					11/01/2000	01/16/2001	01/25/2001	01/25/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units								
Conventional												
Cyanide	Grab	A335 2	0 01	mg/L	0	0	0	0	0		0	
TPH	Grab	A418 1	1	mg/L								
Oil and Grease	Grab	A413.1	1	mg/L	0	1 2	2 2	0	0		0	
Total Phenols	Grab	A420.1	0.1	mg/L	0	0	0	0	0		0	
Indicator Bacteria												
Total Coliform	Grab	C9221B	20	MPN/100ml	240000	800	2800	3000	300		3500	
Fecal Coliform	Grab	C9221C	20	MPN/100ml	17000	500	2800	1100	110		700	
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml	160000	1700	1100	230	40		500	
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml	160000	1400	1100	230	20		130	
General												
Ammonia	Comp	A350 3	0.1	mg/L	0	0.208	0		0	0 136	0	0
Calcium	Comp	A215 2	1	mg/L	52.1	44	56 1		50.1	58 1	48 1	56.1
Magnesium	Comp	C3500MgD	1	mg/L	19 4	17	21 9		12.15	12 2	19 45	15 8
Potassium	Comp	A258.1	1	mg/L	2 8	3.86	3 06		2.62	2 19	2.32	2.29
Sodium	Comp	A273 1	1	mg/L	16.5	15.2	23.9		13 2	15	14.9	16 3
Bicarbonate	Comp	A310.1	2	mg/L	243	175	220		200.4	213	219.84	226.31
Carbonate	Comp	A310.1	2	mg/L	0	0	0		0	0	0	0
Chloride	Comp	B429	2	mg/L	7.06	7.38	7.08		7.1	8 28	7.55	7.54
Flouride	Comp	B429	0 1	mg/L	0.39	0 38	0.41		0.36	0.38	0 38	0 38
Nitrate	Comp	B429	0 1	mg/L	2.13	4 36	2.63		2 87	10	4.93	6 97
Sulfate	Comp	B429	0 1	mg/L	15.7	20.3	18 2		15 7	21 5	19 6	19 4
Alakalinity	Comp	A310.1	4	mg/L	200	143	180		164	174 9	180 2	185.5
Hardness	Comp	A130 2	2	mg/L	210	180	230		175	195	200	205
Dissolved Phosphorus	Comp	A365 2	0 05	mg/L	0 085	0 07	0 07		0	0	0	0
Total Phosphorus	Comp	A365.2	0 05	mg/L	0 128	0 08	0 07		0 05	0	0	0
COD	Comp	A410 4	5	mg/L	48 8	60.9	47.2		29.8	34	0	0
pH	Comp	A150.1	na		8 03	7.77	8.29		7 76	8 32	8.01	8 32
NH3-N	Comp	A350.3	0.1	mg/L	0	0 172	0		0	0.112	0	0
Nitrate-N	Comp	C4110B	0.1	mg/L	0.481	0 985	0 594		0 648	2 26	1.11	1.57
Nitrite-N	Comp	C4110B	0.1	mg/L	0	0	0		0	0.043	0	0.04
Kjeldahl-N	Comp	A351.4	0.1	mg/L	0.354	5 84	0.43		0 756	0.305	0.34	0.436
Specific Conductance	Comp	A120.1	1	umhos/cm	438	360	416		374	429	416	413
Total Dissolved Solids	Comp	A160 1	2	mg/L	250	206	230		214	252	262	264
Turbidity	Comp	A180 1	0 1	NTU	46.6	293	12		4 81	12.7	0 57	0 87
Suspended Solids	Comp	A160.2	2	mg/L	113	873	22		29	16	10	13
Volatile Suspended Solids	Comp	160.4	1	mg/L	20	168	14		17	16	8	3
MBAS	Comp	A425.1	0.05	mg/L	0	0	0		0	0	0	0
Total Organic Carbon	Comp	A415.1	1	mg/L	3 6	8 1	3		4.13	3 68	2 6	2 9
BOD	Comp	A405.1	2	mg/L	6	6 4	4 6		3.5	2 4	9.6	7 9
Metals												
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0		0	0	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	3160	158	0		0	0	0	0
Dissolved Antimony	Comp	A204.2	5	ug/l	0	0	0		0	0	0	0
Total Antimony	Comp	A204 2	5	ug/l	0	0	0		0	0	0	0
Dissolved Arsenic	Comp	A206.2	5	ug/l	0	0	0		0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0		0	0	0	0
Dissolved Barium	Comp	A208 2	10	ug/l	43.7	44 3	44.7		38.5	43.2	40.4	54.6
Total Barium	Comp	A208.2	10	ug/l	69.1	44 3	45 7		39.8	44 7	42.3	55 2
Dissolved Beryllium	Comp	A210.2	1	ug/l	0	0	0		0	0	0	0
Total Berylium	Comp	A210.2	1	ug/l	0	0	0		0	0	0	0

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Table B-6. Summary of Results for the 2000-2001 Routine Monitoring at Sawpit Creek

STATION NO					S11	S11	S11	S11	S11	S11	S11	S11
STATION NAME					Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek	Sawpit Creek
STORM NO.					0001-03	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11
DATE					11/01/2000	01/16/2001	01/25/2001	01/25/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units								
Metals (cont)												
Dissolved Boron	Comp	A212 3	100	ug/l	134	129	136		0	0	0	0
Total Boron	Comp	A212.3	100	ug/l	161	129	137		0	107	100	0
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	0		0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	0		0	0	0	0
Dissolved Chromium	Comp	A218.2	5	ug/l	0	0	0		0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	0	0		0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0		0	0	0	0
Total Chromium +6	Comp		10	ug/l	0	0	0		0	0	0	0
Dissolved Copper	Comp	A220 1	5	ug/l	0	0	0		0	0	0	0
Total Copper	Comp	A220 1	5	ug/l	6.88	5 86	0		0	6	5.18	0
Dissolved Iron	Comp	A236 1	100	ug/l	360	260	0		0	0	0	340
Total Iron	Comp	A236 1	100	ug/l	890	470	120		260	0	0	470
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0		0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	5 05	0	0		0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0		0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	241	0	0		0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0		0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0		0	0	0	0
Dissolved Nickel	Comp	A249.1	5	ug/l	0	0	0		0	0	0	0
Total Nickel	Comp	A249.1	5	ug/l	0	0	0		0	0	0	0
Dissolved Selenium	Comp	A270 2	5	ug/l	0	0	0		0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0		0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0		0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0		0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0		0	0	0	0
Total Thallium	Comp	A279 2	5	ug/l	0	0	0		0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	0	0	0		0	0	0	0
Total Zinc	Comp	A289.1	50	ug/l	0	0	0		0	0	0	0
Semi-Volatiles Organics												
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l	0	3 9	2 3		3.3	5.2	15	2.6
All other SVOCs	Comp	625M	0.5-5.0	ug/l	0	0	0		0	0	0	0
Pesticides												
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0		0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0		0	0	0	0
2,4-D	Comp	515	10	ug/l	0	0	0		0	0	0	0
2,4,5-TP	Comp	515	1	ug/l	0	0	0		0	0	0	0
Bentazon	Comp	515	2	ug/l	0	0	0		0	0	0	0
Glyphosate	Comp	547	25	ug/l	0	0	0		0	0	0	0
All other pesticides	Comp	D608	various	ug/l	0	0	0		0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

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Table B-7. Summary of Results for the 2000-2001 Routine Monitoring at Project 620

STATION NO					S18	S18	S18	S18	S18	S18	S18	S18	S18	S18
STATION NAME					Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620
STORM NO.					0001-02	0001-03	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11	0001-12
DATE					10/28/2000	11/01/2000	01/16/2001	01/25/2001	01/29/2001	02/15/2001	02/20/2001	02/28/2001	03/08/2001	04/11/2001
	Sample Type	EPA Method	DL	Units										
Conventional														
Cyanide	Grab	A335 2	0.01	mg/L										
TPH	Grab	A418 1	1	mg/L										
Oil and Grease	Grab	A413 1	1	mg/L										
Total Phenols	Grab	A420.1	0 1	mg/L										
Indicator Bacteria														
Total Coliform	Grab	C9221B	20	MPN/100ml						8000	30000		1600000	
Fecal Coliform	Grab	C9221C	20	MPN/100ml						5000	16000		1600000	
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml						160000	9000		240000	
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml						90000	9000		240000	
General														
Ammonia	Comp	A350 3	0.1	mg/L	0 182	1 246	1 948	0 776	0 468	0 39	1 82	0 172	0.189	0
Calcium	Comp	A215.2	1	mg/L	20 8	9 62	10 4	8 82	8 68	9 01	8 02	6 01	6 41	46 09
Magnesium	Comp	C3500MgD	1	mg/L	4 86	1 94	1 94	1 94	0.41	1 82	1 62	0 61	0 78	13 37
Potassium	Comp	A258.1	1	mg/L	12 5	5 06	5.94	2 9	2 9	2 88	3 26	1.73	1 53	12.5
Sodium	Comp	A273 1	1	mg/L	8.1	5.2	6 1	15 9	11 7	4 6	5 7	3.4	3.7	32
Bicarbonate	Comp	A310.1	2	mg/L	64 1	29.5	45 3	25 9	19.4	25 86	32 33	19 4	12.93	155.18
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	9 73	3.76	4 81	5.37	3 94	4.79	3 98	3.08	4 42	38 1
Flouride	Comp	B429	0 1	mg/L	0 18	0	0 1	0	0	0	0	0	0	0.11
Nitrate	Comp	B429	0 1	mg/L	2.53	5.53	0	0.51	1.76	0.58	1 3	0.94	1.25	0 17
Sulfate	Comp	B429	0.1	mg/L	11.4	3 81	5.67	7 82	6.32	5 4	7 23	3 88	2 9	34
Alakalinity	Comp	A310 1	4	mg/L	52.5	24 2	37.1	21.2	15 9	21.2	26 5	15.9	10 6	127.2
Hardness	Comp	A130 2	2	mg/L	72	32	34	30	23 8	30	26 7	17.5	19 2	170
Dissolved Phosphorus	Comp	A365 2	0 05	mg/L	0 845	0 566	0 6	0.18	0 23	0 35	0 281	0.179	0 055	0 785
Total Phosphorus	Comp	A365.2	0.05	mg/L	0 867	0 579	0.8	0 25	0.27	0 38	0 326	0 23	0 069	0 793
COD	Comp	A410.4	5	mg/L	123	61.2	109 7	141	78.2	72.1	63 7	0	0	61.9
pH	Comp	A150.1	na		6 74	6.5	6.93	6.88	6.69	6 8	6 94	6 89	6 69	7 93
NH3-N	Comp	A350.3	0 1	mg/L	0.15	1.03	1 61	0 642	0 387	0 321	1 5	0 142	0.156	0
Nitrate-N	Comp	C4110B	0.1	mg/L	0 571	1 25	0	0 115	0 397	0.131	0 294	0.212	0 282	0
Nitrite-N	Comp	C4110B	0 1	mg/L	0.505	0.091	0	0	0 052	0 043	0 052	0.043	0	0 219
Kjeldahl-N	Comp	A351 4	0.1	mg/L	5 2	1 962	12.4	4 84	1.55	3.1		1.212	0 894	4 72
Specific Conductance	Comp	A120 1	1	umhos/cm	227	97	130	96 6	79 6	75 6	68	56.1	55.7	466
Total Dissolved Solids	Comp	A160.1	2	mg/L	144	56	74	54	44	52	38	34	32	302
Turbidity	Comp	A180.1	0.1	NTU	70.4	43.7	132	101	9.69	8.19	26.3	5 16	7.82	29.5
Suspended Solids	Comp	A160 2	2	mg/L	270	184	751	351	50	79	69	28	57	68
Volatile Suspended Solids	Comp	160.4	1	mg/L	104	89	323	151	39	28	50	26	27	42
MBAS	Comp	A425.1	0.05	mg/L	0 064	0 067	0 068	0 153	0 09	0.221	0.059	0	0	0
Total Organic Carbon	Comp	A415.1	1	mg/L	34.4	14.1	17.17	8 6	6 6	7.46	9.17	5.4	3.1	15.7
BOD	Comp	A405 1	2	mg/L	6.1	6 9	29.5	14.2	5 6	4.8	0	5 54	22 9	13.3
Metals														
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	0	0	0	0	0	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	172	890	109		241	0	0	112.4	104	115
Dissolved Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208.2	10	ug/l	24.7	14 8	17.9		10.5	0	13 6	11.3	0	0
Total Barium	Comp	A208 2	10	ug/l	26	32 7	17.9		14 1	0	16 7	14.8	0	11.5
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0

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Table B-7. Summary of Results for the 2000-2001 Routine Monitoring at Project 620

STATION NO.					S18	S18	S18	S18	S18	S18	S18	S18	S18	S18
STATION NAME					Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620	Project 620
STORM NO.					0001-02	0001-03	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11	0001-12
DATE					10/28/2000	11/01/2000	01/16/2001	01/25/2001	01/29/2001	02/15/2001	02/20/2001	02/28/2001	03/08/2001	04/11/2001
	Sample Type	EPA Method	DL	Units										
Metals (cont)														
Dissolved Boron	Comp	A212 3	100	ug/l	141	116	0		0	0	0	0	0	124
Total Boron	Comp	A212 3	100	ug/l	259	137	0		0	0	0	0	0	188
Dissolved Cadmuim	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Total Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	23.9	6.97	9 69		8 68	7 26	5 8	7.76	0	0
Total Copper	Comp	A220 1	5	ug/l	24.3	21.6	11 4		12 7	10 6	8 59	10.5	5 92	34 8
Dissolved Iron	Comp	A236 1	100	ug/l	0	160	230		0	0	0	0	0	130
Total Iron	Comp	A236.1	100	ug/l	120	580	350		280	270	260	260	0	150
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	0	14 8	0		0	0	0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249 1	5	ug/l	6.93	0	0		0	0	0	0	0	0
Total Nickel	Comp	A249 1	5	ug/l	6.93	0	0		0	0	0	0	0	0
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0 0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	70.4	0	0		0	0	0	0	0	0
Total Zinc	Comp	A289.1	50	ug/l	70.4	60.8	0		0	0	0	0	0	0
Semi-Volatiles Organics														
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l		5 5	2 5		13.7	9 5	1.7	4 6	3 1	
All other SVOCs	Comp	625M	0.5-5 0	ug/l		0	0		0	0	0	0	0	
Pesticides														
Diazinon	Comp	8141SOP	0 01	ug/l	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l	0	0	0	0	0	0	0	0	0	0
2,4,5-TP	Comp	515	1	ug/l	0	0	0	0	0	0	0	0	0	0
Bentazon	Comp	515	2	ug/l	0	0	0	0	0	0	0	0	0	0
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	0	0	0	0	0
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

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Table B-8. Summary of Results for the 2000-2001 Routine Monitoring at Dominguez Channel

STATION NO.					S23	S23	S23	S23	S23	S23	S23	S23	S23	S23	S23	S23
STATION NAME					Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel
STORM NO.					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11	0001-12
DATE					10/12/2000	10/28/2000	10/31/2000	01/04/2001	01/17/2001	01/25/2001	01/30/2001	02/15/2001	02/20/2001	02/28/2001	03/07/2001	04/11/2001
	Sample Type	EPA Method	DL	Units												
Conventional																
Cyanide	Grab	A335 2	0.01	mg/L												
TPH	Grab	A418 1	1	mg/L												
Oil and Grease	Grab	A413 1	1	mg/L												
Total Phenols	Grab	A420.1	0.1	mg/L												
Indicator Bactena																
Total Coliform	Grab	C9221B	20	MPN/100ml							35000	11000		50000	50000	
Fecal Coliform	Grab	C9221C	20	MPN/100ml							17000	7000		9000	900	
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml							13000	2600		300000	16000	
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml							13000	1700		30000	9000	
General																
Ammonia	Comp	A350 3	0.1	mg/L	4 08	2 49	0	1 98	0 416	0 915	0 377	0 46	0 215	0	0	0
Calcium	Comp	A215 2	1	mg/L	52 1	14 4	8 02	12	8 01	10	9 35	9 01	8 02	7 01	6 41	9 02
Magnesium	Comp	C3500MgD	1	mg/L	19 4	4 86	1 94	7 2	1 44	1 82	3 24	1 21	2 03	1 82	0 97	7 94
Potassium	Comp	A258 1	1	mg/L	26	5 31	2 11	4 7	1 83	2 92	1 77	2 34	1 96	1 54	1 36	2 62
Sodium	Comp	A273 1	1	mg/L	70 4	11 7	10 2	21 1	6 5	18 7	11	9 4	7 8	6	4 9	11 8
Bicarbonate	Comp	A310 1	2	mg/L	115	38 4	19 2	55 6	19 4	25 9	32 3	25 86	25 86	25 86	12 93	32 33
Carbonate	Comp	A310 1	2	mg/L	0	0	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	88	10.3	13	14 5	3 84	6 37	0	7 71	4 08	3 39	2 27	9 61
Flouride	Comp	B429	0 1	mg/L	0 71	0 2	0 13	0 34	0 1	0 12	0	0 12	0	0	0	0 13
Nitrate	Comp	B429	0.1	mg/L	17 4	4.14	2 52	2 24	3 03	2 39	1 46	2.64	2 04	2 07	1 45	4
Sulfate	Comp	B429	0 1	mg/L	115	16	17 2	25 8	8 51	10 5	1 59	10 5	9.7	6.68	5 08	12 3
Alakalinity	Comp	A310 1	4	mg/L	94 5	31.5	15 8	45 6	15 9	21 2	26 5	21 2	21 2	21 2	10 6	26 5
Hardness	Comp	A130 2	2	mg/L	210	56	28	60	26	32 5	36 7	27 5	28 3	25	20	52 5
Dissolved Phosphorus	Comp	A365 2	0 05	mg/L	1 06	1 07	0 369	1 08	0 62	0 63	0 23	0.45	0 467	1 83	0 07	0 989
Total Phosphorus	Comp	A365 2	0.05	mg/L	1.21	1 08	0 382	1 15	0.75	0 75	0.25	0 48	0 495	2 55	0 151	1 016
COD	Comp	A410.4	5	mg/L	376	84 6	71	104	92 9	118	5 8	47.4	37 9	11 5	0	65
pH	Comp	A150.1	na		7.16	6.67	6 93	7.14	6 38	6 57	6 72	6.52	7 06	6 5	6 88	6 86
NH3-N	Comp	A350.3	0 1	mg/L	3.37	0 206	0	1 64	0 344	0 756	0 312	0 378	0.178	0	0	0
Nitrate-N	Comp	C4110B	0.1	mg/L	3.93	0 935	0 569	0 5	0 684	0 54	0.33	0.596	0 461	0 467	0 327	0 903
Nitrite-N	Comp	C4110B	0.1	mg/L	0 189	0.137	0 07	0 2	0 134	0.222	0.061	0.122	0.088	0.033	0 043	0 1126
Kjeldahl-N	Comp	A351 4	0 1	mg/L	9 64	2.26	1 064	2.52	2 2	2 8	1 41	1.8	1 08	0 696	0.758	1 296
Specific Conductance	Comp	A120 1	1	umhos/cm	888	193	111	211	84.8	112.6	69.1	110.7	83.7	78.7	61	106 4
Total Dissolved Solids	Comp	A160 1	2	mg/L	580	122	62	136	48	66	40	74	48	48	36	68
Turbidity	Comp	A180 1	0.1	NTU	52	96 4	46.7	108	81	62.4	19 8	12.4	24.1	18 5	21 8	15 5
Suspended Solids	Comp	A160 2	2	mg/L	87	158	95	159	171	133	80	41	15	51	35	32
Volatile Suspended Solids	Comp	160 4	1	mg/L	48	60	25	41	54	49	42	25	15	38	19	10
MBAS	Comp	A425.1	0.05	mg/L	0 327	0 113	0 126	0 235	0 074	0.131	0.103	0.312	0 087	0 09	0 068	0 166
Total Organic Carbon	Comp	A415.1	1	mg/L	132 9	28 1	10	26 19	10 18	11.7	6.1	9.13	7.94	5.6	4 4	14 9
BOD	Comp	A405 1	2	mg/L	4.8	0	7.1	3 9	16 1	0	6.5	7 9	0	14 6	6 1	8 7
Metals																
Dissolved Aluminum	Comp	A202 2	1000	ug/l	0	0	0	0	277	0	0	0	126 1	0	108	0
Total Aluminum	Comp	A202 2	1000	ug/l	125	278	1450	2900	277	332	197	103.9	207.9	201	181	105 3
Dissolved Antimony	Comp	A204 2	5	ug/l	31.4	5.44	0	7 67	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204 2	5	ug/l	31 5	5.44	0	10 4	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206 2	5	ug/l	5.2	0	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206 2	5	ug/l	5 5	0	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208 2	10	ug/l	33.5	15 2	19.7	25 8	16	17.6	12.7!	16.6	13 3	0	15 6	20 5
Total Barium	Comp	A208.2	10	ug/l	42.2	21 4	35	95 1	16	23.9	16.7	18 8	15.5	14.5	16 3	24 7
Dissolved Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0

R0012559

Table B-8. Summary of Results for the 2000-2001 Routine Monitoring at Dominguez Channel

STATION NO					S23	S23	S23	S23	S23	S23	S23	S23	S23	S23	S23	S23
STATION NAME					Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel	Dominguez Channel
STORM NO					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11	0001-12
DATE					10/12/2000	10/28/2000	10/31/2000	01/04/2001	01/17/2001	01/25/2001	01/30/2001	02/15/2001	02/20/2001	02/28/2001	03/07/2001	03/11/2001
	Sample Type	EPA Method	DL	Units												
Metals (cont.)																
Dissolved Boron	Comp	A212.3	100	ug/l	424	161	140	180	0	128	0	0	0	0	0	0
Total Boron	Comp	A212.3	100	ug/l	426	231	159	180	100	162	0	0	0	0	0	0
Dissolved Cadmium	Comp	A213.2	1	ug/l	1.99	1.06	0	1.38	0	1.18	0	0	0	0	0	1.38
Total Cadmium	Comp	A213.2	1	ug/l	2.25	1.06	1.11	4.69	0	1.78	0	0	0	0	0	1.38
Dissolved Chromium	Comp	A218.2	5	ug/l	0	0	0	5.38	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	0	5.16	12.4	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	103	58.6	28.5	58.7	32.2	44	21.6	30.7	28.2	16	16.4	60.8
Total Copper	Comp	A220.1	5	ug/l	122	59.6	55.8	186	32.2	50.4	26	35.5	33.2	22.8	21	63.7
Dissolved Iron	Comp	A236.1	100	ug/l	0	0	120	200	370	380	100	0	190	0	110	257
Total Iron	Comp	A236.1	100	ug/l	0	310	430	6540	910	530	260	260	230	240	260	426
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	0	0	11.9	38.2	0	5.25	0	0	0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	132	0	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	154	0	0	127	0	0	0	0	0	0	0	100.1
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249.1	5	ug/l	40.4	0	5.19	16.9	6.29	5.55	0	0	0	0	0	8.06
Total Nickel	Comp	A249.1	5	ug/l	40.4	0	7.62	20.7	6.29	6.06	6.57	5.03	0	0	0	14.3
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	1450	453	239	724	234	230	120	225	180	137	100	337.1
Total Zinc	Comp	A289.1	50	ug/l	1680	453	239	856	234	262	151	235	190	137	114	337.1
Semi-Volatiles Organics																
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l												
All other SVOCs	Comp	625M	0.5-5.0	ug/l												
Pesticides																
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l												
2,4,5-TP	Comp	515	1	ug/l												
Bentazon	Comp	515	2	ug/l												
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	29	0	0	0	0	0	0
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012560

Table B-9. Summary of Results for the 2000-2001 Routine Monitoring at Project 1202

STATION NO.					S24	S24	S24	S24	S24	S24	S24	S24	S24	S24
STATION NAME					Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202
STORM NO.					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-11
DATE					10/12/2000	10/28/2000	10/30/2000	01/04/2001	01/11/2001	01/25/2001	02/01/2001	02/14/2001	02/20/2001	03/06/2001
	Sample Type	EPA Method	DL	Units										
Conventional														
Cyanide	Grab	A335 2	0.01	mg/L										
TPH	Grab	A418.1	1	mg/L										
Oil and Grease	Grab	A413 1	1	mg/L										
Total Phenols	Grab	A420.1	0.1	mg/L										
Indicator Bactena														
Total Coliform	Grab	C9221B	20	MPN/100ml							160000	17000		22000
Fecal Coliform	Grab	C9221C	20	MPN/100ml							160000	17000		9000
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml							28000	300		90000
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml							28000	230		90000
General														
Ammonia	Comp	A350.3	0.1	mg/L	2 3	0	0	1 36	0 249	1 33	0 303	0 32	0	0
Calcium	Comp	A215.2	1	mg/L	19 2	8 98	6 41	14	10.8	24	11 4	28 05	14	6.41
Magnesium	Comp	C3500MgD	1	mg/L	4.86	2 33	1 94	4 86	12.8	3 65	3 65	0	7 29	0.49
Potassium	Comp	A258.1	1	mg/L	7.66	3.37	1 07	4 49	1 95	3.34	2 33	3 63	2.63	1.34
Sodium	Comp	A273.1	1	mg/L	35 6	5 4	1.5	19 6	6 5	21.4	6 6	24.4	18.2	4 9
Bicarbonate	Comp	A310.1	2	mg/L	38.4	19 2	19.2	51.7	19 4	71.1	25 9	51.7	58.19	6 47
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	24.1	6.88	4 77	18 9	5 38	11 9	6 41	22 9	14 7	4 09
Flouride	Comp	B429	0.1	mg/L	0 23	0	0.13	0 2	0.1	0 13	0 1	0.17	0 17	0
Nitrate	Comp	B429	0 1	mg/L	5.2	3	1 78	3.76	2 76	0 36	2.13	3.97	3.45	1 29
Sulfate	Comp	B429	0 1	mg/L	22.8	6.74	5 83	20 9	5 52	17	7 08	21.6	17 6	3 45
Alakalinity	Comp	A310 1	4	mg/L	31.5	15 8	15.8	42.4	15.9	58 3	21 2	42 4	47 7	5 3
Hardness	Comp	A130 2	2	mg/L	68	32	24	55	80	90	43 3	70	65	18
Dissolved Phosphorus	Comp	A365 2	0.05	mg/L	0 281	0 201	0.26	0 46	0 15	0 2	0 1	0 289	0 21	0
Total Phosphorus	Comp	A365.2	0.05	mg/L	0 392	0.207	0 426	0 57	0.17	0.3	0.15	0.323	0 24	0
COD	Comp	A410.4	5	mg/L	106	74 8	34 7	84 4	109	63 3	20.8	40 8	56 4	15 9
pH	Comp	A150.1	na		6.85	6 46	6 93	7.05	6.32	6 91	7 02	7 21	7.25	6 77
NH3-N	Comp	A350.3	0.1	mg/L	1.9	0	0	1 12	0.206	1 1	0.25	0 264	0	0
Nitrate-N	Comp	C4110B	0.1	mg/L	1.17	0.677	0.402	0 85	0 623	0	0.481	0 896	0.779	0 29
Nitnte-N	Comp	C4110B	0.1	mg/L	0 204	0.073	0 064	0.31	0 0304	0.152	0 088	0 24	0 116	0 058
Kjeldahl-N	Comp	A351.4	0.1	mg/L	3 68	1 706	0.808	5.16	1.91	4 68	1 95	2.4	1.09	0 876
Specific Conductance	Comp	A120.1	1	umhos/cm	251	110	76 3	212	77.6	206	105.4	238	145	58 7
Total Dissolved Solids	Comp	A160 1	2	mg/L	164	66	44	140	44	114	68	140	82	34
Turbidity	Comp	A180.1	0 1	NTU	149	68 6	88.5	171	68.7	128	149	9.11	146	41.8
Suspended Solids	Comp	A160.2	2	mg/L	272	188	111	367	164	368	210	96	213	119
Volatile Suspended Solids	Comp	160.4	1	mg/L	55	29	12	69	54	100	42	17	55	42
MBAS	Comp	A425 1	0.05	mg/L	0.179	0.104	0 099	0 346	0.155	0 111	0 139	0.277	0.198	0 146
Total Organic Carbon	Comp	A415.1	1	mg/L	37.1	19	8 8	20 71	8 5	10 7	9	13.63	15 12	4 4
BOD	Comp	A405.1	2	mg/L	5.7	12.5	5.3	9 8	8.8	0	12	5.5	5 9	11 1
Metals														
Dissolved Aluminum	Comp	A202 2	1000	ug/l	0	0	0	0	344	0	0	0	0	118
Total Aluminum	Comp	A202 2	1000	ug/l	114	352	348	7200	409	306	1830	0	129.5	232
Dissolved Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208 2	10	ug/l	28.5	17.1	0	24.7	22	26 1	17.1	22.6	25 7	20
Total Barium	Comp	A208.2	10	ug/l	30	21.9	13 6	154	22.1	31 8	31 5	25.8	28 4	23 7
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0

R0012561

Table B-9. Summary of Results for the 2000-2001 Routine Monitoring at Project 1202

STATION NO					S24	S24	S24	S24	S24	S24	S24	S24	S24	S24
STATION NAME					Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202	Project 1202
STORM NO.					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-11
DATE					10/12/2000	10/28/2000	10/30/2000	01/04/2001	01/11/2001	01/25/2001	02/01/2001	02/14/2001	02/20/2001	03/06/2001
	Sample Type	EPA Method	DL	Units										
Metals (cont.)														
Dissolved Boron	Comp	A212.3	100	ug/l	210	111	111	0	0	133	0	0	0	0
Total Boron	Comp	A212.3	100	ug/l	230	134	139	0	0	137	0	0	0	104
Dissolved Cadmium	Comp	A213.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213.2	1	ug/l	0	0	0	2.06	0	0	0	0	0	0
Dissolved Chromium	Comp	A218.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	5.59	0	15.6	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	12	12.4	5.36	9.33	10.3	12.1	6.48	7.85	7.32	5.45
Total Copper	Comp	A220.1	5	ug/l	13.8	16.7	10.6	63.2	13.8	16.1	13.1	10.6	14.8	9.08
Dissolved Iron	Comp	A236.1	100	ug/l	0	0	0	380	430	0	690	100	280	250
Total Iron	Comp	A236.1	100	ug/l	0	270	350	14300	1050	320	1890	200	470	440
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	0	5.16	0	54.2	0	6.15	9.32	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	0	0	0	207	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249.1	5	ug/l	15	7.53	0	10.6	5.06	0	0	5.22	5.06	0
Total Nickel	Comp	A249.1	5	ug/l	15.2	8.18	0	18.8	5.99	0	5.12	6.03	8.45	0
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	590	413	185	761	327	0	265	400	300	140
Total Zinc	Comp	A289.1	50	ug/l	590	413	185	1680	327	85.5	270	410	320	196
Semi-Volatiles Organics														
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l										
All other SVOCs	Comp	625M	0.5-5.0	ug/l										
Pesticides														
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l										
2,4,5-TP	Comp	515	1	ug/l										
Bentazon	Comp	515	2	ug/l										
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	0	0	0	0	0
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012562

Table B-10 Summary of Results for the 2000-2001 Routine Monitoring at Project 474

STATION NO					S25	S25	S25	S25	S25	S25	S25	S25	S25	S25	S25	S25
STATION NAME					Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474
STORM NO					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11	0001-12
DATE					10/12/2000	10/28/2000	10/31/2000	01/09/2001	01/10/2001	01/25/2001	01/29/2001	02/15/2001	02/20/2001	02/28/2001	03/08/2001	04/11/2001
	Sample Type	EPA Method	DL	Units												
Conventional																
Cyanide	Grab	A335 2	0 01	mg/L												
TPH	Grab	A418 1	1	mg/L												
Oil and Grease	*Grab*	A413 1	*1*	*mg/L*												
Total Phenols	Grab	A420.1	0 1	mg/L												
Indicator Bacteria																
Total Coliform	Grab	C9221B	20	MPN/100ml							22000	140000		500000	22000	
Fecal Coliform	Grab	C9221C	20	MPN/100ml							9000	140000		33000	1100	
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml							7000	50000		22000	17000	
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml							7000	22000		17000	5000	
General																
Ammonia	Comp	A350 3	0.1	mg/L	0.15	0	0	10 77	0 812	0	0	0 22	0 259	0 116	0	0
Calcium	Comp	A215 2	1	mg/L	40 1	9 62	17 3	50	5.61	14	16	10 02	20	9 02	12 8	56 11
Magnesium	Comp	C3500MgD	1	mg/L	14.1	2 72	5 06	14 3	0 48	2 43	7 29	1 82	4.25	1.22	1 94	18 23
Potassium	Comp	A258.1	1	mg/L	12 8	4 1	5 6	12 5	2 27	2 93	3 18	2 02	3 22	1 8	2 17	4 64
Sodium	Comp	A273 1	1	mg/L	69	5.1	15 1	45.9	3 5	13.1	13 7	4 2	18.5	4 8	6 5	51
Bicarbonate	Comp	A310 1	2	mg/L	154	25 6	51.2	84.1	18 1	32 3	44	19.4	58 19	25 86	32 33	84 05
Carbonate	Comp	A310 1	2	mg/L	0	0	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	114	5 14	17	89 2	2 87	5.93	6 37	3 8	31 1	4.01	6 52	134
Flouride	Comp	B429	0 1	mg/L	0 93	0	0 14	0 55	0	0.1	0 11	0	0 16	0	0	0 47
Nitrate	Comp	B429	0 1	mg/L	8 54	2.39	1 84	3 44	2.23	3 09	2.12	1.66	3 12	2 9	1 97	5 91
Sulfate	Comp	B429	0 1	mg/L	52 8	6 09	12 1	112	6 66	11	9 29	4 12	11.3	5.25	6 61	31 6
Alakalinity	*Comp*	A310 1	4	*mg/L*	126	21	42	68 9	14 8	26 5	36	15.9	47.7	21 2	26 5	68 9
Hardness	Comp	A130 2	2	mg/L	158	35 2	64	184	16	45	70	32.5	67.5	27 5	40	215
Dissolved Phosphorus	Comp	A365.2	0.05	mg/L	0.38	0 478	0 498	0.5	0.17	0 17	0.15	0 13	0 074	0 071	0 077	0 099
Total Phosphorus	Comp	A365.2	0.05	mg/L	0 38	0.491	0 512	0.55	0 18	0 22	0.26	0 17	0.13	0.221	0 117	0 115
COD	Comp	A410.4	5	mg/L	88 7	80.3	107	111	55.9	108	58 3	61.7	112.9	0	14 9	15 5
pH	Comp	A150.1	na		7 54	6.93	7 23	6.94	6 54	7	7 44	7 04	7.23	6 97	7.14	7 79
NH3-N	Comp	A350.3	0.1	mg/L	0 12	0	0	8.9	0.671	0	0	0 179	0 214	0	0	0
Nitrate-N	Comp	C4110B	0 1	mg/L	1.93	0.54	0 415	0 78	0 504	0.698	0 479	0 375	0.705	0 655	0.445	1 33345
Nitrite-N	Comp	C4110B	0.1	mg/L	0	0 216	0 058	1.05	0.091	0 107	0.222	0 073	0.1	0	0 097	0 2039
Kjeldahl-N	Comp	A351.4	0.1	mg/L	1.1	1.08	1.114	11.2	2.46	2.62	1.61	1.11	0.851	0.928	2.76	0 79
Specific Conductance	Comp	A120.1	1	umhos/cm	749	113	203	664	69 3	119 2	128.2	78.3	233	86 5	105 2	298
Total Dissolved Solids	Comp	A160.1	2	mg/L	428	66	124	390	42	70	76	50	140	60	60	204
Turbidity	Comp	A180.1	0.1	NTU	87.4	46.6	39	45.9	53.9	40	129	46.1	70.1	21.5	50 4	25 7
Suspended Solids	Comp	A160.2	2	mg/L	39	63	41	48	103	172	182	96	69	75	141	73
Volatile Suspended Solids	Comp	160 4	1	mg/L	19	15	13	19	33	40	0	30	20	29	37	34
MBAS	Comp	A425 1	0.05	mg/L	0	0	0 054	0.154	0.09	0.081	0,068	0	0.076	0 084	0	0
Total Organic Carbon	Comp	A415.1	1	mg/L	7 4	9.3	11.6	22 24	6 95	7.6	6.5	3 95	9.01	6	4 5	4.3
BOD	Comp	A405.1	2	mg/L	5 7	6 6	7.1	4 4	8 9	0	11 2	8.8	4.5	5 94	10 1	6 7
Metals																
Dissolved Aluminum	*Comp*	A202.2	*1000*	*ug/l*	*0*	119	128	0	171	*0*	*0*	138.8	205 8	0	377	*0*
Total Aluminum	Comp	A202.2	1000	ug/l	0	475	657	817	211	446	1010	162.9	239.7	471	940	0
Dissolved Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208 2	10	ug/l	27.7	13 5	19.2	42.8	13.4	13.4	15 8	12.9	28.3	12.7	22	42 7
Total Barium	Comp	A208 2	10	ug/l	35.5	21.4	23.5	54.3	13 4	18.6	29.3	22.2	29 3	16 8	22	43 8
Dissolved Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0

R0012563

Table B-10. Summary of Results for the 2000-2001 Routine Monitoring at Project 474

STATION NO					S25	S25	S25	S25	S25	S25	S25	S25	S25	S25	S25	S25
STATION NAME					Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474	Project 474
STORM NO.					0001-01	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-08	0001-09	0001-10	0001-11	0001-12
DATE					10/12/2000	10/28/2000	10/31/2000	01/09/2001	01/10/2001	01/25/2001	01/29/2001	02/15/2001	02/20/2001	02/28/2001	03/08/2001	04/11/2001
	Sample Type	EPA Method	DL	Units												
Metals (cont.)																
Dissolved Boron	Comp	A212 3	100	ug/l	380	0	139	389	0	136	126	0	176	118	0	188
Total Boron	Comp	A212 3	100	ug/l	388	137	160	389	0	144	129	0	228	134	116	296
Dissolved Cadmium	Comp	A213 2	1	ug/l	1 42	0	0	1.46	1 2	0	0	0	0	0	0	0
Total Cadmium	Comp	A213 2	1	ug/l	1 43	0	0	1.53	1 2	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	37 3	7 86	9 89	18.7	10 4	10.9	6 3	0	8 64	5 73	5 85	0
Total Copper	Comp	A220.1	5	ug/l	37.3	13 8	13 2	30 3	11 3	13 5	11.3	19 5	11.3	8 93	12	7 64
Dissolved Iron	Comp	A236.1	100	ug/l	0	0	280	250	230	0	420	210	260	190	430	192
Total Iron	Comp	A236 1	100	ug/l	0	430	610	1230	550	720	1850	320	310	720	570	318
Dissolved Lead	Comp	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239 2	5	ug/l	0	0	0	5 24	0	0	0	0	0	0	0	0
Dissolved Manganese	Comp	A243 1	100	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243 1	100	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249 1	5	ug/l	0	0	0	6 48	0	0	0	0	0	0	0	0
Total Nickel	Comp	A249 1	5	ug/l	0	0	0	7 47	0	0	5 37	0	0	0	0	0
Dissolved Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	210	101	93 9	156	58 9	0	0	50 8	100	65.6	60	151 4
Total Zinc	Comp	A289.1	50	ug/l	210	101	93 9	164	58.9	94.7	72.9	52 8	125	70.5	71	152 8
Semi-Volatiles Organics																
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l												
All other SVOCs	Comp	625M	0.5-5 0	ug/l												
Pesticides																
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l												
2,4,5-TP	Comp	515	1	ug/l												
Bentazon	Comp	515	2	ug/l												
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	85	0	0	0	0	0	0
All other pesticides	various	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012564

Table B-11. Summary of Results for the 2000-2001 Routine Monitoring at Project 404

STATION NO.					S26	S26	S26	S26	S26	S26	S26	S26	S26
STATION NAME					Project 404	Project 404	Project 404	Project 404	Project 404	Project 404	Project 404	Project 404	Project 404
STORM NO.					0001-01	0001-02	0001-03	0001-05	0001-06	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/28/2000	10/31/2000	01/16/2001	01/25/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units									
Conventional													
Cyanide	Grab	A335 2	0 01	mg/L									
TPH	Grab	A418.1	1	mg/L									
Oil and Grease	Grab	A413.1	1	mg/L									
Total Phenols	Grab	A420.1	0.1	mg/L									
Indicator Bacteria													
Total Coliform	Grab	C9221B	20	MPN/100ml						220000		28000	
Fecal Coliform	Grab	C9221C	20	MPN/100ml						140000		28000	
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml						90000		2200	
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml						90000		1700	
General													
Ammonia	Comp	A350.3	0.1	mg/L	1.6	0		0 699	1.31	0 62	0 56	0.225	0
Calcium	Comp	A215 2	1	mg/L	72.1	20 8	10 3	6.41	24	24 04	64 1	16 03	56.1
Magnesium	Comp	C3500MgD	1	mg/L	20.7	5 83	3 5	0.72	0	3 64	14 6	3 65	12.2
Potassium	Comp	A258.1	1	mg/L	12.9	5.57	2.66	2 09	2.39	2.28	3 48	2.37	6.26
Sodium	Comp	A273.1	1	mg/L	64.2	8.9	12	3.7	15 3	13 9	18 3	11.7	59 5
Bicarbonate	Comp	A310 1	2	mg/L	224	58 9	34 6	19.4	32 3	71.1	90 52	38.8	161 65
Carbonate	Comp	A310.1	2	mg/L	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	127	11.9	4 12	2.6	4 05	12 1	339	9 46	68
Flouride	Comp	B429	0 1	mg/L	0 56	0 19	0 11	0	0 1	0 16	0 21	0 12	0 44
Nitrate	Comp	B429	0 1	mg/L	14.7	8.87	4.36	3	4 07	6.22	8 05	5.09	11 9
Sulfate	Comp	B429	0 1	mg/L	54 5	14 6	5.96	4 1	7 66	14 9	17 3	11	55 8
Alakalinity	Comp	A310.1	4	mg/L	184	48 3	28 4	15 9	26.5	58 3	74 2	31.8	132 5
Hardness	Comp	A130 2	2	mg/L	265	76	40	19	60	75	220	55	190
Dissolved Phosphorus	Comp	A365 2	0.05	mg/L	0 901	0 465		0 24	0 26	0.208	0 276	0.099	0 4576
Total Phosphorus	Comp	A365 2	0.05	mg/L	1.05	0 482		0.26	0 31	0 226	0 317	0.137	0 4982
COD	Comp	A410.4	5	mg/L	81 9	108	56 5	53.7	80 3	59 2	52 5	11	43 1
pH	Comp	A150 1	na		7.81	7 11	7.27	6 39	7.09	7 59	7 88	7 03	7.42
NH3-N	Comp	A350.3	0.1	mg/L	1 32	0		0 578	1 08	0.513	0 46	0 186	0
Nitrate-N	Comp	C4110B	0.1	mg/L	3.32	2	0.985	0 677	0 919	1.4	1.82	1 149	2 69
Nitrite-N	Comp	C4110B	0.1	mg/L	1	0.405	0 049	0 055	0.122	0.088	0	0.064	0.38
Kjeldahl-N	Comp	A351.4	0.1	mg/L	1.64	1 53	1.096	2 2	1 97	1.4	0 854	0 624	2.86
Specific Conductance	Comp	A120.1	1	umhos/cm	884	224	116	66.4	110	205	1173	163.6	636
Total Dissolved Solids	Comp	A160.1	2	mg/L	522	132	66	40	62	136	706	98	376
Turbidity	Comp	A180.1	0.1	NTU	16.2	6.22	8.14	16 2	19 8	2.03	8.46	4.39	3 08
Suspended Solids	Comp	A160.2	2	mg/L	42	10	16	70	53	7	19	9	22
Volatile Suspended Solids	Comp	160.4	1	mg/L	29	2	9	55	8	6	8	7	17
MBAS	Comp	A425.1	0.05	mg/L	0	0	0	0	0	0	0	0	0
Total Organic Carbon	Comp	A415.1	1	mg/L	17.7	13 9	7 9	7 83	6 9	7 77	8.47	5.5	7 1
BOD	Comp	A405.1	2	mg/L	6 5	12	7 5	0	0	5.5	5 5	24.3	7.6
Metals													
Dissolved Aluminum	Comp	A202.2	1000	ug/l									
Total Aluminum	Comp	A202.2	1000	ug/l	0	0	524	117	199	0	0	0	0
Dissolved Antimony	Comp	A204 2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208.2	10	ug/l	44.7	17.3	0	0	11 3	14 2	57.2	13.4	55.7
Total Banum	Comp	A208 2	10	ug/l	52.1	20 2	16.9	0	15 3	14.7	61 3	13 5	57.5
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0

R0012565

Table B-11. Summary of Results for the 2000-2001 Routine Monitoring at Project 404

STATION NO					S26	S26	S26	S26	S26	S26	S26	S26	S26
STATION NAME					Project 404	Project 404	Project 404	Project 404	Project 404	Project 404	Project 404	Project 404	Project 404
STORM NO					0001-01	0001-02	0001-03	0001-05	0001-06	0001-08	0001-09	0001-10	0001-11
DATE					10/12/2000	10/28/2000	10/31/2000	01/16/2001	01/25/2001	02/14/2001	02/20/2001	02/28/2001	03/06/2001
	Sample Type	EPA Method	DL	Units									
Metals (cont.)													
Dissolved Boron	Comp	A212.3	100	ug/l	298	133	166	0	105	0	120	102	257
Total Boron	Comp	A212.3	100	ug/l	321	229	229	0	121	0	136	126	267
Dissolved Cadmium	Comp	A213.2	1	ug/l	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213.2	1	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	13.1	11.2	10.7	8.93	7.22	7.28	9.24	5.22	6.47
Total Copper	Comp	A220.1	5	ug/l	16.2	14.2	17.1	10.6	11.9	10.8	12.1	9.38	8.47
Dissolved Iron	Comp	A236.1	100	ug/l	0	0	170	0	0	0	0	0	0
Total Iron	Comp	A236.1	100	ug/l	0	0	470	440	320	100	100	180	200
Dissolved Lead	Comp	A239.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239.2	5	ug/l	0	0	7.96	0	0	0	0	0	0
Dissolved Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249.1	5	ug/l	6.5	0	0	0	0	0	0	0	5.41
Total Nickel	Comp	A249.1	5	ug/l	7.02	0	0	0	0	0	5.8	0	20.1
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272.2	1	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	110	84.4	55.6	89.8	0	55	110	63	80
Total Zinc	Comp	A289.1	50	ug/l	114	84.4	86.1	89.8	96.6	60	130	69.1	97.2
Semi-Volatiles Organics													
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l	33.4			1.6		1.7		0	2.1
All other SVOCs	Comp	625M	0.5-5.0	ug/l	0			0		0		0	0
Pesticides													
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531.1	5	ug/l	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l	0	0	0	0	0	0	0	0	0
2,4,5-TP	Comp	515	1	ug/l	0	0	0	0	0	0	0	0	0
Bentazon	Comp	515	2	ug/l	0	0	0	0	0	0	0	0	0
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	0	0	0	0
All other pesticides	various	ug/l	0	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012566

Table B-12 Summary of Results for the 2000-2001 Routine Monitoring at Project 156

STATION NO					S27	S27	S27	S27	S27	S27	S27	S27	S27	S27	S27
STATION NAME					Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156
STORM NO					0001-02	0001-03	0001-04	0001-05	0001-07	0001-08	0001-08	0001-10	0001-10	0001-11	0001-12
DATE					10/28/2000	11/01/2000	01/09/2001	01/16/2001	01/26/2001	02/11/2001	02/15/2001	02/24/2001	02/28/2001	03/08/2001	04/11/2001
	Sample Type	EPA Method	DL	Units											
Conventional															
Cyanide	Grab	A335 2	0 01	mg/L											
TPH	Grab	A418 1	1	mg/L											
Oil and Grease	Grab	A413 1	1	mg/L											
Total Phenols	Grab	A420 1	0.1	mg/L											
Indicator Bactena															
Total Coliform	Grab	C9221B	20	MPN/100ml					220000	900000		50000			
Fecal Coliform	Grab	C9221C	20	MPN/100ml					21000	900000		2200			
Fecal Streptococcus	Grab	C9230B	20	MPN/100ml					170000	28000		90000			
Fecal Enterococcus	Grab	C9230B	20	MPN/100ml					170000	17000		70000			
General															
Ammonia	Comp	A350 3	0.1	mg/L	0	0 201	2 37	1 164	0	0 975	0 73	0 11	0 108	0 438	2 238
Calcium	Comp	A215 2	1	mg/L	32 1	6 41	28	8 41	14	9.35	10 02	12	12 02	52 1	9 02
Magnesium	Comp	C3500MgD	1	mg/L	8.75	1 56	12 1	1 21	3 65	1 22	3 64	18 2	2.43	13 4	1 82
Potassium	Comp	A258.1	1	mg/L	7.38	2 04	5.8	2 23	2 97	1 99	2 55	2 27	2.2	5 85	3 3
Sodium	Comp	A273 1	1	mg/L	14 7	5	36 7	4	20 8	13.5	10 4	13 5	11.6	59 5	6.2
Bicarbonate	Comp	A310 1	2	mg/L	51 2	16.7	77 6	27 2	32 3	25 9	25 86	32.33	32.33	103 45	32 33
Carbonate	Comp	A310 1	2	mg/L	0	0	0	0	0	0	0	0	0	0	0
Chloride	Comp	B429	2	mg/L	26 7	2.92	42 7	2 48	12 6	5 65	11	12	9.76	64	6 54
Flouride	Comp	B429	0 1	mg/L	0 19	0	0.43	0.12	0 11	0 1	0	0.1	0	0.19	0 1
Nitrate	Comp	B429	0 1	mg/L	2 83	3 28	2.63	0 79	1 94	2 23	2 23	2.38	2 23	2.5	0 83
Sulfate	Comp	B429	0 1	mg/L	28 4	4.74	60 9	6.45	21	11 5	12	19 5	16	102	7 14
Alakalinity	Comp	A310 1	4	mg/L	42	13 7	63 6	22 3	26 5	21 2	21 2	26 5	26 5	84 8	26 5
Hardness	Comp	A130 2	2	mg/L	116	22 4	120	26	50	28 3	40	105	40	185	30
Dissolved Phosphorus	Comp	A365 2	0 05	mg/L	0 879	0 271	0 51	0 15	0 16	0 11	0 25	0 142	0 234	0 562	0 312
Total Phosphorus	Comp	A365 2	0.05	mg/L	0 916	0.284	0 59	0.19	0 21	0 15	0 28	0.166	0 306	0 618	0 383
COD	Comp	A410 4	5	mg/L	105	78.3	109	58 5	141	124	60 7	40 1	11.8	46.3	17 7
pH	Comp	A150 1	na		6 52	6 54	7.16	6 69	6 94	6 7	6.75	7 22	6 89	7.54	6 73
NH3-N	Comp	A350 3	0.1	mg/L	0	0.166	1.96	0.962	0	0 806	0 36	0	0	0 362	1 85
Nitrate-N	Comp	C4110B	0.1	mg/L	0 639	0.74	0.59	0.178	0.438	0.504	0 504	0.537	0.503	0 565	0
Nitnte-N	Comp	C4110B	0.1	mg/L	0.359	0.055	0 47	0 03	0.177	0.107	0.177	0 131	0.143	0 161	0 3104
Kjeldahl-N	Comp	A351.4	0.1	mg/L	4.38	1.456	5 08	6.08	2.66	1 9	2.5	1.7	0.914	5 76	3 02
Specific Conductance	Comp	A120.1	1	umhos/cm	279	71.3	423	103	174 3	100.4	132.8	170	147	601	94 3
Total Dissolved Solids	Comp	A160.1	2	mg/L	180	40	268	60	96	58	90	94	92	374	64
Turbidity	Comp	A180.1	0 1	NTU	50	14.7	37	102	24 8	20 3	3.77	12.9	5.46	4.3	15 8
Suspended Solids	Comp	A160.2	2	mg/L	188	59	103	438	126	63	29	38	25	41	69
Volatile Suspended Solids	Comp	160 4	1	mg/L	65	26	62	221	10	29	29	16	24	30	45
MBAS	Comp	A425.1	0.05	mg/L	0 073	0.105	0.247	0.146	0.098	0 148	0 233	0	0.083	0 116	0 093
Total Organic Carbon	Comp	A415.1	1	mg/L	35.7	10 3	26.22	8.74	9.5	7	8 44	9.24	6.9	9 9	12 3
BOD	Comp	A405.1	2	mg/L	0	7.1	5	15.1	0	3.3	13	4.7	5 79	9.1	13 5
Metals															
Dissolved Aluminum	Comp	A202.2	1000	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Aluminum	Comp	A202.2	1000	ug/l	211	647	956	128	165	136	0	0	114	0	0
Dissolved Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Antimony	Comp	A204.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Arsenic	Comp	A206 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Barium	Comp	A208.2	10	ug/l	27.2	13.7	38.9	14.4	20.4	12	15.5	18 5	14.8	55.7	15 9
Total Barium	Comp	A208.2	10	ug/l	29.3	24.3	62.1	14.4	24	13 8	19.7	18.9	15.9	57 5	17.7
Dissolved Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Berylium	Comp	A210.2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0

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Table B-12. Summary of Results for the 2000-2001 Routine Monitoring at Project 156

STATION NO					S27	S27	S27	S27	S27	S27	S27	S27	S27	S27	S27
STATION NAME					Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156	Project 156
STORM NO.					0001-02	0001-03	0001-04	0001-05	0001-07	0001-08	0001-08	0001-10	0001-10	0001-11	0001-12
DATE					10/28/2000	11/01/2000	01/09/2001	01/16/2001	01/26/2001	02/11/2001	02/15/2001	02/24/2001	02/28/2001	03/08/2001	04/11/2001
	Sample Type	EPA Method	DL	Units											
Metals (cont)															
Dissolved Boron	Comp	A212 3	100	ug/l	104	162	168	0	0	0	0	0	0	0	0
Total Boron	Comp	A212 3	100	ug/l	104	226	168	0	101	0	0	0	105	0	112
Dissolved Cadmium	Comp	A213 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Cadmium	Comp	A213.2	1	ug/l	0	0	1.38	0	0	0	0	0	0	0	0
Dissolved Chromium	Comp	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Chromium	Comp	A218.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium +6	Comp		10	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Copper	Comp	A220.1	5	ug/l	22.7	9 98	16 6	7 23	15 1	9 02	6 33	8.31	5 88	15 2	6 95
Total Copper	Comp	A220.1	5	ug/l	26 2	18 3	46.9	8 86	19.5	13.1	9 78	11 7	10 2	17 5	22 6
Dissolved Iron	Comp	A236.1	100	ug/l	0	170	350	220	0	0	0	0	0	0	634
Total Iron	Comp	A236.1	100	ug/l	0	370	1890	300	230	120	120	230	300	240	683
Dissolved Lead	Comp	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Lead	Comp	A239 2	5	ug/l	0	13.5	16 1	0	0	0	0	0	0	0	0
Dissolved Manganese	Comp	A243 1	100	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Manganese	Comp	A243.1	100	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Mercury	Comp	A245.1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Mercury	Comp	A245 1	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Nickel	Comp	A249.1	5	ug/l	10	0	7.55	0	0	0	0	0	0	6 81	0
Total Nickel	Comp	A249.1	5	ug/l	10	0	8 94	0	0	0	0	0	0	8 58	0
Dissolved Selenium	Comp	A270.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Selenium	Comp	A270 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Silver	Comp	A272 2	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Thallium	Comp	A279.2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Total Thallium	Comp	A279 2	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
Dissolved Zinc	Comp	A289.1	50	ug/l	296	153	221	84 2	161	0	100	100	109	360	118 1
Total Zinc	Comp	A289.1	50	ug/l	296	153	332	84.2	179	104	105	120	110	370	118 1
Semi-Volatiles Organics															
Bis(2-ethylhexyl)phthalate	Comp	625M	3	ug/l	41	0		3 4	9 1	10	3 6	1 4	21 4	1 1	6 5
All other SVOCs	Comp	625M	0.5-5 0	ug/l	0	0		0	0	0	0	0	0	0	0
Pesticides															
Diazinon	Comp	8141SOP	0.01	ug/l	0	0	0	0	0	0	0	0	0	0	0
Carbofuran	Comp	531 1	5	ug/l	0	0	0	0	0	0	0	0	0	0	0
2,4-D	Comp	515	10	ug/l	0	0	0	0	0	0	0	0	0	0	0
2,4,5-TP	Comp	515	1	ug/l	0	0	0	0	0	0	0	0	0	0	0
Bentazon	Comp	515	2	ug/l	0	0	0	0	0	0	0	0	0	0	0
Glyphosate	Comp	547	25	ug/l	0	0	0	0	0	0	0	0	0	0	0
All other pesticides	Comp	D608	various	ug/l	0	0	0	0	0	0	0	0	0	0	0

Note:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012568

Table B-13. Data Summary for Auto Dismantlers and Auto Repair Companies for 2000-2001

Control and Test Sites			SITE No.	C01	C02	C03	T01	T02	T03	C04	C05	C06	T04	T05	T06
			Date	01/10/2001	01/10/2001	01/10/2001	01/10/2001	01/10/2001	01/10/2001	01/08/2001	01/08/2001	01/08/2001	01/10/2001	01/10/2001	01/10/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID (YR-#)	0001-02	0001-02	0001-02	0001-02	0001-02	0001 02	0001-01	0001-01	0001-01	0001-02	0001 02	0001 02
Parameter	EPA Method	PQL	Units												
Oil and Grease	A413.1	1	mg/l	13.3	10 3	5	9 9	12.4	11 8	4 1	3	13	6.7	2 8	1 7
TPH as Gasoline	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0 5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	33.9	27	13.3	14	40.7	59 8	6 3	29 9	4 1	11.3	16.6	9.8
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0

NOTE: 1) blank cell indicates sample was not analyzed 2) 0 indicated level below detection limit

R0012569

Table B-14. Data Summary for Fabricated Metals Company for 2000-2001

Control and Test Sites			SITE No.	C07	C07	C07	C08	C08	C08	C09	C09	C09	T07	T07	T08	T08	T09	T09
			Date	01/08/2001	01/10/2001	01/26/2001	01/08/2001	01/10/2001	01/26/2001	01/08/2001	01/10/2001	01/26/2001	01/08/2001	01/10/2001	01/08/2001	01/10/2001	01/08/2001	01/10/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID (YR-#)	0001-01	0001-02	0001-04	0001 01	0001-02	0001-04	0001-01	0001-02	0001-04	0001-01	0001-02	0001-01	0001-02	0001-01	0001-02
Parameter	EPA Method	POL	Units															
Oil and Grease	A413.1	1	mg/l	8 2	2.1	4 7	6 2	0	1.4	1 2	1 3	1 1	1 3	1 8	3 1	0	0	7 7
TPH as Gasoline	G-DHS	0 5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0 5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	7.2	10.4	10.2	33	21.9	17.3	7	29.4	13.4	10 1	8.3	16 1	0		75 5
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTE: 1) blank cell indicates sample was not analyzed 2) 0 indicated level below detection limit

R0012570

Table B-15. Data Summary for Motor Freight Companies for 2000-2001

Control Sites			SITE No.	C10	C10	C10	C10	C11	C11	C11	C11	C12	C12	C12	C12
			Date	01/26/2001	02/12/2001	02/24/2001	03/05/2001	01/26/2001	02/12/2001	02/24/2001	03/05/2001	01/26/2001	02/12/2001	02/24/2001	03/05/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID(YR-#)	0001-04	0001-05	0001-06	0001-07	0001-04	0001-05	0001 06	0001-07	0001-04	0001-05	0001-06	0001-07
Parameter	EPA Method	POL	Units												
Oil and Grease	A413 1	1	mg/l	0	1.6	3 7	1	2 8	2 2	1 5	1 1	3.7	1.2	3.9	2
TPH as Gasoline	G-DHS	0 5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0 5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3 0	ug/l	21.1	5.4	18.6	5.4	31 8	7 4	14 8	0	36.1	29.5	14 3	6 7
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0

Test Sites			SITE No.	T10	T10	T10	T11A	T11A	T11A	T11B	T11B	T11B	T12A	T12A	T12A	T12A	T12B	T12B	T12B	T12B	T12C	T12C	T12C	T12C
			Date	01/24/2001	02/12/2001	02/24/2001	01/24/2001	02/12/2001	02/24/2001	01/24/2001	02/12/2001	02/24/2001	01/24/2001	02/12/2001	02/24/2001	03/04/2001	01/24/2001	02/12/2001	02/24/2001	03/04/2001	01/24/2001	02/12/2001	02/24/2001	03/04/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID(YR-#)	0001-03	0001-05	0001-06	0001-03	0001-05	0001-06	0001-03	0001-05	0001-06	0001-07	0001-03	0001-05	0001-06	0001-07	0001-03	0001-05	0001-06	0001-07	0001 05	0001 06	
Parameter	EPA Method	POL	Units																					
Oil and Grease	A413.1	1	mg/l	2 1	0	1.6	8.3	5 8	0	1.4	8	0	10 6	5.4	3.7	26.1	5 6	6.4	3.6	15.7	23.5	7 5	4 8	
TPH as Gasoline	G-DHS	0 5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
TPH as Diesel	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l		10.2	9.9	13.4	11.5	24	8 3	16.8	8.3	17.2	31.6		65.5	7.7	52	13.1	0	6.1	5 1	11 1	
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

NOTE: 1) blank cell indicates sample was not analyzed 2) 0 indicated level below detection limit

R0012571

Table B-16. Data Summary for Automobile Dealers for 2000-2001

Control Sites			SITE No.	C13	C13	C13	C13	C13	C14	C14	C14	C14	C14	C14	C15	C15	C15	C15	C15
			Date	01/10/2001	01/24/2001	01/26/2001	02/12/2001	02/24/2001	01/10/2001	01/24/2001	01/26/2001	02/12/2001	02/24/2001	03/04/2001	01/10/2001	01/24/2001	01/26/2001	02/12/2001	02/24/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID (YR-#)	0001-02	0001-03	0001-04	0001-05	0001-06	0001-02	0001-03	0001-04	0001-05	0001-06	0001-07	0001-02	0001-03	0001-04	0001-05	0001-06
Parameter	EPA Method	PQL	Units																
Oil and Grease	A413.1	1	mg/l	4.4	1.8	13.2	1.8	7.2	0	0	2.1	3.4	2.4	1.2	10	4	5	23.2	7.4
TPH as Gasoline	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	5.8	0	0	0	0	0	0	0	0	0	0	5.1
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	35.5	53.9	13.9	12.9	48.4	39.8	35.2	39.2	3.6	37.4	11	272.2	28.6	26.3	81	50.6
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTE: 1) blank cell indicates sample was not analyzed 2) 0 indicated level below detection limit

Test Sites			SITE No.	T13	T13	T13	T14	T14	T14	T15	T15
			Date	01/10/2001	01/24/2001	01/26/2001	01/10/2001	01/24/2001	01/26/2001	01/10/2001	01/26/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID(YR-#)	0001-02	0001-03	0001-04	0001-02	0001-03	0001-04	0001-02	0001-04
Parameter	EPA Method	PQL	Units								
Oil and Grease	A413.1	1	mg/l	0	0	1.4	0	2.9	1.5	2.6	9.8
TPH as Gasoline	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	12.5	6.4	18.3	29.7	13.1	40.9	4.4	27.3
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0

P.0012572

Table B-17. Data Summary for Chemical Manufacturing Companies and Machinery Manufacturing Companies for 2000-2001

Control Sites			SITE No.	C16	C16	C16	C16	C17	C17	C17	T16	T16	T16	T16	T16	T17	T17	T17	T17	T17
			Date	01/10/2001	01/24/2001	02/12/2001	02/24/2001	01/10/2001	01/24/2001	02/12/2001	01/10/2001	01/24/2001	01/26/2001	02/12/2001	02/24/2001	01/10/2001	01/24/2001	01/26/2001	02/12/2001	02/24/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID (YR-#)	0001-02	0001-03	0001-05	0001-06	0001-02	0001-03	0001-05	0001-02	0001-03	0001-04	0001-05	0001-06	0001-02	0001-03	0001-04	0001-05	0001-06
Parameter	EPA Method	PQL	Units																	
Oil and Grease	A413.1	1	mg/l	3.5	1.3	0	0	3.4	2	1.9	2.2	2.7	12.3	3.9	0	4.9	0	12.4	3.7	1
TPH as Gasoline	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	1.2	3.8	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	6.2	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	1.6	3.9	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	1.5	5.7	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	235.5	15.7	6.2	9.1	20.4	29.8	9.3	5.9	16.2	18.8	4.7	7.3	14	6.7	5.6	18	5.1
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Test Sites			SITE No.	C19	C19	C19	C20	C20	C20	T19	T19	T19	T19	T20	T20	T20
			Date	01/24/2001	02/12/2001	02/24/2001	01/24/2001	02/12/2001	02/24/2001	01/24/2001	01/26/2001	02/12/2001	02/24/2001	01/24/2001	01/26/2001	02/24/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID(YR-#)	0001-03	0001-05	0001-06	0001-03	0001-05	0001-06	0001-03	0001-04	0001-05	0001-06	0001-03	0001-04	0001-06
Parameter	EPA Method	PQL	Units													
Oil and Grease	A413.1	1	mg/l	2.2	2.2	9.8	6.7	3.1	5.3	0	3.1	1	0	2.2	1.2	0
TPH as Gasoline	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	7.5	29.8	20.7	9.3	13.5	16.7	14.2	0	0	68.4	22.4	4	6.5
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTE: 1) blank cell indicates sample was not analyzed 2) 0 indicated level below detection limit

R0012573

Table B-18. Data Summary for Rubber/Miscellaneous Plastics Companies for 2000-2001

Control and Test Sites			SITE No.	C22	C22	C23	C23	T22	T22	T22	T23	T23	T23	T24	T24	T24
			Date	01/26/2001	02/12/2001	01/25/2001	02/12/2001	02/12/2001	02/24/2001	03/05/2001	02/12/2001	02/24/2001	03/05/2001	02/12/2001	02/24/2001	03/05/2001
			Sample Type	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab	Grab
			Event ID (YR-#)	0001-04	0001-05	0001-04	0001-05	0001-05	0001-06	0001-07	0001-05	0001-06	0001-07	0001-05	0001-06	0001 07
Parameter	EPA Method	PQL	Units													
Oil and Grease	A413 1	1	mg/l	1 1	1.1	1 5	1	1 2	0	1.5	1.3	0	0	0	1.1	0
TPH as Gasoline	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0
TPH as Diesel	G-DHS	0.5	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)anthracene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	1.1	0
Benzo(b)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(k)fluoranthene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Benzo(a)pyrene	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
BENZYL_BUT	625		ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0
Bis(2-ethylhexyl)phthalate	625	3.0	ug/l	31.8	0	0	4 9	18.1	11.8	4 1	7 8	5.3	0	7.9	80.1	0
All other SVOCs	625	0.5-5.0	ug/l	0	0	0	0	0	0	0	0	0	0	0	0	0

NOTE: 1) blank cell indicates sample was not analyzed 2) 0 indicated level below detection limit

R0012574

Table B-19. Data Summary for Auto Dismantling Companies, Auto Repair Companies, and Fabricated Metals Companies for 2000-2001

Parameter	EPA Method	PQL	Units	SITE No. / Date / Sample Type / Event ID(YR-#)	C96* 01/10/2001 Comp 0001-02	T96 01/11/2001 Comp 0001-02	C97** 01/08/2001 Comp 0001-01	T97 01/10/2001 Comp 0001-02	C98*** 01/08/2001 Comp 0001-01	C98 01/10/2001 Comp 0001-02	C98 01/26/2001 Comp 0001-04	T98 01/08/2001 Comp 0001-01	T98 01/11/2001 Comp 0001-02
COD	A410 4	5	mg/l		110	59.7	106	31.1	85.5	33 3	121	253	35.3
pH	A150.1	0-14			6.46	6 66	5.83	6.5	5 82	6.46	5.94	6 08	6.4
Specific Conductance	A120 1	1.0	umhos/cm		136	154	146	38 6	146	50.2	65.3	394	32 7
Total Dissolved Solids	A160.1	2.0	mg/l		88	88	90	24	84	30	36	250	20
Suspended Solids	A160 2	2.0	mg/l		67	125	63	52	79	18	135	1052	154
MBAS	A425.1	0.05	mg/l		0.137	0 163	0.404	0 097	0 47	0.122	0.236	0.491	0.133
Total Organic Carbon	A415.1	1 0	mg/l		24 42	16 68	24 75	5.84	24 65	5.64	9 9	87 2	4.42
Dissolved Aluminum	A202 2	1000	ug/l		0	0	0	0	124	0	0	373	104
Total Aluminum	A202 2	1000	ug/l		367	791	800	340	1750	191	384	8560	137
Dissolved Cadmium	A213 2	1	ug/l		3.36	2 3	0	0	1.29	0	0	2.82	0
Total Cadmium	A213.2	1	ug/l		3.36	2.85	1.51	0	1.62	0	0	5.8	0
Dissolved Chromium	A218 2	5	ug/l		0	0	0	0	5.9	0	0	6.57	0
Total Chromium	A218 2	5	ug/l		0	0	5.18	0	31.1	5.1	0	26	7.21
Dissolved Copper	A220.1	5	ug/l		46.5	31 8	45.4	22.5	171	51.8	164	852	79.5
Total Copper	A220.1	5	ug/l		48.1	42.5	69.2	39.5	332	60.3	271	1500	192
Dissolved Iron	A236.1	100	ug/l		250	330	0	0	150	350	550	810	160
Total Iron	A236.1	100	ug/l		1030	1840	1970	790	3420	580	790	10500	4210
Dissolved Lead	A239 2	5	ug/l		0	0	0	36.2	42.3	30.6	37.6	27.1	0
Total Lead	A239.2	5	ug/l		17.5	32.2	21.2	172	234	53.1	203	328	84.1
Dissolved Nickel	A249 2	5	ug/l		39 5	0	14.9	0	41.8	8.78	9	27.5	0
Nickel	A249 2	5	ug/l		39 5	25 6	15.3	0	45.8	8.78	10.3	36.4	7.72
Dissolved Zinc	A289 1	50	ug/l		325	425	299	156	424	126	190	4090	502
Total Zinc	A289.1	50	ug/l		325	425	350	156	500	126	240	4500	517

*C96 and T96 are composites of control sites C1, C2, C3 and test sites T1, T2, T3 respectively
**C97 and T97 are composites of control sites C4, C5, C6 and test sites T4, T5, T6 respectively
***C98 and T98 are composites of control sites C7, C8, C9 and test sites T7, T8, T9 respectively

NOTE:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012575

Table B-20. Data Summary for Motor Freight Companies Composites and Auto Dealers Composites for 2000-2001

Parameter	EPA Method	PQL	Units	SITE No.	C99A*	C99A	C99A	T99A	T99A	T99A	C99B**	C99B	C99B	T99B	T99B
				Date	01/26/2001	02/12/2001	02/24/2001	01/24/2001	02/12/2001	02/24/2001	01/10/2001	01/26/2001	02/12/2001	01/11/2001	01/26/2001
				Sample Type	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp
				Event ID(YR-#)	0001-04	0001-05	0001-06	0001-03	0001-05	0001-06	0001-02	0001-04	0001-05	0001-02	0001-04
COD	A410 4	5	mg/l		46 4	42 2	27 6	61 8	16 7	40 7	16 4	41 3	21 2	25.4	54 3
pH	A150.1	0-14			5 94	5.96	6 73	5.9	5 76	6 54	6 45	5.52	6.06	6 08	5 8
Specific Conductance	A120 1	1 0	umhos/cm		94	112 7	69 4	118	35 8	81.7	42 5	39.1	66.1	25 4	47
Total Dissolved Solids	A160 1	2 0	mg/l		56	64	40	76	24	46	26	22	44	16	26
Suspended Solids	A160.2	2 0	mg/l		101	73	44	147	27	190	75	152	125	31	62
MBAS	A425.1	0 05	mg/l		0.181	0.153	0 069	0 24	0 127	0.083	0.067	0.179	0.115	0.104	0 246
Total Organic Carbon	A415.1	1.0	mg/l		9.5	7 83	4.34	14 7	3 89	6 41	3.67	4 9	4 43	4.51	8.1
Dissolved Aluminum	A202 2	1000	ug/l		0	0	0	139	0	0	0	0	0	0	0
Total Aluminum	A202.2	1000	ug/l		635	1060	364	448	318	0	1650	104	146	137	169
Dissolved Cadmium	A213 2	1	ug/l		0	0	0	0	0	0	0	0	0	0	0
Total Cadmium	A213 2	1	ug/l		0	0	0	0	0	0	0	0	0	0	0
Dissolved Chromium	A218 2	5	ug/l		0	0	0	0	0	0	0	0	0	0	0
Total Chromium	A218 2	5	ug/l		0	0	0	0	0	0	6.39	0	0	0	0
Dissolved Copper	A220 1	5	ug/l		8 83	11 5	0	20 7	5 66	6.26	8 46	13	10.8	6 85	11 2
Total Copper	A220 1	5	ug/l		13 3	18 9	10 5	27	15 6	10 2	52 9	13 9	15.1	9.77	13 8
Dissolved Iron	A236 1	100	ug/l		590	300	320	200	210	0	0	0	0	0	170
Total Iron	A236 1	100	ug/l		920	1320	380	830	270	0	388	110	0	240	240
Dissolved Lead	A239.2	5	ug/l		0	0	0	0	0	0	0	0	0	0	0
Total Lead	A239 2	5	ug/l		7.62	13.1	0	12 9	12 6	0	30.4	0	0	5	5.99
Dissolved Nickel	A249 2	5	ug/l		0	0	0	6 43	0	0	0	0	0	0	0
Nickel	A249 2	5	ug/l		0	0	0	6 79	0	0	6 33	0	0	0	0
Dissolved Zinc	A289 1	50	ug/l		110	125	78.9	370	117	178	149	100	133	84 4	0
Total Zinc	A289.1	50	ug/l		182	157	81 1	403	136	245	274	150	137	84.4	87

*C99A and T99A are composites of control sites C10, C11, C12 and test sites T10, T11, T12 respectively
**C99B and T99B are composites of control sites C13, C14, C15 and test sites T13, T14, T15 respectively

NOTE:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012576

Table B-21. Data Summary for Chemical Manufacturing Companies, Machinery Manufacturing Companies, and Rubber/Miscellaneous Plastics Companies for 2000-2001

			SITE No	C00A*	C00A	C00A	T00A	T00A	T00A	T00A	C00B**	C00B	T00B	T00B	T00B	C00C***	C00C	T00C	T00C	T00C
			Date	01/10/2001	02/12/2001	02/24/2001	01/10/2001	01/26/2001	02/12/2001	02/24/2001	02/12/2001	02/24/2001	01/26/2001	02/12/2001	02/24/2001	01/26/2001	02/12/2001	02/11/2001	02/24/2001	03/05/2001
			Sample Type	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp	Comp
			Event ID(YR-#)	0001-02	0001-05	0001-06	0001-02	0001-04	0001-05	0001-06	0001-05	0001-06	0001-04	0001-05	0001-06	0001-04	0001-05	0001-05	0001-06	0001-07
Parameter	EPA Method	PQL	Units																	
COD	A410 4	5	mg/l	44.8	26.1	95 3	26 4	49 5	45 6	70 9	35 7	179	10 9	23 1	58 9	175	59 7	41 2	53 8	24 9
pH	A150 1	0-14		6.74	5.9	6 77	6 34	6	6 09	6 62	6 19	6 76	6 12	6 46	6 56	5.72	5 99	6 16	6 16	6 6
Specific Conductance	A120 1	1 0	umhos/cm	189	72.4	77 4	39 2	50 4	87.9	80 5	41.9	71.8	46	55 4	62 3	58	26 8	107 5	74 4	113
Total Dissolved Solids	A160 1	2 0	mg/l	106	50	50	24	32	61	46	28	40	26	37	36	32	16	60	42	64
Suspended Solids	A160 2	2.0	mg/l	201	14	2	123	105	393	48	127	109	92	136	108	257	78	96	11	173
MBAS	A425 1	0 05	mg/l	0.118	0.12	0 138	0.109	0 209	0 203	0 098	0.179	0 101	0.11	0 116	0.068	0.368	0.163	0.145	0 111	0 108
Total Organic Carbon	A415 1	1.0	mg/l	6.99	8.27	12 25	4 31	6.1	11 69	7.49	6 48	6 77	3 9	5 14		9.4	3 37	11 45	4 86	6 3
Dissolved Aluminum	A202 2	1000	ug/l	365	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Aluminum	A202 2	1000	ug/l	3320	397	0	1680	386	850	0	154	0	0	152	0	189	156	973	107	190
Dissolved Cadmium	A213 2	1	ug/l	0	0	0	0	0	0	0	1 52	2 04	0	0	0	0	0	4 26	2 07	2 37
Total Cadmium	A213 2	1	ug/l	0	0	0	0	0	0	0	1.75	2 19	0	0	0	0	0	7 02	2 1	2 51
Dissolved Chromium	A218 2	5	ug/l	0	0	0	0	0	0	0	0	0	55 3	88 9	45.1	0	0	6 21	0	0
Total Chromium	A218.2	5	ug/l	8 36	0	0	6 84	0	0	0	0	0	101	95.7	45 2	0	0	7 68	0	0
Dissolved Copper	A220.1	5	ug/l	6.41	8.34	11.3	7.5	10 6	17	15.1	24 2	18 9	6.62	13 2	10 2	11.4	6 8	21.8	8 35	0
Total Copper	A220 1	5	ug/l	27 8	12.2	14.4	34	13.8	26.3	17 2	25 3	29 5	13 6	15 4	13 9	14 7	10.6	27 5	13 3	12 7
Dissolved Iron	A236 1	100	ug/l	460	0	120	330	500	310	0	0	0	0	130	110	210	0	240	0	310
Total Iron	A236 1	100	ug/l	7060	520	220	4210	720	1320	100	240	210	0	170	190	300	260	720	140	340
Dissolved Lead	A239 2	5	ug/l	0	0	0	0	0	0	0	0	0	9 42	0	0	0	0	0	0	0
Total Lead	A239 2	5	ug/l	23	5	0	19 4	0	8 94	0	5 79	0	10 7	5 56	0	0	0	14 1	0	0
Dissolved Nickel	A249 2	5	ug/l	0	0	0	0	0	0	0	0	0	10 9	8 43	7.03	0	0	8 1	5 7	15 3
Nickel	A249 2	5	ug/l	9 62	0	0	7 8	0	6 25	0	0	0	11.5	8 45	7 25	0	0	10.8	5 72	15 5
Dissolved Zinc	A289 1	50	ug/l	224	397	142	108	50	207	132	94	130	0	73	98	100	123	148	126	140
Total Zinc	A289 1	50	ug/l	369	416	184	285	118	214	132	98 7	168	88 4	89 9	125	146	137	183	126	150

*C00A and T00A are composites of control sites C16, C17 and test sites T16, T7 respectively
**C00B and T00B are composites of control sites C19, C20 and test sites T19, T20 respectively
***C00C and T00C are composites of control sites C22, C23 and test sites T22, T23 respectively

NOTE:
1) blank cell indicates sample was not analyzed
2) 0 indicated level below detection limit

R0012577

Appendix C
Industrial Stormwater Discharge

This Appendix includes, at the request of Natural Resources Defense Council and the Santa Monica Bay Keeper, industrial stormwater permit sampling data from the Regional Water Quality Control Board (RWQCB) for all industrial stormwater permitees in Los Angeles County for the 1999-2000 wet season, the latest season available. The data set contains sampling results for 9 constituents and three parameters. The data include the dates samples were taken. Furthermore, permittees may have more than one sampling location and are required to sample from all designated sampling locations.

The CRWQCB requires Industrial Stormwater permittees to obtain and report stormwater samples according to the document entitled ***Waste Discharge Requirements (WDR) for Discharges of Stormwater Associated with Industrial Activities Excluding Construction Activities***. Section B, *Monitoring Program and Reporting Requirements*, states:

Monitoring Program and Reporting Requirements

Section 5.c Facility operators shall collect stormwater samples during the first hour of discharge from (1) the first storm event for the wet season [Oct. 1st - May 1st], and (2) at least one other storm event in the wet season. All stormwater discharge locations shall be sampled. . . Facility operators that do not collect samples from the first storm event of the wet season are still required to collect samples from two other events of the wet season and shall explain in the Annual Report why the first storm event was not sampled.

Section 5.b Sample collection is only required of stormwater discharges that occur during scheduled facility operating hours and that are preceded by at least (3) three working days without stormwater discharge.

Section 5 further explains what constituents should be analyzed and what are valid sample collection locations.

The count, maximum, and minimum values are presented in the table.

Note.- At the time of printing, Industrial Stormwater Discharge data was still being compiled. Therefore, this appendix represents only a partial view of the complete data set. For more information on who to contact, refer to Appendix E (Contacts).

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000008	2/27/00	2/27/00	7 4	59	93	3 6									
000010	2/14/00	2/16/00	7 5	230	290	10			0 15	4 5					
000010	4/17/00	4/18/00	6 8	17	170	5			0 03	1 1					
000025	1/25/00	1/26/00	7 34	49	93	0 5		0 001	0 178				0 001		
000027															
000030	3/8/00	3/9/01	6 16	16	100	2		0 07	0 03	2 31			0 05		
000035	1/25/00	1/25/00	7	19	30	5	5 8								
000035	1/25/00	1/25/00	7 5	24	45	5	8 2								
000035	2/23/00	2/24/00	6	9	26	5	2 1								
000035	2/23/00	2/24/00	6	13	15	5	4 6								
000037	2/21/00	2/23/00	7 46	8	30		5 5								
000037	4/17/00	4/18/00	6 49	5	46		17								
000044	11/8/99	11/8/99	7 1	24	180	4									
000044	11/8/99	11/8/99	7 2	910	1100	23									
000044	12/31/99	1/4/00	6 8	130	380	8 5									
000044	12/31/99	1/4/00	5 6	250	745	11									
000044	2/10/00	2/14/00	5 9	200	91	2 1									
000044	2/10/00	2/14/00	6	160	94	2 6									
000044	2/10/00	2/14/00	7 2	910	1100	23									
000060	1/25/00	1/27/00	5 96	42	76		48 9	0 055	0 058	0 538					
000066															
000067															
000068	11/8/99	11/8/99	7 01	49	166	1 5		0 012		0 76			0 007	208	
000068	11/8/99	11/8/99	7 08	10	279	1 3		0 018		0 71			0 005	206	
000068	11 8 99	11/8/99	7	14	113	1 1		0 016		0 76			0 003	245	
000068	11 8 99	11/8/99	6 61	33	125	1 7		0 013		0 69			0 003	155	
000068	2 10 00	2/10/00	5 71	32	3240	0 5		0 024				1 3	0 003	31	
000068	2 10 00	2/10/00	5 86	42	3000	0 5		0 04				2 2	0 003	26	
000068	2 10 00	2/10/00	6 09	10	3500	0 5		0 015				0 43	0 003	20	
000068	2/10/00	2/10/00	6 57	34	448	0 5		0 035				1 9	0 025	75	
000069															
000070	2/10/00	2/11/00	7 24	95											
000070	4/17/00	4/18/00	6 78	52		5									
000070	4/17/00	4/18/00	6 68	50		5									
000074	2/16/00	2/16/00	6 74	20	83	9 1									
000074	2/16/00	2/16/00	6 88	75	42	8 2									
000074	2/16/00	2/16/00	9 12	1320	112	16 4									
000074	2/16/00	2/16/00	8 85	74	102	15 4									
000074	2/16/00	2/16/00	8 56	115	87	16 6		0 05		0 05	3 33				
000074	3/8/00	3/8/00	7 97	17	59	5 8									
000074	3/8/00	3/8/00	7 46	16	31	12 9									
000074	3/8/00	3/8/00	9 48	183	94	29									
000074	3/8/00	3/8/00	9 28	64	60	15 5									
000074	3/8/00	3/8/00	9 47	139	77	27 2		0 1		0 58	4 5				
000080	2/10/00	2/11/00	7 03	52	81	5	18		0 06	1 7					
000080	4/17/00	4/18/00	6 48	18	69	5	18		0 02	1 2					
000081															
000087															
000098	11/8/99		6 9	1009	346	5	12 4								
000098	11/8/99		7 2	255	217	6	11 9								
000098	2/10/00		7 8	3071	743	36	15								
000098	2/10/00		7 8	2272	369	9	19								
000106	1/25/00	1/25/00	6 6	90	170	7				0 7	0 87				
000106	1/25/00	1/25/00	7 2	170	66	7				0 4	1				
000106	4/17/00	4/18/00	7 1	68	86	4				1	0 99				
000106	4/17/00	4/18/00	6.2	140	120	19				0 4	2 8				
000107	4/17/00	4/24/00	6 5	62	218	5	24								
000107	4/17/00	4/24/00	6 9	45	172	5	59								
000107	4/17/00	4/24/00	6 9	63	100	5	42								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000110															
000115	2/16/00	2/18/00	7	39	100	6			0 02	0 89					
000115	4/17/00	4/20/00	6 6	180	63	6			0 08	2 5					
000118	11/17/99	11/22/99	6 34	92	830	19						1 21			
000118	11/17/99	11/22/99	5 2	25	368	3						0 392			
000118	1/25/00	1/31/00	6 71	25	485	5	88								
000118	1/25/00	1/31/00	6 63	106	994	8	163								
000118	2/10/00	2/11/00	7 38	63	453	2	94								
000118	2/10/00	2/11/00	6 62	133	364	42	48 2								
000118	2/10/00	2/11/00	6 6	417	641	12	88								
000119	1/25/00	1/25/00	7 63	45	52	1	3 4								
000119	4/17/00	4/18/00	6 7	1	36	1	3 6								
000121	1/25/00	1/25/00	7.48	40	32	1	3 4								
000121	4/17/00	4/18/00	6 78	1	23	1	2 2								
000122	2/10/00	2/11/00	6 36	30 5	98	3 6			2 7	7 2	0 7	0 5			
000122	2/10/00	2/11/00	6 62	13	99	5 5			0 47	13	0 5	0 48			
000122	2/10/00	2/11/00	6 8	21	47	3 1			0 56	0 95	12	0 93			
000125		1/25/00	7 4	120	4	11						0 7			
000125		1/25/00	9 4	130	1930	1 6						2 9			
000125		1/25/00	9	228	652	3 6						0 5			
000125		2/22/00	7 1	2	150	2000						24 7			
000125		2/22/00	9	2	1000	1						6			
000125		2/22/00	9 2	2	500	1 5						0 5			
000130	4/17/00	4/17/00	6 7	240	710	12	220								
000131	1/25/00	1/25/00	7 99	28	310	28									
000131	4/14/00	4/18/00	7 09	38	170	16									
000132	1/25/00		7 29	77	170	6	33								
000132	2/16/00		7 94	131	140	0	8 7								
000137	2/10/00	2/10/00	7 5	180	370	16									
000137	2/10/00	2/10/00	8 4	36	620	39									
000137	2/21/00	2/22/00	6 6	160	130	11									
000137	2/21/00	2/22/00	8	8	330	13									
000146	3/7/00	3/8/00	5 78	5	16	1									
000146	3/7/00	3/8/00	5 79	1	15	1									
000146	3/7/00	3/8/00	5 78	5	16	1									
000146	3/7/00	3/8/00	5 79	1	15	1									
000147	1/25/00		6 8	31	13	7				2 32	0 4	1 07			
000151	4/18/00	4/19/00	9 6	130	1400	52		0 036		1 1	0 99	1 7			
000151	4/18/00	4/19/00	7 4	36	49	11		0 011		0 65	0 17	0 41			
000151	1/25/00	1/25/00	8 3	250	130	1 1		0 036		1 3	2 4	4 8			
000151	1/25/00	1/25/00	9 2	29	1500	31		0 017		0 91	1 2	2 3			
000163	11/8/99	11/8/99	6 2	81	210	5									
000163	11/8/99	11/8/99	6 5	20	220	5									
000163	2/10/00	2/11/00	7 1	53	290	5									
000163	2/10/00	2/11/00	6 7	290	380	13									
000178	12/31/99	1/3/00	6 88	137	140	10	12				6 9	7.2	0.35		
000178	1/25/00	1/27/00	6 39	288	66	5	3 4				2 3	1 6	0 04		
000189	1/17/00	1/18/00	7 62	11	168	17									
000189	1/25/00	1/26/00	7 24	100	171	66									
000199															
000204	2/10/00	2/10/00	10 4	194	2500	1									
000204	2/10/00	2/10/00	9 88	266	820	1									
000204	2/10/00	2/10/00	8 74	86	180	1									
000205	11/8/99	11/8/99	7 2	82	900	7		0 067	0 48	12			0 15	1500	230
000205	11/8/99	11/8/99	7 3	71	910	5		0 027	0 22	2 4			0 042	370	140
000205	11/8/99	11/8/99	7 3	150	580	11		0 07	0 16	4 2			0 12	290	53
000205	2/20/00	2/21/00	6 9	16	210	6		0 0086	0 063	0 76			0 011	490	56
000205	2/20/00	2/21/00	7 6	14	122	5		0 0053	0 016	0 16			0 012	20	12
000205	2/20/00	2/21/00	7 1	29	140	5		0 0088	0 038	0 22			0 016	89	14
000221															
000222															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000231	2/16/00	2/16/00	7 27	154	557	0 5	6 9								
000231	3/5/00	3/6/00	6 98	78	176	0 5	3								
000238	1/25/00	1/30/00	7 9	5	58	5				0 18	0 3	0 1			
000247															
000250															
000254	11/8/99	11/8/99	7 36	45	130	5	33								
000254	1/25/00	1/25/00	7 65	68	59	6	9 4								
000266	1/17/00		7 27	5	98	10		0 05	0 08	0 65					
000266	1/17/00		7 26	5	91	10		0 05	0 06	0 62					
000266	1/25/00		6 2	1	26	10		0 05	0 06	0 31					
000266	1/25/00		6	1	29	10		0 05	0 07	0 21					
000273															
000275	4/17/00	4/18/00	6 9	15	50		8 2								
000276	2/14/00		6 9	5	785	5			0 02	0 45	0 4	0 51	0 4		
000278	11/8/99	11/15/00	5 13	84	1700		560								
000278	11/8/99	11/15/00	3 96	346	4740		337								
000278	2/10/00	2/17/00	5 35	30	65		16								
000278	2/10/00	2/17/00	5 38	64	92		23								
000284	11/8/99	6/21/00	8 43	47	1006	6									
000284	3/3/00	6/21/00	8 27	15	1052	6									
000284	4/17/00	6/21/00	8 43	33	798	6									
000284	2/10/00	6/21/00	8 72	14	890	6									
000289	4/18/00	4/18/00	6 6	120	46	10		0 05							
000289	4/18/00	4/18/00	5 1	19	72	10		0 05							
000289	1/17/00	1/19/00	6 4	93	250	14		0 05							
000289	1/17/00	1/19/00	6 4	74	550	10		0 1							
000292															
000297	11/8/99	11/8/99	5 75	51	190	21	160		0 23	7 8					
000297	11/8/99	11/8/99	7 06	82	2200	5	270		0 39	18					
000297	1/25/00	1/25/00	7	46	200	5	38		0 02	3 1					
000297	1/25/00	1/25/00	6 71	42	210	8	40		0 02	3					
000309	1/25/00		7 3	15	16	5		0 02	0 06	0 23	1 7	0 62	0 02		
000309	1/25/00		7 3	7	16	5		0 02	0 02	0 05	1 4	0 21	0 02		
000309	1/25/00		7 3	7	11	5		0 02	0 18	0 57	1 5	0 21	0 37		
000309	1/25/00		8 3	5	38	5		0 02	0 02	0 49	0 1	0 11	0 02		
000309	4/25/00		7 9	7	56	5		0 02	0 02	0 27	0 2	0 26	0 02		
000309	4/25/00		7 4	5	39	5		0 02	0 02	0 07	0 1	0 1	0 02		
000310	4/17/00	4/19/00	6 5	32	6	20									
000310	4/17/00	4/19/00	6 5	12	21	26									
000317															
000321		11/9/99		42	660	3 6		0 024		114					
000321		11/9/99		16	290	3 5		0 013		11 4					
000321		11/9/99		100	210	3 2		0 013		7 6					
000321		11/9/99		62	96	0 4		0 022		1 39					
000321		11/9/99		66	3	0 5		0 033		4 9					
000321	1/25/00	1/25/00		2	4	0 05		0 012							
000321	1/25/00	1/25/00		2	4	0 05		0 017							
000321	1/25/00	1/25/00		2	78	0 7		0 015							
000321	1/25/00	1/25/00		6 9	44	0 4		0 017							
000321	1/25/00	1/25/00		19	330	0 4		0 01							
000323	1/25/00	1/26/00	5 2	27	115	10	26 1								
000323	1/25/00	1/26/00	7 01	36	98	10	17 2								
000323	1/25/00	1/26/00	5 82	17	145	10	21 3								
000323	1/25/00	1/26/00	6 26	30	66	10	17								
000323	3/8/00	3/8/00	6 25	16	31	10	3 85								
000323	3/8/00	3/8/00	6 41	7	37	10	4 69								
000323	3/8/00	3/8/00	6 46	7	46	10	4 57								
000323	3/8/00	3/8/00	6 6	7	35 5	10	2 29								
000335	11/8/99	11/9/99	5 9	90	340	5				1 41	0 28	1 29			
000335	11/8/99	11/9/99	6 3	1314	287	2060				1 88	0 37	2 95			
000335	11/8/99	11/9/99	5 2	93	94	33				1 18	0 34	2 02			
000341	1/25/00	1/25/00	5 85	16	36 4	2	11								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000341	1/25/00	1/25/00	6 07	21	41 8	2	9								
000341	1/25/00	1/25/00	6 1	11	35 7	57 6	8 9								
000341	11/8/99	11/8/99	6 1	16	90 2	2	20								
000341	11/8/99	11/8/99	6 21	19	89 6	4 8	21								
000341	11/8/99	11/8/99	6 41	19	87 8	9 4	20								
000341	12/31/99	1/3/00	5 89	2	110	2	29								
000341	12/31/99	1/3/00	6 03	2	109	2	32								
000341	12/31/99	1/3/00	6 1	2	110	2	32								
000341	2/10/00	2/14/00	5 29	226	137	162	17								
000341	2/10/00	2/14/00	5 35	216	123	18 3	16								
000341	2/10/00	2/14/00	5 53	276	148	62 7	18								
000341	3/3/00	3/6/00	5 68	26	140	2 2	5 1								
000341	3/3/00	3/6/00	5 71	22	142	4 1	7 2								
000341	3/3/00	3/6/00	6 03	14	62 9	5 2	2 16								
000346															
000350	3/7/00	3/8/00	6 42	30	15		4 4								
000350	4/17/00	4/18/00	6 3	58	66		27								
000353															
000355	3/8/00	3/8/00	7 8	77	37	5									
000355	2/10/00	2/10/00	7 22	84	36	13									
000359	11/8/99	11/9/99	7 93	30	10000										
000359	2/27/00	2/29/00	6 56	51	800	1									
000364															
000389	1/25/00	1/25/00	7 06	36	110	5									
000395															
000397	11/8/99	11/8/99	7 1	44	450	4 3									130
000399	2/10/00	2/10/00	7 26	49	62	5									
000399	2/10/00	2/10/00	7 45	38	58	5									
000399	4/17/00	4/17/00	6 89	26	110	5									
000399	4/17/00	4/17/00	6 95	30	130	6									
000399	4/17/00	4/17/00	6 78	16	86	5									
000399	4/17/00	4/17/00	6 92	12	150	5									
000399	4/17/00	4/17/00	6 5	100	150	5									
000399	2/10/00	2/10/00	8 1	38	64	5									
000399	2/10/00	2/10/00	7 77	37	64	5									
000399	2/10/00	2/10/00	7 38	5	40	5									
000404	11/9/99	11/9/99	5	122	2560		1994	0 18		10 2		12 4			
000404	11/9/99	11/9/99	6	48	2475		537	0 18		21 8		2 76			
000404	11/9/99	11/9/99	6 6	6	208		35 2	0 18		5 69		11 7			
000404	1/6/00	1/6/00	4 6	287	669		12 7	0 18		1 52		9 38			
000404	1/6/00	1/6/00	7	192	628		4 45	0 18		0 76		8 18			
000404	1/6/00	1/6/00	6 8	20	590		0 65	0 44		0 18		0 44			
000404	1/6/00	1/6/00	5 8	6				0 18	0 02	0 08		0 08			
000406	2/17/00	2/17/00	6.74	364	448	5	20 8		0 14	2 5			0 07		
000406	2/17/00	2/17/00	6 93	14	901	5	34 9		0 02	0 08			0 07		
000406	1/26/00	1/27/00	7 15	29	364	5 7	44		0 08	0 44			0 07		
000406	1/26/00	1/27/00	6 82	54	793	5 1	50 3		0 15	2 15			0 07		
000410	1/25/00	1/25/00	6 98	70	330	11	53								
000410	2/16/00	2/16/00	7	112	227	14	27								
000411															
000412	11/8/99	11/11/99	5 79	97	283	9	95 5							382	
000412	1/25/00	1/25/00	7 06	14	74	0 5	17 4							90	
000416	2/16/00		9 2	17	190	7									
000416	2/2/00		9 37	90	110	6									
000416	2/2/00		8 27	20	140	5									
000422	4/17/00	4/18/00	7.21	85	279	8 6	34							283	
000422	1/25/00	1/27/00	7 16	92	2833	0 5	83 4								
000438															
000459															
000480	4/17/00	4/21/00	6 86	16	49	0 5									
000480	4/17/00	4/21/00	6 97	14	49	0 5									
000483	2/23/00	2/24/00	7 8	11	61	5	3 7								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000483	2/23/00	2/24/00	8	10	100	5	2 9								
000483	1/25/00	1/27/00	7 7	41	230	5	8 6								
000486															
000487															
000488															
000489															
000490															
000491	4/17/00	4/19/00	6 8	261	373	33	70								
000493	4/17/00	4/19/00	5 65	50	275	33	165								
000494															
000495															
000496															
000497	4/17/00	4/19/00	7 42	141	172	8	16								
000499															
000500															
000502															
000503															
000504															
000505															
000522	2/10/00					4 4								1270	
000522	1/31/00		7 2	77	767										
000522	1/25/00	1/28/00				6 1	31 6					63 6		160	
000522	2/23/00		8 4	870	124										
000524															
000525	1/25/00		6 8	215	5	5	15 4	0 02	0 21	0 33			0 02		
000525	1/25/00		5 8	361	88	5	20 1	0 02	0 1	0 44			0 04		
000525	2/16/00		6 7	224	23	5	4 4	0 02	0 02	0 21			0 02		
000525	2/16/00		6 8	1 8	482	5	16	0 02	0 6	0 39			0 02		
000526	1/25/00		6 8	23	37	5	10	0 02	0 08	0 51			0 02		
000526	2/16/00		6 7	13	65	5	7 7	0 02	0 02	0 62			0 02		
000527	1/25/00		6 7	145	21	6	10	0 2	0 21	0 81			0 02		
000527	1/25/00		6 2	65	13	5	13 4	0 02	0 4	0 69			0 02		
000527	1/25/00		6 5	29	17	5	18 8	0 02	0 08	0 7			0 02		
000527	2/16/00		6 7	54	30	5	8 6	0 07	0 11	0 24			0 02		
000527	2/16/00		6 7	131	571	5	15 4	0 02	0 06	33			0 02		
000527	2/16/00		6 8	138	54	5	15	0 02	0 03	0 31			0 02		
000528	1/25/00		6 5	62	20	5	21 4	0 02	0 06	0 21			0 02		
000528	1/25/00		6 4	36	21	5	16 4	0 02	0 06	0 36			0 02		
000528	2/16/00		6 7	69	71	5	11 4	0 02	0 03	0 18			0 02		
000528	2/16/00		6 9	80	62	5	22 1	0 02	0 02	0 1			0 02		
000530	2/16/00	2/16/00	8 3	4000	180	32			0 22	0 57		140			
000531	2/16/00	2/16/00	7 8	28	42	3 1			0 01	0 021		1 1			
000531	2/16/00	2/16/00	7 7	14	41	3 9			0 01	0 06		0 38			
000538	1/25/00	1/25/00	8 4	230	140	4									
000547															
000552	1/26/00	1/27/00	7 56	756	129 8	2 24									
000553	2/10/00	2/21/00	6 7	36	150	2	130			0 49					
000553	11/8/99	11/10/99	6 2	33	360	4 8	48			3 3					
000557	1/26/00		6 9	1100	310		26								
000557	1/26/00		7.1	150	560		80								
000557	2/10/00		6 9	70	340		110								
000557	2/10/00		5.6	120	1800		710								
000561	2/10/00	2/11/00	7	78	560		200								
000561	2/10/00	2/11/00	7 1	600	1600		100								
000561	2/16/00	2/17/00	6 6	260	400		230								
000561	2/16/00	2/17/00	6 9	100	170		64								
000563	1/26/00	1/27/00	7	367	1050	34 3									
000563	1/26/00	1/27/00	6 6	1140	1010	105									
000563	11/8/99	11/8/99	6 46	141	2330	44									
000563	11/8/99	11/8/99	7 03	215	2110	10									
000564															
000577	3/8/00		7.53	77	36	5		0 58				3 9			10

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000584	2/10/00		6 7	47	78	5				2 38	0 4	0 51			
000588	3/8/00	3/8/00	7 03	19	30	0.69									
000588	3/8/00	3/8/00	7 08	222	40	0 83									
000588	3/8/00	3/8/00	7 1	45	40	0 74									
000588	3/8/00	3/8/00	7 36	185	70	2 8									
000588	3/8/00	3/8/00	7 32	10	33	95									
000588	3/8/00	3/8/00	7 18	11	52	1 2									
000588	3/8/00	3/8/00	7 41	10	20	0 5									
000588	3/8/00	3/8/00	7 2	10	35	1 1									
000588	3/8/00	3/8/00	7 17	10	38	0 05									
000588	3/8/00	3/8/00	7 17	19	47	6 1									
000588	3/8/00	3/8/00	6 83	29	40	0 57									
000591	3/8/00		7 1	15	38	4									
000597															
000603	1/25/00	1/25/00	7 1	14	36	4	3								
000603	1/25/00	1/25/00	7 2	150	89	17	44								
000604	2/10/00	2/14/00	9 81	109	98	5									
000604	11/8/99	11/8/99	8 03	6	370	5									
000612															
000618	1/25/00	1/28/00	7 56	28	103	5								32	3
000618	1/25/00	1/27/00	7 5	189	104	5								64	2
000618	4/17/00	4/18/00	6 6	44	52 8	5 4								19 1	11 6
000618	4/17/00	4/18/00	6 8	24	91 1	7								95 3	33 7
000640	1/25/00	1/28/00				5									
000640	2/21/00	2/22/00				5									
000642	11/8/99		6 4	44	130	4									
000642	11/8/99		6 7	78	300	6									
000642	11/8/99		6 8	27	130	4									
000642	11/8/99		6 8	34	120	4									
000642	2/16/00		7 9	47	100	4									
000642	2/16/00		7 9	32	80	4									
000642	2/16/00		7 7	52	100	6									
000642	2/16/00		7 8	9	130	4									
000642	4/17/00		7 6	4	20	4									
000642	4/17/00		7 6	4	20	4									
000642	4/17/00		7 6	4	20	4									
000642	4/17/00		7 6	4	20	4									
000643															
000645	4/17/00	4/18/00	8 9	12	760	15	80								
000656	3/8/00	3/16/00	6 54	9	14		1 2								
000656	4/17/00	4/17/00	6 53	50	220		83							380	
000660	1/25/00	1/27/00	6 94	408	132	30	43 8							571	
000660	2/16/00	2/17/00	7 33	492	150	45 5	25							562	
000662															
000663	4/17/00	4/18/00	6	95	284	7			0 2	2 56	5 62			296	73
000663	4/17/00	4/18/00	7 3	78	166	5			0 04	1 01	5 76			82	16
000667															
000668	1/25/00		5 08	17 3	4	1 73	2								
000668	11/8/99		4 3	20 6	4	2 3	2								
000673	1/25/00	1/26/00	7	30	340	5			0 12	5					
000673	11/8/99	11/11/99	6 5	78	380	24			0 23	14					
000675															
000677															
000680	2/10/00	2/11/00	5 58	47	159	15 4									
000685	11/8/99	11/8/99	6 7	37		2 8	92								
000685	11/8/99	11/8/99	6 7	20		5 2	119								
000685	1/25/00	1/26/00	6 9	6		2	6 8								
000685	1/25/00	1/26/00	7	5		4	8 5								
000687															
000688															
000718	4/17/00	5/17/00	6 64	69	532	10									
000719															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000723	11/8/99	11/9/99	6 2	220	1000		64				7 7	15 1			
000724	1/25/00		8 85	9352	130	2	11								
000724	1/25/00		10 39	363	198	1 1	11								
000724	2/12/00			165		0 3	7 5								
000724	2/12/00			165		0 8	6 8								
000729	1/25/00		6 12	34	94 5	1 65									
000729	2/14/00		6 75	10	69 1	1 1									
000748															
000751	4/17/00	4/21/00	6 17	86	20	1					1 86			70	
000752	4/17/00	4/20/00	6 63	164	144	4					0 388			170	
000759	1/25/00	1/26/00	6 55	12	51	30									
000759	4/17/00	4/17/00	6 2	27	41 9	5									
000759	9/23/99	9/23/99	1 36	420	19400	6									
000762	1/24/00		6	5	14	5				1 45	0 1	0 03			
000771															
000773	1/25/00		6 4	24	24	5	11								
000773	1/25/00		6 6	19	47	5	13								
000777	1/25/00	1/25/00	6 6	96	990	34	120					850			
000777	1/25/00	1/25/00	8 6	95	270	5 2	27					1800			
000777	11/8/00	11/8/00	8 8	56	340	9 6	100					1			
000777	11/8/00	11/8/00	9 3	59	320	5	49					2 7			
000779															
000787															
000797	1/25/00	1/26/00	7 18	8	718	5 2									
000797	1/25/00	1/26/00	9 28	34	725	5 2									
000797	1/25/00	1/26/00	7 01	40	697	5 2									
000797	1/25/00	1/26/00	7 25	86	577	5 2									
000797	2/14 00	2/16/00	6 47	2	778	5 2									
000797	2/14 00	2/16/00	7 06	4	744	5 2									
000797	2/14/00	2/16/00	7 11	4	711	5 2									
000797	2/14/00	2/16/00	7 18	8	718	5 2									
000799															
000805	11/8/99	11/8/99	6 1	47			82								
000805	11/8/99	11/8/99	6 1	170			250								
000812	2/9/00		6 96	15 85											
000812	2/9/00		7 03	16 02											
000830	11/8/99	11/8/99	7 7	760	200	11									
000830	3/6/00	3/6/00	8	24	120	4									
000835															
000835	11/8/99	11/11/99	6 46	39	115	8 5		0 02		0 84					
000835	11/8/99	11/11/99	6 24	55	157	1		0 02		0 27					
000841	1/4/00	1/4/00	8.2	98			42								
000841	1/4/00	1/4/00	8 2	10			18								
000841	1/4/00	1/4/00	8 3	38			35								
000841	1/4/00	1/4/00	2.23	24			13								
000847	2/16/00	2/18/00	2 6	430	1100	11	11			0 95					
000847	2/16/00	2/18/00	2 2	180	3400	12	6 4			0 56					
000847	4/17/00	4/18/00	6 6	76	120		22			0 44					
000847	4/17/00	4/18/00	6.8	39	61		24			0 38					
000850	1/25/00	1/26/00	7	84	1800		24 4								
000850	2/14/00	2/15/00	7	10	670		16 5								
000858	4/17/00	4/19/00	6 9	20	676	3									
000858	1/25/00	1/26/00	7 7	130	590	4		0 04	0 14	0 15	7 7		0 01		
000858	1/30/00	2/1/00	8 4	1560	463	4		0 12	0 18	0 34	91		0 03		
000858	2/10/00	2/11/00	7 7	350	425	3		0 03	0 09	0 14	29 3		0 01		
000858	2/10/00	2/11/00	7 6	20	685	3		0 01	0 1	0 17	2 4		0 01		
000858	2/10/00	2/11/00	7 4	70	234	3									
000858	4/17/00	4/19/00	6 9	50	668	4		0 01	0 09	0 11	3 6		0 01		
000858	4/17/00	4/19/00	8 4	20	299	3		0 01	0 03	0 07	7 5		0 01		
000862	11/8/99	11/17/99	7 1	54	0 261	2	44			1 6					
000862	2/21/00	2/28/00	7 3	35	0 14	3 3	3			0 24					
000865	2/14/00	2/14/00	8 89	196	91										

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000865	2/28/00	2/28/00	7 92	224	86										
000868	1/25/00		6 48	48 6	57 9	5									
000868	1/25/00		6 09	76 1	81	5									
000868	2/14/00		6 78	10	119	5									
000868	3/5/00		5 73	56 7	53 9	5									
000868	3/5/00		6 47	10	54 6	5									
000869	1/25/00	1/25/00	7 53	35	100	5	14								
000869	1/25/00	1/25/00	7 43	299	83	5	11								
000869	1/25/00	1/25/00	7 72	145	72	5	6 7								
000869	2/16/00	2/16/00	7 91	34	110	5	14								
000869	2/16/00	2/16/00	7 45	142	110	5	16								
000869	2/16/00	2/16/00	7 17	31	56	5	6 9								
000871	1/25/00	1/26/00	7 05	55	4 1	0 5	29								
000871	2/16/00	2/16/00	6 89	86	186	0 5	3 3								
000881															
000883	2/10/00	2/14/00	6 47	149	93	14 5		0 99	0 39	0 63				234	
000888	11/8/99	11/8/99	6 98	676	3500		390								
000888	1/25/00	1/25/00	7 14	96	440		37								
000904	1/28/00	2/2/00	6 27	10	471	18		0 037	0 347	3 85					
000909															
000910	2/10/00	2/10/00	6 81	5 5	73 3	1			0 08						
000910	1/17/00	1/17/00	7 24	10 5	95 6	2			0 05						
000913	11/8/99	11/9/99	7 2	570	1410		171							750	
000913	11/8/99	11/9/99	7 6	170	410		71 9							370	
000913	11/8/99	11/9/99	7	260	1400		197							710	
000913	1/25/00	1/26/00	6 08	181	90		16							122	
000913	1/25/00	1/26/00	6 84	133	70		16 5							24	
000913	1/25/00	1/26/00	6 77	224	100		27							53	
000913	4/17/00	4/19/00	6 5	148	152		41 6							104	
000913	4/17/00	4/19/00	7	178	143		44 4							98 8	
000913	4/17/00	4/19/00	7 2	840	316		102							258	
000914	1/25/00	1/25/00	7 08	28	62	10 3	12 6			0 31					
000914	2/10/00	2/10/00	7 9	15	70	8 7	10			0 39					
000915	1/25/00	2/4/00	6 3	43	0 105	46									
000915	2/16/00	2/18/00	2 9	6	0 473	2									
000923	1/25/00	1/25/00	7 2	138	67	5		0 05	0 03	0 3					
000923	2/23/00	2/23/00	8 3	96	52	7		0 05	0 02	0 15					
000929															
000930	11/8/99	11/10/99	6 23	242	612	3 65									
000930	2/16/00	2/23/00	7.54	2240	68 5	1									
000935															
000947	1/25/00	1/31/00	6 87	244		15									
000948	1/27/00	1/27/00	6 7	5	43	6 7								35	
000948	2/14/00	2/14/00	6 78	18	30	8 5								39	
000949	2/10/00	2/14/00	6 42	45	188	5	14 4					4 54			
000949	2/10/00	2/14/00	6 12	38	45	5 1	8 2					2 7			
000949	2/10/00	2/14/00	6 8	25	276	8 4	30 2					1 5			
000952	4/17/00	4/17/00	7	81		14	310								
000952	4/17/00	4/17/00	7 1	160		12	310								
000952	4/17/00	4/17/00	7 1	19		6 7	85								
000952	4/17/00	4/17/00	7 2	19		3 7	76								
000954	1/24/00	1/25/00	7 4	14	104	1									
000954	11/8/00	11/9/00	7 1	15	170	4 6									
000954	11/8/00	11/8/00	6 7	8	160	3 8									
000954	1/24/00	1/25/00	7 2	11	82 8	0 8									
000955	2/10/00		6 3	52	180	5	82								
000955	2/10/00		6 8	32	180	6	58								
000955	2/10/00		7 2	260	290	33	80								
000955	3/3/00		6 3	96	220	5	84								
000955	3/3/00		6 8	53	200	5	55								
000955	3/3/00		7 1	370	230	5	60								
000956															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
000959	4/17/00	4/19/00	6	180	640		11 7		0 1	4 4	3 1	7 4			
000959	4/17/00	4/19/00	5 6	120	44		13 2		0 2	7 5	3 6	17			
000961	11/8/99	11/8/99	9 19	66	310	9 4									
000961	11/8/99	11/8/99	7 04	126	249	20 5									
000961	11/8/99	11/8/99	8 51	57	124	14 3									
000961	1/17/00	1/18/00	8 11	342	243	39 5									
000961	1/17/00	1/18/00	7 99	345	171	79 2									
000961	1/17/00	1/18/00	8 28	686	577	12 9									
000965	1/25/00	1/25/00	7 2	18	4450	9 4	12								
000965	1/25/00	1/25/00	7 4	757	1020	28 2	46								
000965	2/16/00	2/17/00	7 4	28	3520	8 8	22								
000965	2/20/00	2/20/00	7 2	8	3440	4 6	6 2								
000965	2/20/00	2/20/00	7 1	6	43000	3 7	0 5								
000965	3/1/00	3/7/00	6	48	330	6 2	3 7								
000965	3/1/00	3/7/00	7 1	10	3500	4	0 5								
000965	3/5/00	3/7/00	6 3	37	227	5	5 7	0 413	0 149	1 22			0 069	79	
000965	1/25/00	1/25/00	7 2	18	4450	9 4	12								
000965	1/25/00	1/25/00	7 4	757	1020	28 2	46								
000965	2/16/00	2/17/00	7 4	28	3520	8 8	22								
000965	3/1/00	3/7/00	6 3	37	227	5	5 7							79	17 6
000965	3/1/00	3/7/00	7 1	10	3500	4	0 5							0 1	2
000965	3/1/00	3/7/00	6	48	330	6 2	3 7							0 1	2
000965	3/1/00	3/7/00	6 3	37	227	5	5 7							79	227
000965	2/20/00	2/20/00	7 2	8	3440	4 6	6 2								
000965	2/20/00	2/20/00	7 1	6	43000	3 7	0 5								
000969	9/21/99	10/5/99	7 12	23		1	110		0 08	2 09					
000969	2/10/00	2/14/00	6 73	52		10 5	10 6		0 01	0 09					
000973	1/25/00	1/27/00	8 8	4	19	4	3								
000973	4/17/00	4/20/00	6 5	23	110	4	20								
000981	11/8/99	11/9/99		40	325		104								
000981	1/25/00	1/26/00	6 9	17	85		20 8								
000986	11/16/00	11/16/00	7	54	346	2	17								
000986	6/5/00	6/5/00	6 6	44	638	7	85								
000994	1/25/00	1/25/00	6 83	41	49	3			0 16			0 78			
000994	1/25/00	1/25/00	6 42	29	113	4			0 16			0 5			
000994	1/25/00	1/25/00	6 35	21	326	3									
000994	1/25/00	1/25/00	6 67	11	150	3			0 16			0 5			
000994	1/25/00	1/25/00	6 44	9	217	3									
000994	1/25/00	1/25/00	6 89	81	71	3			0 16			5 2			
000994	1/25/00	1/25/00	6 25	11	85	3			0 29			0 5			
000994	1/25/00	1/25/00	6 66	1909	117	7									
000994	1/25/00	1/25/00	6 95	25	39	3									
000994	1/25/00	1/25/00	6 37	10	173	3									
000994	2/20/00	2/21/00	7 01	29	90	6 8			0 16			0 5			
000994	2/20/00	2/21/00	7 15	17	45	6 8			0 16			0 05			
000994	2/20/00	2/21/00	7 32	7	53	6 8									
000994	2/20/00	2/21/00	7 96	4	58	6 8			0 16			0 5			
000994	2/20/00	2/21/00	7 27	6	85	6 8									
000994	2/20/00	2/21/00	7 58	15	97	6 8			0 16			0 6			
000994	2/20/00	2/21/00	6 9	14	34	6 8			0 16			0 5			
000994	2/20/00	2/21/00	7 39	8	34	6 8									
000994	2/20/00	2/21/00	7 41	8	25	6 8									
000994	2/20/00	2/21/00	7 35	4	24	6 8									
001009	2/10/00		6	83	40	5				1 65	3 4	3 73			
001017	1/25/00	1/25/00	8 53	26	6280	4					0 25	0 438			
001017	11/8/99	11/9/99	6 5	60	5490	1					2 44	2 44			
001029	11/8/99	11/8/99	6 33	110	690	5									
001029	2/10/00	2/11/00	6 92	144	87	8									
001030	1/25/00	1/25/00	7 37	379	140	5	7 8				4 7		0 02		
001030	1/25/00	1/25/00	6 8	39	42	5	5 3				1		0 02		
001030	1/25/00	1/25/00	7 32	404	330	11	19				8		0 05		
001030	1/25/00	1/25/00	7 08	59	77	5	19				0 97		0 05		

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001038	1/25/00	1/28/00	6 29	188	110		16	0 05	0 07	0 49					
001038	1/25/00	1/28/00	6 49	243	110		19	0 07	0 08	0 51					
001038	1/25/00	1/28/00	6 63	100	50		6 3	0 02	0 04	0 38					
001038	2/16/00	2/18/00	7 48	344	150		14	0 11	0 2	0 65					
001038	2/16/00	2/18/00	7 19	210	140		22	0 16	0 11	0 54					
001038	2/16/00	2/18/00	6 74	220	75		9 6	0 06	0 2	0 62					
001041															
001060	2/10/00	2/15/00	6 17	68	50	0 5								100	
001069	1/25/00		7	31	33	7				0 19	0 3	0 25			
001070	4/17/00	4/18/00	6 4	21	100	4 1	15								
001071	11/8/99	1/27/00	6 55	220	236	2 3	68								
001071	12/31/99	1/27/00	6 6	355	196	6 6	45								
001071	1/25/00	1/27/00	6 86	70	123	3	39								
001071	1/25/00	1/27/00	6 79	100	320	15	81								
001071	12/31/99	1/27/00	6 36	485	358	16	65								
001071	11/8/99	1/27/00	7 07	640	920	31	332								
001071	2/23/00	2/29/00	7 18	448	67	31	2 2								
001071	2/23/00	2/29/00	6 37	164	29	4 9	3 3								
001071	2/23/00	2/29/00	5 76	8	20	4 6	12								
001076															
001082															
001093															
001096															
001102															
001106	4/17/00	4/21/00	6 2	12	21	1									
001107		1/25/00	5 84	18	84 6	5									
001107		11/8/00	7 01	23 5	144	16 2									
001107	1/25/00	1/25/00	5 91	16 3	66 8	5									
001107	11/8/99	11/8/99	7 01	23 5	144	16 2									
001134															
001135	4/17/00	4/19/00	6 77	48	118	5		0 046	0 055	9 35					
001136	2/23/00	2/23/00	6 23	153		5									5
001136	3/8/00	3/8/00	6 97	19		5									
001136	4/17/00	4/18/00	5 78			5				0 37					
001136	1/25/00	1/25/00	6 92	280		14 3									25 3
001136	2/16/00	2/16/00	8 9	18		18 4									5
001137	1/25/00	1/25/00	7 2	45	293	3		0 57	0 16	0 77				200	
001137	2/10/00	2/11/00	7 04	57	170	3		0 57	0 16	2				158	
001140															
001141		10/10/99	7	19	0 091	28									
001141	2/23/00	2/24/00	6 6	28	0 049	2 6									
001142	1/25/00	1/25/00	6 2	61	19		3 6								
001142	11/8/00	11/8/00	6 38	319	90		25								
001142	11/8/99	11/8/99	6 38	319	90		25								
001142	1/25/00	1/25/00	6 2	61	19		3 6								
001142	2/10/00	2/11/00	6 66	182	95		22								
001143	1/17/00	1/18/00	6 8	23	86		40								
001143	1/17/00	1/18/00	7 3	64	220		91								
001143	1/17/00	1/18/00	7 3	21	77		37								
001143	4/17/00	4/17/00	6 7	10	17		4								
001143	4/17/00	4/17/00	6 6	10	19		4								
001143	4/17/00	4/17/00	6 2	17	37		18								
001165	1/25/00	1/26/00	6 92	81	75	5									
001165	2/10/00	2/11/00	6 9	58	69	5									
001178															
001183	1/25/00	1/26/00	6 9	36	86	5			0 03	1 3					
001183	1/25/00	1/28/00	6 4	88	400	5			0 04	3 7					
001183	2/10/00	2/14/00	6 8	150	100	5			0 07	1 6					
001183	2/10/00	2/14/00	6 9	110	95	5			0 05	1 3					
001196															
001198	2/16/00	2/17/00	6 3	11	17	3	6 3			0 0771	0 094	0 139			
001198	2/16/00	2/17/00	6 3	42	18	3	3 8			0 222	0 424	0 632			

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001198	2/16/00	2/17/00	6 7	4	23	3	7 2			0 119	0 059	0 1			
001198	2/16/00	2/17/00	6 8	41	27	4	5 3			0 156	2 07	2 72			
001199	11/8/99	11/10/99	7 33	50	235	2 85		0 016		0 668					
001205															
001217															
001231	2/21/00	2/22/00	5 76	6 8	71000	1 9			0 2	7 2	0 3	0 83			
001231	2/21/00	2/22/00	6 41	59 3	62000	9 6			0 24	0 49	0 4	0 81			
001235	2/21/00	2/22/00	8 4	41	20	4				1 1	2	3 1			
001235	4/17/00	4/18/00	7 4	40	20	4				0 2	0 1	1 4			
001238	2/10/00	2/11/00	6 57	116	320	5	81								
001238	3/8/00	3/8/00	7 33	5	23	5	3 3								
001264	1/25/00	1/25/00	6 8	110	110	4									
001264	1/25/00	1/25/00	7 3	7	16	4									
001264	1/25/00	1/25/00	7 1	32	62	4									
001264	3/8/00	3/8/00	7 6	4	36	4									
001264	3/8/00	3/8/00	7 1	4	37	4									
001264	3/8/00	3/8/00	5 9	6	31	4									
001265	2/23/00	2/23/00	6 4	35	134			0 1	0 25	0 23	1 1	3 15	0 1	40	
001267															
001268															
001270	11/8/99	11/8/99	6 9	110	580		110								48
001270	1/25/00	1/25/00	7	21	50		13								13
001271	2/10/00	2/10/00	6 45	166	358	7							0 755		
001271	2/10/00	2/10/00	8 31	80	174	12									
001271	2/10/00	2/10/00	8 52	962	211	38									
001271	2/10/00	2/10/00	8 82	50	127	19							0 0534		
001271	4/17/00	4/17/00	6 86	183	1110	9							0 474		
001271	4/17/00	4/17/00	6 96	59	347	8							0 0532		
001271	4/17/00	4/17/00	7 07	67	255	13									
001271	4/17/00	4/17/00	7 83	363	232	39									
001292															
001298	1/25/00	1/31/00	6 22	40	568	1		0 012		0 514					
001299	11/8/99	11/8/99	6 04	35	200			0 15	0 09	1 1					
001299	11/8/99	11/8/99	6 15	21	150			0 14	0 07	0 73					
001299	1/25/00	1/25/00	6 75	59	47			0 17		0 28					
001299	1/25/00	1/25/00	7 41	112	52	8		0 09		0 32					
001300	1/25/00	1/25/00	7 41	88	59			0 16		0 63					
001300	11/8/99	11/8/99	7 13	362	450	5		0 38	0 13	2 7					
001300	11/8/99	11/8/99	6 8	66	240	6		0 25	0 1	2 3					
001300	1/25/00	1/25/00	7 62	124	91	6		0 2		0 83					
001306	11/8/99	11/9/99	7 5	382	1770		32 5					29			
001309															
001310	4/17/00	4/20/22	6 58	150	193		22	0 065	0 163	2 95			0 128		
001310	4/17/00	4/20/00	6 4	100	286		150	0 047	0 2	3 24			0 235		
001310	4/17/00	4/20/00	6 67	170	167		66	0 171	0 137	0 957			0 481		
001310	4/17/00	4/20/00	6 6	140	286		38	0 044	0 116	5 02			0 082		
001310	4/17/00	4/20/00	6 3	90	178		52	0 026	0 075	1 87			0 225		
001330	4/17/00	4/18/00	6 79	42 4	375	39 7		0 11	0 31	0 43			0 06	736	
001338	1/25/00		8 32	66	0 91	5						3 59			
001338	1/25/00		8 3	294	0 11	5						14 8			
001338	1/25/00		9 8	180	0 34	5						8 69			
001338	11/10/99		6 75	1840	0 32	21						12 4			
001338	11/23/99		6 87	3500	147	31 7						54 1			
001338	11/8/00		6 26	64	186	5						1 12			
001338	11/8/99		9 04	1090	0 67	5						13 8			
001338	11/8/99		8 35	749	0 22	7 6	5 25								
001338	11/8/99		8 01	1570	1 06	5						6 25			
001338	2/10/00		7 23	89	111	5						1 47			
001338	2/10/00		8 2	25	0 3	11 6						1 03			
001338	2/10/00		8 85	433	0 42	13 8						2 06			
001338	2/10/00		9 58	192	0 28	17 7						2 36			
001338	2/10/00		10 29	128	0 28	10 8						2 95			

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001338	2/14/00		7 97	47	0 24	5						2 95			
001338	2/15/00		7 3	2	0 55	4 6						0 65			
001338	2/16/00		7 82	19	147	5						1 08			
001338	2/16/00		8 18	26	0 27	5									
001338	2/16/00		8 35	7	70	5									
001338	2/16/00		8 25	206	0 25	5									
001338	2/16/00		6 85	16	0 29	5									
001338	2/16/00		6 95	44	124	16 2						1 31			
001338	2/16/00		7 9	218	141	14 6						1 41			
001338	2/16/00		8 3	70	395	5						1 54			
001338	2/21/00		8 82	50	0 85	5						1 7			
001338	2/21/00		7 93	112	1 49	32						1 7			
001338	2/21/00		9 07	181	1 69										
001338	2/23/00		7 92	138	51 8	5									
001338	2/23/00		8 59	608	0 39	5									
001338	2/23/00		9 31	3670	0 71	5						85 3			
001338	2/24/00		9 5	213	165	5						8 48			
001338	2/25/00		8 3	14	74 9	5									
001338	4/17/00		10 99	221	1 37	18 3						6 44			
001338	4/17/00		8 32	830	76 1	5						58 1			
001338	4/17/00		9 27	1630	150	6						8 86			
001338	4/17/00		10 98	140	0 58	7 6						2 28			
001338	4/18/00		7 67	75	0 77	5						2 28			
001338	4/18/00		7 68	137	3 06	5						1 74			
001338	4/18/00		8 2	360	134	5						10 5			
001338	4/18/00		9 3	23	102	8 6						4 16			
001339															
001358	4 17-00	4/18/00	5 9	730	1800	4 6	29	0 37	0 45	7 5			0 14		
001358	1 25-00	1/25/00	5 92	8	46		8								
001359	2 16 00	2/16/00	6 39		47	1	6 3								
001359	3/8-00	3/8/00	5 86	4	23	1	2 2								
001360															
001360															
001361															
001362															
001363															
001365	4/17/00	4/17/00	7 82	282	197	3 1		0 071	0 17	3 9			0 88		
001365	4/17/00	4/17/00	8 1	102	84	1 5		0 026	0 063	0 32			1 3		
001380	4/6/00	4/6/00	6 28	21	27	3									
001380	7/5/00	7/5/00	5 69	8	41	3									
001400	2/10/00	2/10/00	7 7	160	2000	5									
001400	1/25/00	1/25/00	6 4	34	140	2 8									
001401															
001412	1/25/00	1/25/00	6 26	5 8	131	5				10 6	0 5				
001412	1/25/00	1/25/00	6 24	9 4	820	5				6 21	0 5				
001412	1/25/00	1/25/00	6 4	5 2	77 5	5				1 4	0 5				
001412	1/25/00	1/25/00	6 32	5	86 4	5				7 71	0 5				
001412	1/25/00	1/25/00	6 34	4 2	49 7	5				1 19	0 5				
001412	2/14/00	2/15/00	6 01	1	59 1	5				0 36	0 5				
001412	2/14/00	2/15/00	6 02	1	82 9	5				0 59	0 5				
001412	2/14/00	2/15/00	6 04	1	61 4	5				1 13	0 5				
001412	2/14/00	2/15/00	6 05	1	102 2	5				4 68	0 5				
001412	2/14/00	2/15/00	6 64	1	55 1	5				0 45	0 5				
001413	1/25/00	1/25/00	6 31	14 4	137	5				9 77	0 56				
001413	2/14/00	2/15/00	5 92	1	185 2	5				8 87	0 5				
001421	4/17/00	4/18/00	6 4	1100	1300	1 6	27	0 29	0 18	1 9	1		0 06	500	
001421	4/17/00	4/18/00	6 1	130	300	1	18	0 05	0 13	0 68			0 04	160	
001423	3/8/00	3/16/00		39		10 4	4 18								
001423	2/10/00	2/29/00		175		6 4	25 9								
001424	2/10/00	2/29/00		40		7.1	61.9								
001424	3/8/00	3/16/00		250		8.7	81.3								
001425	4/18/00	4/19/00	6 38	180	441		450								

R0012591

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001431	11/8/99	11/8/99	6 7	18	180	4 2									
001431	1/25/00	1/25/00	7 1	19	83	5									
001431	1/25/00	1/25/00	6 6	32	21										
001433	11/9/99	11/9/99	7 87	293	876	65	180								
001433	11/9/99	11/9/99	8 11	358	415		42								
001433	1/25/00	1/25/00	7 3	69	398		30								
001433	1/25/00	1/25/00	7 7	140	228		30								
001433	2/18/00	2/18/00	6 54	170	251	35	165								
001433	2/18/00	2/18/00	7 46	623	258		11								
001433	4/20/00	4/24/00	6 82	87	812	60	111								
001433	4/20/00	4/24/00	6 92	763	967		169								
001434															
001435	2/11/00	2/11/00	9 3	284	1 31	32	36							882	226
001435	4/17/00	4/19/00	6 88	36	0 63	5	26							119	26 5
001436	4/17/00	6/16/00	6 59	25	11000		6 2								
001436	4/17/00	6/16/00	6 57	20	410		3								
001448	1/25/00	1/26/00	6 77	16	108	2	18	0 018		0 51					
001448	1/25/00	1/26/00	6 74	16	124	2 7	24	0 061		0 63					
001448	11/8/99	11/9/99	6 67	10	1850	3 3	141	0 29		2 9					
001451	2/1/00	2/1/00	8 1	110	100	8		0 36			3 5	6 9			
001451	2/21/00	2/21/00	7 6		55	0 7		0 021			0 62	0 84			
001463															
001469															
001477	4/17/00	4/17/00	8	30	28 5										
001477	4/17/00	4/17/00	1 38	167	32 7										
001477	4/17/00	4/17/00	1 28	105	27 5										
001477	4/17/00	4/17/00	7 5	51	22 9										
001482	11/8/99	11/8/99	7 24	46	210		118			0 39					
001482	1/25/00	1/26/00	6 79	22	84		32 5			0 254					
001490	4/19/00	4/20/00						5	25	250					
001493															
001502	1/17/00		7 1	4	120	0 4									
001502	1/17/00		7 9	88	87	7 8									
001502	11/8/99		7 6	28	170	11									
001502	2/16/00	2/17/00	7 9	88	87	7 8									
001502	4/17/00	4/19/00	7 09	5	102	0 7									
001511	1/10/00	1/10/00	6 4	71	187				0 087	0 138					
001511	3/10/00	3/10/00	6 18		17					1 35					
001524															
001526	11/8/00	11/15/99		82		47	119								
001526	1/25/00	1/25/00	6 76	53	121	10 9	26 6								
001527	1/25/00	1/25/00	7 37	815	188	14 7						41 9			
001527	1/25/00	1/25/00	7 78	1530	148	8 4						62 4			
001527	2/14/00	2/14/00	7 86	1800	313	19 9						115			
001527	2/14/00	2/14/00	7 27	1180	254	12 5						69 8			
001540	2/16/00	2/16/00	7 9	218	141	14 6						1 41			
001542	2/16/00	2/16/00	6 95	44	124	16 2						1 31			
001543	2/10/00	2/10/00	10 29	128	0 28	10 8						2 95			
001571															
001580	1/25/00	1/26/00	7 2	28	53	21									
001580	2/21/00	2/23/00	7 2	72	41	7 5									
001584	1/25/00	1/25/00	7 5	60	26 1	3									
001584	1/25/00	1/25/00	7 4	36	67 6	12									
001584	1/25/00	1/25/00	7 8	95	228	3									
001584	2/13/00	2/13/00	7 9	48	33 8	3									
001584	2/23/00	2/23/00	7 2	492	28 7	5									
001584	2/23/00	2/23/00	8	8150	337	5									
001584	2/23/00	2/23/00	8 3	1550	393	5									
001584	3/5/00	3/5/00	8 3	62	35 5	2									
001585	1/25/00	1/28/00	6 46	180	128	5	44							250	86
001585	1/25/00	1/28/00	7 09	188	457	5	135							730	330
001585	11/8/00	11/9/00	7.68	113	965	200	190							1000	390

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001585	11/8/99	11/9/99	7 55	114	804	86	82							420	76
001585	2/1/00	2/5/00	7 48	64	751	60	58							300	96
001585	2/1/00	2/5/00	6 66	280	549	22	69							490	160
001590															
001594	2/20/00	2/22/00	7 6	133	120	5									
001594	4/17/00	4/17/00	6 93	14	38	1									
001597															
001604	1/25/00	1/26/00	9 2	330	127		7 8								
001604	1/25/00	1/26/00	9 2	70	229		10								
001604	1/25/00	1/26/00	8 4	70	175		14 3								
001604	1/25/00	1/26/00	7 6	110	139		14 7								
001604	1/25/00	1/26/00	7 3	50	80		16 1								
001604	1/25/00	1/26/00	7 5	130	88		8 8								
001606	11/8/99	11/8/99	6	45	2650							0 08			
001606	1/25/00	1/26/00	4 9	177	578							7 02			
001606	4/17/00	4/19/00	5 8	18	283	5 1						1 1			
001609															
001612															
001617	11/8/00	11/8/00	7	124	436				7 36	28 2	5 29	6 64			
001617	11/5/00	11/8/00	7 03	79	420				6 24	22 6	2 11	2 7			
001621	4/17/00	4/18/00	5 73	180	420	0									
001635															
001637	2/10/00	2/10/00	6 3	94	96										
001637	2/10/00	2/10/00	5 91	37	96										
001637	4/17/00	4/17/00	5 63	12	15		4 8								
001637	4/17/00	4/17/00	5 97		283		5 1								
001637	4/17/00	4/17/00	5 87	8	66		14								
001637	4/17/00	4/17/00	5 93	550	72		19								
001651															
001660															
001661	1/25/00		6 88	42	288	0 5	4 7								
001661	1/25/00		6 92	41	293	0 5	6 2								
001661	1/25/00		6 83	41	271	0 61	118								
001661	2/10/00		7 18	30	152	0 5	4 4								
001661	2/10/00		7 62		159	0 5	3								
001661	2/10/00		8 36	46	149	0 5	3								
001679	1/25/00	1/25/00	6 29	53	160		77			2 9					
001679	1/25/00	1/25/00	6 85	13	67		14			4 1					
001679	2/16/00	2/16/00	7.16	17	98		16		0 03	4					
001679	2/16/00	2/16/00	7 18	28	79		7 3		0 03	4 5					
001684															
001687	12/31/99	1/10/00	6 45	28	67			0 011	0 075	0 079					
001687	3/8/00	3/10/00	6 1	9	30					0 16					
001689															
001690															
001693															
001697															
001716	1/31/00	2/1/00	7 3	56	280	130				2 7	0 6				
001716	3/8/00	3/9/00	7 4	5	39					1	0 1				
001717															
001740															
001748															
001760															
001761	1/25/00	1/26/00	6 16	10	55	10	13								
001761	1/25/00	1/26/00	6 46	21	28	12	6 2								
001761	1/25/00	1/26/00	6 44	50	22	14	4 3								
001761	1/25/00	1/26/00	6 54	23	25	12	4 3								
001761	4/17/00	4/19/00	6 27	22	15.7	31	6 9								
001761	4/17/00	4/19/00	6 86	13	71	19	4 1								
001761	4/17/00	4/19/00	6 23	18	13 8	24	6								
001761	4/17/00	4/19/00	6 36	32	16	38	6 4								
001772	4/17/00	5/3/00	6 53	98	47	7 3			0 13	0 57	1 3	1 7			

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001777	1/25/00	1/26/00	4 51	83	240			0 08	0 39		21				
001777	2/27/00	2/29/00	6 11	25	85	5		0 01	0 02		0 73				
001781															
001782	1/25/00	1/25/00	7 3	16	68					0 47	0 46	0 63			
001782	1/25/00	1/25/00	6 79	16	92					0 47	0 55	0 68			
001782	4/17/00	4/17/00	7 82	32	172					1 2	1 2	1 6			
001782	4/17/00	4/17/00	7 34	114	146					1 1	2 6	3			
001786	1/14/00	1/17/00	6 3	24	445									292	
001786	4/17/00	4/19/00	6 71	26	118	5 5								30	
001786	2/22/00	2/23/00	7 22	24	106	15 8								2320	
001786	2/10/00	2/10/00	6 64	16	310	6 3								191	
001791	1/25/00	1/25/00	6 57	33	160		12								
001794	1/25/00	5/10/00	6 09	24	140										
001794	2/23/00	5/10/00	6 01	16	90 3										
001798	2/10/00	2/11/00	6 56	28	77	5	27		0 15	3 9					
001798	4/17/00	4/18/00	6 47	47	72		35		0 16	2 9					
001799	4/18/00		6 2	30	1171	5				19 6	2 7	1 17			
001800															
001801															
001802	2/23/00	2/23/00	2 54	158	1863	7 7		0 79	0 14	0 92			0 13	101	
001803	11/8/99	11/9/99	6 8	23	210	8			0 08	0 61					
001803	1/25/00	1/26/00	6 9	6	78				0 03	0 2					
001811	1/25/00	1/31/00	7 4	13	88	0 4									
001811	1/25/00	1/31/00	7 3	27	52	0 4									
001811	11/8/99	11/18/99	7 1	19	150	1 3									
001811	11/8/99	11/18/99	7	6	85	0 2									
001812	1/25/00	1/31/00	7 1	3	33	0 1									
001812	1/25/00	1/31/00	6 9	8	233	0 2									
001812	2/10/00	2/23/00	6 7	120	250	0 6									
001829															
001829	2/10/00	2/12/00	7 17	6	123	3									
001829	2/10/00	2/12/00	6 74	14	105	2									
001830	2/14/00	2/18/00	6 48		37 2		3 4								
001830	2/14/00	2/18/00	6 55		33 5		2 3								
001830	3/8/00	3/15/00	6 35		7 8		0 9								
001830	3/8/00	3/15/00	6 25		14 5		1								
001831															
001836	2/16/00	2/18/00	6 45	25 9		5 46		0 4	0 078	0 307			0 3	39	
001838	2/14/00	2/14/00	7 47		588										
001838	4/18/00	4/18/00	6 26	75	338		10								
001848	2/10/00	2/11/00	6 9	170	160		35								
001848	4/17/00	4/24/00						0 011	0 011	3 6					
001848	4/17/00	4/18/00	6 4	340	160		23								
001848	4/17/00	4/18/00	7 2	330	140		7 8								
001848	4/17/00	4/18/00	6 6	50	59		6 7								
001848	4/17/00	4/18/00	6 3	190	270		14								
001848	4/17/00	4/18/00	6 5	35	31		5 5								
001848	4/17/00	4/18/00	6 6	82	43		5 9								
001848	4/17/00	4/18/00	8 5	1300	300		7								
001848	4/17/00	4/18/00	6 8	82	330		7 4								
001848	11/8/99	11/9/99	7 3	560	420		34								
001848	11/8/99	11/9/99	6 6	37	270		44								
001848	11/8/99	11/9/99	6 9	50	490		80								
001848	11/8/99	11/9/99	6 5	23	250		70								
001848	11/8/99	11/9/99	7 3	480	540		80								
001848	11/8/99	11/9/99	7	31	260		80								
001848	11/8/99	11/10/99						0 0082	0 042	1 8			0 015		
001848	1/25/00	1/26/00						0 059	0 087	2 3			0 026		
001848	1/25/00	1/25/00	7.6	670	220		20								
001848	1/25/00	1/25/00	7 3	270	540		25								
001848	1/25/00	1/26/00	7.4	150	130		14								
001848	1/25/00	1/26/00	8 7	30	690		24								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001848	1/25/00	1/26/00	7 2	58	65		12								
001848	1/25/00	1/26/00	7 2	42	100		42								
001848	1/25/00	1/26/00	8 2	420	340		14								
001848	1/25/00	1/26/00	7 3	170	70		8 6								
001848	1/25/00	1/26/00	7 3	140	180		21								
001848	2/10/00	2/11/00	7 2	48	120		14								
001848	2/10/00	2/11/00	7 6	26	720		33								
001848	2/10/00	2/11/00	7 2	32	120		21								
001850															
001894	11/8/99	11/8/99	7 3	369	107	3	15								
001894	11/8/99	11/8/99	7 9	488	425	42	25								
001894	11/8/99	11/8/99	7 4	2300	617	42	2001								
001894	2/10/00	2/10/00	7 9	796	767	22	107 8								
001894	2/10/00	2/10/00	7 8	636	74	109	19								
001894	2/10/00	2/10/00	8	340	334	18	146 7								
001895	11/8/99	11/8/99	7 4	2300	617	42	2001								
001895	2/10/00	2/10/00	7 9	796	767	22	107 8								
001895	2/10/00	2/10/00	7 8	636	74	109	19								
001895	2/10/00	2/10/00	8	340	334	18	146 7								
001895	11/8/99	11/8/99	7 3	396	107	3	15								
001917	1/25/00	1/27/00	7 5	136		1									
001917	1/25/00	1/28/00	7 6	22	242	1					3 03				
001917	1/31/00	2/3/00	7 1	143		1									
001917	2/10/00	2/15/00	6 8	66		2									
001917	2/16/00	2/18/00	8 6	113		1									
001917	2/20/00	2/24/00	8 2	266		1									
001917	2/23/00	2/24/00	7 8	1	198	2					0 297				
001917	3/3/00	3/9/00	7 7	83		1									
001917	4/17/00	4/20/00	7 5	144		4									
001923	2/14:00	2/23/00	6 85	70	18	5	0 5								
001923	2/14/00	2/23/00	7 05	5	36	56	0 5								
001923	2/14/00	2/23/00	7 1	50	68	5	0 5								
001923	3/8/00	3/16/00	6 93	105	67		0 5								
001923	3/8/00	3/16/00	6 97	66	66		0 5								
001923	3/8/00	3/16/00	6 9	204	73		0 5								
001924	3/8/00	3/8/00	7 48		94		34								
001924	3/8/00	3/9/00	7 06	94	66		9 4								
001924	1/25/00	1/25/00	7 3		120	5	26								
001924	1/25/00	1/25/00	7.1	50	135		38								
001924	1/25/00	1/25/00	7 4	70	181	19	45								
001947	2/10/00	2/19/00	6 51	71	257	360		0 106	0 124	0 572					
001953	11/8/99	11/8/99	7 37	174	12450	15	104								
001953	11/8/99	11/8/99	7 95	104	404	0 05	69								
001953	11/8/99	11/8/99	6 91	26	117	10	63								
001953	11/8/99	11/8/99	6 14	62	197	30	102								
001953	11/8/99	11/8/99	6 14	72	106	0 05	35								
001953	12/31/99	1/8/00	7 55	727	9400	30	8 1								
001953	12/31/99	1/8/00	7 67	221	556	35	120								
001953	12/31/99	1/8/00	6 58	72	637	5	215								
001953	12/31/99	1/8/00	6 41	81	661	5	263								
001953	12/31/99	1/8/00	7 16	424	393	15	157								
001969	1/25/00	1/25/00	6 1	24	173	5			0 02	0 19					
001969	1/25/00	1/25/00	7	44	105	5			0 07	0 99					
001969	1/25/00	1/25/00	5 9	6	47 6	5			0 13	0 37					
001969	1/25/00	1/25/00	7 7	53	270	5			0 13	0 5					
001969	1/25/00	1/25/00	6 2	10	34 9	5			0 07	0 85					
001969	1/25/00	1/25/00	6	6	68	5			0 16	0 71					
001969	1/25/00	1/25/00	6 1	49	73 4	5			0 04	0 31					
001969	1/25/00	1/25/00	6 2	146	135	5			0 03	0 26					
001969	1/25/00	1/25/00	5 9	116	324	5			0 04	0 25					
001969	1/25/00	1/25/00	6 3	190	126	5			0 04	0 34					
001969	2/12/00	2/14/00	6.7	41	60 6	5			0 11	0 08					

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
001969	2/12/00	2/14/00	6 4	6	70 3	5			0 12	0 32					
001969	2/12/00	2/14/00	8	56	159	5 2			0 08	0 63					
001969	2/12/00	2/14/00	7 4	100	91 4	5			0 1	0 09					
001969	2/12/00	2/14/00	6 4	6	62 6	5			0 12	0 1					
001969	2/12/00	2/14/00	6 5	7	57 3	5			0 12	0 35					
001969	2/12/00	2/14/00	7 1	22	121	5			0 12	0 08					
001969	2/12/00	2/14/00	6 8	9	85	5			0 12	0 08					
001969	2/12/00	2/14/00	6 7	10	145	5 4			0 12	0 08					
001969	2/12/00	2/14/00	6 5	6	57	5			0 12	0 08					
001996															
001998	2/14/00	2/17/00	6 18	70	83 6	6				1 25					
001998	4/18/00	4/20/00	6 91	80	46 6	20				2 89					
002002	1/25/00	1/25/00	6 6	24	151		14 4								
002002	2/23/00	2/28/00	6 74	7	37		11 4								
002024															
002034															
002047	1/25/00	1/26/00	6 76	148	46	19									
002047	1/25/00	1/26/00	6 73	81	23	5									
002047	1/25/00	1/26/00	7 15	46	110	5									
002047	1/25/00	1/26/00	6 64	446	51	44									
002047	4/17/00	4/18/00	5 33	190	150	5									
002047	4/17/00	4/18/00	6 66	140	89	5									
002047	4/17/00	4/18/00	5 59	32	31	5									
002047	4/17/00	4/18/00	5 9	20	14	5									
002054	1/25/00	1/26/00	7	38	57		18								
002054	1/25/00	1/26/00	6 9	24	24		18 8								
002054	2/10/00	2/17/00	5 6	18	21		3 2								
002054	2/10/00	2/17/00	6 7	16	17		3 1								
002066	11/8/99	11/18/99	7 6	52	690	12	130								
002066	2/17/00	2/25/00	6 5	8	80	0 79	11								
002066	2/24/00	3/3/00	6 2	4	120	0 8	5 1								
002078	2/10/00		7	550	410	23									
002080															
002082															
002083															
002089															
002090	4/17/00			12	17	5									
002091	3/7/00		8 4	240	570	24									
002095	2/10/00		8 7	18	150	11									
002095	2/10/00		7 9	14	130	16									
002110															
002113	3/24/00		2 62	10	1800	5									
002113	3/24/00		6 71	7	140	5									
002113	3/24/00		6 35	7	140	5									
002113	3/24/00		3 1	13	710	5									
002130	11/8/99	11/16/99	6 49	62	0 47	9 6									
002130	2/10/00	2/16/00	6 9	130	220	100									
002134	1/25/00	2/7/00	6 67	18	46		9 4								
002134	2/14/00	2/23/00	7 19	10	29		4 9								
002134	4/18/00	5/1/00	6 13	5	12		2 8								
002142	1/25/00	2/15/00	6 06	24	79 2	0 5	18								
002142	4/19/00	4/26/00	6 58	10	53	0 5									
002146	1/25/00	2/25/00		250		5	17								
002146	1/25/00	2/25/00		130		5	16								
002146	2/10/00	3/2/00		1380		5	5 5								
002146	2/10/00	3/2/00		630		5	5 5								
002147	12/31/99	1/10/00	7	44	630	5		0 054	0 034	3 2					
002147	4/17/00	4/27/00	6 1	42	150	5		0 098	0 034	3 3					
002179	1/25/00	2/9/00	6 68	68	74		8								
002179	1/25/00	2/9/00	6 9	26	65		11								
002179	2/23/00	3/13/00	6 91	10	44		3								
002179	2/23/00	3/13/00	6 65	10	55		5								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
002226															
002255															
002283	11/8/99	11/24/99	7	10	270	5									
002283	11/8/99	11/24/99	7 11	44	410	5									
002283	2/10/00	3/2/00	6 87	122	230	25									
002283	2/10/00	3/2/00	6 75	122	140	5									
002294															
002295	11/11/99		8 1	86	160	9	90								
002295	2/4/00		7 9	80	158	8 1	89								
002334	2/21/00	3/13/00	7 9	170	55 2		3 13								
002334	2/21/00	3/13/00	6 92	62	72 3		10 8								
002334	2/21/00	3/13/00	6 46	11	34 4		3 67								
002334	3/3/00	3/21/00	6 77	15	44		6 28								
002334	3/3/00	3/21/00	6 32	11	32 1		6 74								
002334	3/3/00	3/21/00	6 74	29	37 6		5 11								
002334	4/17/00	5/9/00	6 8	109	30		7 86								
002334	4/17/00	5/9/00	5 8	24	36		6 74								
002334	4/17/00	5/9/00	6 3	22	40		6 59								
002338	2/22/00	2/24/00	7 77	2480	229	45									
002338	4/25/00	5/2/00	7 36	282	199	2 3									
002342															
002368	1/25/00	2/4/00	7 6	62	85	12									
002368	1/25/00	2/4/00	7 9	63	170	19									
002368	1/25/00	2/4/00	7 7	38	110	5									
002368	2/10/00		8	68	200	5									
002372	2/17/00	2/17/00	6 57	89 6	438	50 8		0 06	0 18	1 21					
002401															
002411															
002451															
002461															
002467	4/17/00	4/18/00	6 8	480	280	1		0 14		0 14					
002467	4/17/00	4/18/00	6 8	1100	500	1	14	0 16					4		
002469															
002469															
002548		1/25/00	8 6	1000	1600	0								90	
002548		1/25/00	8 8	1600	1000	0								96	
002548		1/25/00	9	340	99	0								36	
002548		1/25/00	9 1	980	1000	0								100	
002548		3/8/00	0	0	0	0									
002548		3/8/00	7 9	160	910	0								31	
002548		3/8/00	9 6	270	160	0								20	
002555	11/8/99		5 94	35	256	3 7									
002555	11/8/99		5 77	64	749	6 4									
002555	11/8/99		5 96	42	1030	4 3									
002555	11/8/99		6 17	31	1400	4									
002555	1/25/00		6 96	43	135	0 5									
002555	1/25/00		6 82	10	92	0 5									
002555	1/25/00		6 02	10	92	0 5									
002555	1/25/00		6 28	33	742	0 5									
002555	11/8/99		6 14	65	933	2									
002555	1/25/00		6 05	35	368	0 5									
002566	1/25/00		7	26	140	2 3	48								
002566	2/16/00		7 4	48	53	15	8 3								
002578	1/6/00	1/6/00	9 67			0		0 28	0 04	0 13					
002578	10/12/99	10/12/99	10 1			17 2			0 04	0 2					
002582	1/26/00	1/29/00		36			14								
002582	11/8/99	11/9/98	6 24	35	160		22 5								
002583	1/25/00	1/26/00		10			12								
002583	11/9/99	11/9/99		14	140		36 6								
002595	4/25/00	5/4/00	7 41	31	263	3	7 7								
002595	4/25/00	5/4/00	7 01	70	138	2	13 8								
002596	4/25/00	5/4/00	7 36	78	139	3	12 2								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
002596	2/22/00	2/25/00	6 93	1	141	1	7 7								
002596	2/22/00	2/25/00	8 16	1	125	1	6 3								
002596	1/27/00	1/31/00	7 1	10	198	2	29								
002597	11/8/99	11/9/99	6 9	59	860		230								
002597	1/25/00	1/25/00	7 08	33	47		7 5								
002597	2/14/00	2/14/00	7 69	22	96		12								
002597	3/8/00	3/8/00	7 64	5	23		3 3								
002600															
002616	11/8/99	11/8/99	6 6	22	291	5	5 6								77
002616	11/8/99	11/8/99	6 6	17	391	5	6 6								92
002616	2/10/00	2/11/00	6 8	32	90	5	33								37
002616	2/10/00	2/11/00	7 1	15	142	5	23								10
002619	1/25/00		6 95	16	31	10		0 05	0 05				0 2		
002619	2/10/00		6 65	117	115	10		0 24	0 23				0 17		
002619	3/3/00		6 5	7	31	10		0 05	0 05				0 06		
002621	7/8/99	7/12/99	6 5	24	392	1		6 1	0 198	10 46			0 093		
002621	7/8/99	7/12/99	5 1	93	1000	1		10 02	0 907	40 6			0 209		
002621	11/8/99	11/15/99	5 9	12 8	418	4		2 77	0 323	3 2			0 159		
002621	11/8/99	11/15/99	5 5	17 4	581	8		4 48	0 413	15 6			0 056		
002621	1/25/00	1/25/00	6 7	12	111	1		1 7	0 065	1 38			0 056		
002621	1/25/00	1/25/00	6 5	14	104	1		1 01	0 043	1 46			0 05		
002627	1/25/00	1/26/00	8 5	4	530	4	3								
002627	1/25/00	1/26/00	8 7	4	530	4	3								
002627	1/25/00	1/26/00	8 4	4	510	4	3								
002627	1/25/00	1/26/00	8 4	4	520	4	3								
002627	2/16/00	2/16/00	7 7	4	440	4	3 9								
002627	2/16/00	2/16/00	7 6	4	490	4	3								
002627	2/16/00	2/16/00	7 1	4	500	4	3								
002627	2/16/00	2/16/00	7 7	4	460	4	3								
002636															
002639															
002642															
002644	12/31/99	1/4/00	7 08	96	290	5									
002644	12/31/99	1/4/00	6 88	51	200	5									
002644	2/27/00	2/28/00	6 79	76	120	5									
002644	2/27/00	2/28/00	6 69	21	120	5									
002651															
002653	4/17/00		8 8	90	65	5	27								
002653	4/17/00		6 5	70	51	5	19								
002653	4/17/00		7 1	51	29	5	13								
002657	11/8/99	11/8/99	7 1	43	440	101									
002657	11/8/99	11/8/99	6 7	30	270	74									
002657	11/8/99	11/8/99	7 9	75	580	94									
002657	1/25/00	1/25/00	8 8	28	4	0 4				0 78					
002657	1/25/00	1/25/00	7 6	18	164	0 3				1 8					
002657	1/25/00	1/25/00	8 1	18	141	2				1 04					
002657	1/25/00	1/25/00	7 4	18	163	0 8				0 9					
002657	1/25/00	1/25/00	8 1	58	193	1 2				1 9					
002657	11/8/99	11/8/99	8 1	82	350	41									
002657	11/8/99	11/8/99	7 7	38	870	127									
002660	1/25/00	1/26/00	9	220	2300	6 8									
002660	1/25/00	1/26/00	8 8	85	3800										
002660	1/25/00	1/26/00	8 7	380	900	4 3									
002660	1/31/00	2/2/00					22 7								
002660	1/31/00	2/2/00					27 2								
002660	1/31/00	2/2/00					47 1								
002660	4/17/00	4/19/00	8 8	100	1670	0 9									
002660	4/17/00	4/19/00	10 7	45	2790	0									
002660	4/17/00	4/19/00	8 8	50	3690										
002661	1/25/00	1/27/00	6 43	136	104	49									
002661	4/19/00	4/19/00	5 594	117	107	92									
002666	2/23/00	2/24/00	7 5	107	148										

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
002666	2/23/00	2/24/00	6 7	864	243										
002669	4/17/00	4/17/00	7 2	110	46	4								74	
002669	4/17/00	4/17/00	8 6	160	38	11								50	
002671	4/17/00	4/17/00	7 34	139	534	11 3									
002674	2/17/00	2/19/00	6 45	80	49 5		8 7								
002674	2/17/00	2/17/00	5 84	50	80 4	60									
002677	11/8/99	11/9/99	6 3	14	283	8 2	56								
002677	11/8/99	11/9/99	6 5	14	208	9	60								
002677	1/25/00	1/25/00	6 5	22	108	7	22								
002677	1/25/00	1/25/00	6 5	16	78	8 7	18								
002692	1/25/00	1/25/00	7 4	18	125	1 1									
002692	1/25/00	1/25/00	7 2	118	122	11									
002692	3/8/00	3/8/00	7 2	21	30	1 1									
002692	3/8/00	3/8/00	7	14	25	3 4									
002693															
002702	1/25/00	1/25/00	6 9	46	38		9 6								
002702	1/25/00	1/27/00		130		9 7	25								
002702	4/17/00	4/18/00	8 1		150										
002702	4/17/00	4/24/00		66		3 7	44								
002702	4/7/00	4/18/00	5 5	110	240	5 3	41								
002719															
002724	2/10/00	2/11/00	6 5	85	201	8 2		0 18	0 1	1 08	6 03	6 9	0 07		
002724	2/10/00	2/11/00	6 8	17	241	5		0 18	0 11	0 73	3 14	3 56	0 07		
002724	2/10/00	2/11/00	6 4	61	176	7 5		0 18	0 06	0 67	2 46	1 96	0 07		
002724	2/10/00	2/11/00	6 1	50	71 3	8 9		0 18	0 02	3 83	1 75	1 93	0 07		
002724	4/17/00	4/18/00	6 2	28	355	5 6		0 18	0 18	1 6	1 14	1 33	0 08		
002724	4/17/00	4/18/00	5 5	32	442	6 1		0 18	0 2	2 86	1 13	4 61	0 1		
002724	4/17/00	4/18/00	6 9	236	270	5		0 18	0 17	1 41	13 2	12 5	0 07		
002724	4/17/00	4/18/00	7 1	50	255	5		0 18	0 2	1 18	2 72	5 26	0 07		
002724	4/17/00	4/18/00	5 7	74	371	7 4		0 18	0 02	2 61	3 65	4 4	0 07		
002724	4/17/00	4/18/00	6 4	76	503	6 9		0 18	0 34	2 79	2 5	2 86	0 07		
002724	4/17/00	4/18/00	6 5	48	111	5		0 18	0 1	0 37	1 57	1 83	0 07		
002724	2/10/00	2/11/00	6 1	49	129	7 1		0 18	0 05	0 5	0 99	1 24	0 07		
002724	2/10/00	2/11/00	6 3	13	76 1	5		0 18	0 04	0 26	0 62	0 73	0 07		
002724	2/10/00	2/11/00	5 8	100	258	5 5		0 18	0 09	1 2	4 87	4 9	0 07		
002724	2/10/00	2/11/00	7 1	151	207	5 8		0 19	0 2	0 73	18 2	17 3	0 07		
002724	4/17/00	4/18/00	6 9	84	174	5 6		0 18	0 19	0 5	3 34	3 26	0 07		
002724	4/17/00	4/18/00	6 7	50	369	6 5		0 18	0 15	1 97	1 63	1 83	0 07		
002736	4/17/00	4/19/00	5 7	84	640	7 2									110
002736	5/24/00	5/25/00	6 8	140		5								150	31
002737	1/17/00	1/17/00	6 98	13 5	50 4	3		0 05					0 05		
002737	4/17/00	4/17/00	6 3	5	42 4	1 4		0 05	0 12	0 92			0 13		
002738	1/24/00	1/31/00	6 8	305	159	1	13 5								
002738	1/24/00	1/31/00	7 28	4700	100	2	16 7								
002739	11/8/99	11/9/99	7 14		1220	1	29 2								
002739	11/8/99	11/9/99	7 17		1530	1	38 9								
002739	1/25/00	1/25/00	8 02		752		30								
002739	1/25/00	1/25/00	8 17		922		30								
002739	1/25/00	1/25/00	8 79		401	2	19 6								
002739	1/25/00	1/25/00	8 03		55	1	19 7								
002744	4/17/00		6 5	379	1697	5	158		0 42	9 65			0 35	1187	224
002744	2/10/00		7 1	164	787	5	67		0 25	3 07			0 28	397	65
002750	2/10/00	2/11/00	6 5		71	5 9			0 034	0 72		3 1			
002750	2/10/00	2/11/00	6 3		110	5 1			0 043	2		3 8			
002750	2/10/00	2/11/00	6 5		60	2 5			0 0036	0 59		53	0 04		
002750	2/10/00	2/11/00	6 8		241	3			0 042	0 4		0 96	0 04		
002750	2/10/00	2/11/00	6 2		97	4 8			0 059	0 69		1 8			
002754	11/8/99	11/8/99	10	425	3160		620								
002754	2/10/00	2/10/00	6 4	115	204		24								
002754	2/10/00	2/10/00	6 6	80	86		9 6								
002754	2/10/00	2/10/00	6 6	70	40		7 6								
002754	4/17/00	4/17/00	6 6	160 2	47 4		42								

R0012599

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
002754	4/17/00	4/17/00	6 5	20	200		95								
002754	4/17/00	4/17/00	7	25	184		82								
002754	11/8/99	11/8/99	7 1	53	369		53								
002754	11/8/99	11/8/99	7 4	12	258		50								
002754	11/8/99	11/8/99	6 8	20	582		140								
002764	1/25/00	1/26/00	6 28	5	63 8	2		0 006		0 571					
002767	4/17/00	4/17/00	7 71	258	103	6 1		0 15		0 23			0 021	77	12
002767	2/12/00	2/14/00	7 08	25	85	5		0 1		0 05			0 05	20	5
002768	3/8/00	3/9/00	6 51	17	48	17 2		0 1	0 05	0 18				98	
002768	2/10/00	2/11/00	6 04	385	168	25 3		0 9	0 19	1 12				480	
002771	2/16/00	2/22/00	6 49	123	161	6 2		0 09	0 07	0 72			0 04	57 4	
002772	11/8/99	11/8/99	6 48	31	380	5									
002772	11/8/99	11/8/99	6 4	23	390	5									
002772	1/25/00	1/25/00	6 83	5	59	10									
002772	1/25/00	1/25/00	6 78	5	60	10									
002774	1/25/00		6 8	5	26	10									
002774	1/25/00		6 71	10	25	10									
002774	2/16/00	2/17/00	7 32	5	20	5									
002774	2/16/00	2/17/00	7.13	5	19	5									
002775	2/10/00		8 3	10	27	5									
002776	1/24/00		8 1	10	210	5									
002783	1/22/00	1/28/00	6 3	340	19					0 77	0 68	0 61			
002783	1/22/00	1/28/00	7	48	105					0 99	2 87	2 59			
002783	2/10/00	2/24/00	5 9	60	66	66	8 6				1 11	1 35			
002783	2/10/00	2/24/00	5 9	48	62	60	10				0 78	0 93			
002785	4/17/00		7 57	400	151		57								
002785	4/17/00		6 79	100	65		17								
002785	4/17/00		6 79	190	112		28								
002785															
002800	11/8/99	11/8/99	6 07	178	121	6 3									
002802	1/25/00		6 68	111	132	8 4									
002816	4/17/00	4/18/00	7 6	21	63	5		0 016	0 2	0 2					
002816	2/10/00	2/11/00	6 61	22	244	10 9		0 1	0 07	0 22					
002817	1/17/00	1/17/00	7 37	40	82	5	14								
002817	11/8/99	11/9/99	5 53	20	21	5	52								
002837	2/10/00	2/15/00	7 08	170	489	5	30								
002837	4/17/00	4/20/00	7 18	20	188	80	26								
002839	1/17/00	1/19/00	7 54	20	659	6									
002839	2/10/00	2/14/00	7 02	29	82	1									
002842	2/10/00	2/17/00	5 74	87	110	1				1 52					
002845	2/10/00	2/14/00	6 81	203	20400	41 3	93 3	0 16	0 11	0 88	13 9	24 3	0 05		
002845	2/10/00	2/14/00	6 91	94	18500	10 4	17 5	0 1	0 05	0 2	2 9	4 9	0 05		
002845	4/17/00	4/17/00	7 32	684	370	34 8	118	0 16	0 12	1 02	13 7	22 4	0.04	931	
002845	4/17/00	4/17/00	7 38	159	114	8 4	23	0 1	0 06	0 38	3 6		0 02	134	
002846															
002847															
002849	1/25/00	1/25/00	7 1	5		10									5
002849	1/25/00	1/25/00	7 3	120	360	10	3								
002849	2/10/00	2/10/00	7 3	10		10									5
002849	2/20/00	2/21/00	6 6	63	260	10	10								
002849	2/20/00	2/21/00	6 9	5		11		0 02	0 1	0 01			0 01		5
002849	2/27/00	2/28/00	6 9	5		10									5 2
002849	3/8/00	3/8/00	6 2	5		10									5
002849	4/17/00	4/17/00	7 4	13		24									5
002850	1/25/00	1/25/00	6 7	140	740	10	140								
002850	2/10/00	2/10/00	7 3	10		10									
002850	2/20/00	2/21/00	6 9	5		10		0 02	0 01	0 01			0 01		
002850	2/27/00	2/28/00	6 9	5		10									
002850	3/8/00	3/8/00	6 2	5		10									
002850	4/17/00	4/17/00	7 4	13		24									
002850	4/17/00	4/17/00	7 8	210	320	14	64								
002878	11/8/99	11/8/99	5 92	22	94	5								110	

R0012600

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
002878	11/8/99	11/8/99	5 9	70	320	5								150	
002878	2/10/00	2/10/00	5 5	50	123	2								160	
002878	2/10/00	2/10/00	5 55	154	58	6								160	
002878	2/10/00	2/10/00	5 47	27	66	3								120	
002878	2/10/00	2/10/00	6 01	52	224	2								110	
002878	4/12/00	4/17/00	6 78	89	138	3								250	
002878	4/17/00	4/17/00	6 68	76	81	3								200	
002878	4/17/00	4/17/00	6 89	54	176	3								100	
002878	4/17/00	4/17/00	7 6	45	99	2								120	
002879															
002884	2/11/00	2/15/00	7 17	113	27	102									
002887	2/10/00	2/11/00	6 46	28	98		32								
002887	2/16/00	2/17/00	7 13	32	53		9 4								
002892	1/25/00		7	22	41	5				1 08		1 34			
002892	1/25/00		7 5	42	62	6				1 34		3 46			
002896	4/14/00	4/25/00	6 8	10 2	482		16 5								
002896	4/14/00	4/25/00	6 7	12 4	272		23								
002896	4/14/00	4/25/00	6 5	185	246		48 1								
002896	4/14/00	4/25/00	6 7	410	281		53 6								
002911															
002911															
002916	4/17/00	4/18/00	7	21	364		40								
002916	4/17/00	4/18/00	5 8	82	128		32 9	0 28	0 05	1 21					
002916	4/17/00	4/18/00	6 3	46	164		39 4								
002916	4/17/00	4/18/00	6 1	36	159		35 3								
002916	4/17/00	4/18/00	6 3	33	104		27 5								
002917	1/25/00	1/28/00	6 36	80	141		17			0 434	2 83	4 25			
002917	1/25/00	1/28/00	6 21	60	139		15			0 287	1 04	1 72			
002917	1/25/00	1/28/00	6 69	60	162		162			1 09	1 22	2 53			
002917	2/10/00	2/18/00	6 67	20	77 3		11			0 22					
002917	2/10/00	2/18/00	6 34	20	261		17			0 347					
002917	2/10/00	2/18/00	5 92	50	118		18			0 523					
002920															
002921															
002923															
002924															
002927	1/25/00	1/25/00	5 54	69	55	6 9	15 9								
002927	1/25/00	1/25/00	6 78	76	51	6 6	17 9								
002927	2/23/00	2/23/00	7 35	30	22	7 6	0 5								
002927	2/23/00	2/23/00	7 37	31	22	7	0 5								
002928															
002929	11/8/99	2/21/00	6 1	2	87	1 2									
002929	1/25/00	2/21/00	6 2	2	28	0 09									
002930															
002937															
002950	1/25/00		8 5	39	157		42 6								
002950	1/25/00		7 3	32	98 3		12 9								
002950	3/8/00		6 9	24 8	63 5		3 1								
002950	3/8/00		7 1	35 6	94 5		15 9								
002956															
002957	1/25/00	1/26/00	7 4	140	160	0	27								
002957	1/25/00	1/26/00	7 2	74	170	6 6	44								
002961	4/17/00	4/18/00	6 6	44	68	6			0 11	1 55	1 93	1 84	0 21	118	12
002961	4/17/00	4/18/00	6 6	47	48	9			0 19	0 91	1 42	2 49	1 11	85	9
002962	2/21/00	2/24/00	6 24	5	52		9 6								
002962	2/21/00	2/24/00	6 48	1	47		7 7								
002962	2/21/00	2/24/00	6 65	2	60		11								
002962	2/21/00	2/24/00	6 49	2	77		12								
002962	2/21/00	2/24/00	6 12	3	29		7 6								
002964	11/8/99	11/9/99	6 63	46	293	7									
002964	1/17/00	1/18/00	6 59	30	139	18									
002969	4/17/00	4/17/00	4 7	30	480		380	0 1	0 23	2 95	2	2 63	0 14		

R0012601

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
002969	4/17/00	4/17/00	5	49	400		170	0 1	0 65	3 9	1 7	2 7	0 17		
002970	4/17/00	4/20/00	4 53	49	42 1	27		0 065	0 039	0 0816				29	
002970	4/17/00	4/20/00	7 08	15	33 3	30		0 032	0 031	2 79				28	
002977															
002979	11/8/99	11/8/99	6 7	38	97										
002979	11/8/99	11/8/99	6 9	34	85										
002979	11/8/99	11/8/99	7 1	12	140										
002979	1/17/00	1/18/00	8 1	65	120										
002979	1/17/00	1/18/00	7 6	39	160	5 7									
002979	1/17/00	1/18/00	8 3	140	210	8 4									
002991															
002998	4/17/00	4/18/00	7 44	210	160		46								
002998	4/17/00	4/18/00	6 98	330	580		96								
003000	1/25/00		6	84	63	4									
003000	1/25/00		5 56	56	45	3									
003000	2/10/00		6 02	383	98	4									
003000	2/10/00		6 28	478	10 9	5									
003021															
003043															
003044	2/16/00	2/17/00	7 02	24	23		9 4								
003044	2/16/00	2/17/00	6 92	31	45		9 1								
003044	2/10/00	2/14/00	6 8	33	61		22								
003044	2/10/00	2/14/00	6 66	27	77		28								
003045	2/10/00	2/15/00	6 48	126	156	1 2		0 131		1 05					
003059	2/16/00	2/17/00	7 81	1760	408	69 2		1	0 42	4					
003059	4/17/00	4/18/00	7 56	151	64	9 3		0 1	0 04	0 42					
003067															
003068															
003072	1/25/00	1/25/00	6 6	59	187	10 7									
003072	1/25/00	1/25/00	6 9	109	42	3 5									
003072	1/25/00	1/25/00	6 7	85	49	4									
003072	2/21/00	2/21/00	6 5	6	38	2 5									
003072	2/21/00	2/21/00	6 8	115	36	2 5									
003072	2/21/00	2/21/00	6 8	60	20	4 5									
003076															
003119															
003124															
003126															
003126															
003134															
003135	2/27/00	3/9/00	7 01	90	299		77 1				0 711				
003143	2/10/00	2/10/00	6 7	7	52		7 4				0 48				
003143	2/10/00	2/10/00	6 8	48	79	5	15 4				2 77				
003143	2/10/00	2/10/00	6 8	60	225	1	11 9				0 523				
003143	2/21/00	2/21/00	6 7	13	34		3 7				2 34				
003143	2/21/00	2/21/00	6 7	202	39		4 6				3 82				
003143	2/21/00	2/21/00	6 7	182	64		6								
003145	1/27/00	1/27/00	6 22	70	71 5		20			0 405	0 652	0 945			
003145	1/27/00	1/29/00	6 82	30	76 8		5 7			0 147	0 854	1 26			
003145	1/27/00	1/29/00	6 69	20	75 1		4 6			0 263	0 771	2 18			
003146	1/25/00	1/28/00	6 06	0	0 28	8 3								217	
003146	3/9/00	3/9/00	6 3	11		0								52	
003148															
003169	2/23/00	2/23/00	7 41	16	34 7	0									
003169	2/23/00	2/23/00	6 72	140	24 3	0									
003169	2/23/00	2/23/00	7.16	141	31 3	0									
003169	2/23/00	2/23/00	7 2	108	37 6	0									
003170	1/25/00	1/25/00	7 03	210	0 12	13 3									
003170	1/25/00	1/25/00	7 03	173	0 12	12.3									
003170	2/23/00	2/23/00	6 43	147	36 3	0									
003170	2/23/00	2/23/00	7 37	157	61 7	0									
003173															

R0012602

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003192	1/25/00	1/27/00		79	230		22			2					
003192	1/25/00	1/27/00		40	77		11			1 9					
003192	2/14/00	2/17/00		45	54		6 1			0 56					
003192	2/14/00	2/17/00		45	80		18			0 49					
003212	1/25/00	1/27/00	6 43	420	180	54	32								
003212	1/25/00	1/27/00	6 63	150	117	52	27								
003212	2/24/00	2/26/00	6 81	660	80 5	17	7 1								
003212	2/24/00	2/26/00	6 7	146	77 9	11	5 6								
003212	2/24/00	2/26/00	6 81	660	80 5	17	7 1								
003212	2/24/00	2/26/00	6 81	660	80 5	17	7 1								
003212	4/17/00	4/20/00	6 6	270	311	130	106								
003212	4/17/00	4/20/00	6 54	240	228	100	86								
003221	2/10/00		6 4	141	311	14				5 32	2 8	3 55			
003221	4/18/00		6 6	22	114	5				3 2	1 5	1 22			
003226															
003237	1/25/00	1/25/00	6 02	33			9 5	0 55							
003237	2/14/00	2/15/00	7 11	17			7	0 64							
003240	1/25/00	1/25/00	5 81	18	138										
003240	2/4/00	2/15/00	6 02	26	202										
003240	2/16/00	2/17/00	5 73	4	47 8										
003241	2/14/00	2/14/00	6 9	70	110	2 5	15								
003241	2/14/00	2/14/00	6 8	35	80	3 7	42								
003241	11/8/99	11/8/99	7 2	12	340	19	100								
003241	11/8/99	11/8/99	7 2	65	440	8 2	140								
003241	7/8/99	7/8/99	5 6	41	300	6	181								
003245	4/17/00	4/18/00					49								
003245	4/17/00	4/18/00					40								
003246	1/25/00	1/25/00	5 36	19	35		8 5								
003246	2/10/00		6 71	33	40		9 4								
003247															
003248	4/17/00	4/19/00	5 31	14	27	6 2			0 02	0 243					
003269	4/17/00	4/19/00	6 18	23	312	4		0 053	0 069	0 29	0 27	2 1	0 069	397	
003269	2/10/00	2/11/00	6 02		1250			0 021	0 012		0 11	10	0 006	687	
003276	1/25/00	1/25/00	6 7	8	71	5				0 85		0 11			
003284	1/25/00	1/25/00	6 49	80	128		9								
003284	1/25/00	1/25/00	6 33	100	50		37								
003284	1/25/00	1/25/00	6 42	40	89		26								
003284	1/25/00	1/25/00	6 58	80	142		3								
003284	1/25/00	1/25/00	6 33	100	40		23								
003284	1/25/00	1/25/00	6 34	84	70		38								
003284	1/25/00	1/25/00	6 72	390	20		27								
003284	1/25/00	1/25/00	6 58	80	142		30								
003284	1/25/00	1/25/00	6 34	84	70		38								
003285	2/10/00		8 85	433	0 42	0									
003285	2/10/00		8 2	25	0 3	11 6									
003285	2/16/00		7 82	19	147										
003285	2/16/00		7 9	218	141	14 6									
003285	2/21/00		8 82	50	0 85										
003285	2/21/00		8 82	50	0 85										
003285	2/23/00		7 92	138	51 8	0									
003285	2/23/00		9 31	3670	0 71	0									
003285	2/25/00		8 3	14	74 9	0									
003285	4/17/00		10 98	140	0 58	7 7									
003285	4/18/00		7 68	137	3 06	0									
003300															
003301															
003307	2/10/00	2/11/00	6 66	123									0 057		
003307	2/10/00	2/11/00	6 29	36									0 06		
003307	4/17/00	4/24/00	6 09	50									0 041		
003307	4/17/00	4/24/00	5 92	18									0 021		
003319	2/10/00	2/15/00	6 19	98	92	10 1								142	
003319	2/10/00	2/15/00	6 38	22	65	10 5								116	

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003319	2/10/00	2/15/00	6 44	61	37	17 2								63	
003319	2/10/00	2/15/00	7 05	216	70	10 6									
003319	1/25/00	1/25/00	6 68	78	79	11 8									
003321	1/25/00	1/26/00	1 65	10	19600										
003321	1/25/00	1/26/00	1 78	8	10600										
003321	2/10/00	2/10/00	7 11	12	67										
003321	2/10/00	2/10/00	7 09	16	62										
003336	1/24/00	1/27/00	6 83	832		10			0 19						
003336	1/24/00	1/27/00	6 74	74					0 06						
003336	1/24/00	1/27/00	6 57	90					0 06						
003336	2/12/00	2/16/00	6 38	184		25			0 15						
003336	2/12/00	2/16/00	6 86	190		35			0 21						
003336	2/12/00	2/16/00	6 57	526		45			0 28						
003352															
003352															
003356	11/8/99	11/9/99	6 21	62	310										
003356	12/31/99	1/5/00	6 94	470	230	14									
003357	11/8/99	11/9/99	5 1	14	560										
003357	11/8/99	11/9/99	6 5		37 5										
003357	11/8/99	11/9/99	6 36	50	69 5										
003357	4/17/00	4/19/00	5 1	11	62 4	7									
003357	4/17/00	4/19/00	6 27	53	32 5	9									
003357	4/17/00	4/19/00	6 23	3	15 5	5									
003359	4/17/00		6 85	26	173	26		0 065	0 132	1 72					
003360	7/8/99	7/8/99	9 9	105	1860	34	193								
003360	7/8/99	7/8/99	6 8	242	560	4	301								
003360	11/8/99	11/8/99	7 1	145	649	9 5	140								
003360	11/8/99	11/8/99	7 8	118	368	7 2	140								
003360	2/14/00	2/14/00	6 9	260	48	11	15								
003360	2/14/00	2/14/00	7	50	130	5 5	15								
003371	4/17/00	4/17/00	6.72	93	828	0 75		0 037	0 31	2 5			0 059	729	
003371	4/17/00	4/17/00	6 68	87	785			0 021	0 11	0 77			0 18	428	
003373	11/8/99		6 17	95	546	4									
003373	11/8/99		6 06	65	559	1									
003373	11/8/99		5 88	37	532	3									
003373	2/10/00		7 25	38	545	4									
003373	2/10/00		7 52	63	460	6									
003373	2/10/00		7 97	25	417	3									
003377	11/8/99		6 7	376	398	12	6 8								
003377	11/8/99		7 1	234	270	45	8								
003377	1/25/00		8 9	43	44	53	15								
003377	1/25/00		6 6	44	16	15	24								
003379	2/10/00	2/10/00	6 3	130	19	3 4									
003379	2/10/00	2/11/00	6 4	220	28	2 7									
003382															
003386	1/25/00	1/26/00	6 9	44	0 16	3									
003386	2/23/00	2/28/00	7 1	269	0 045	4									
003387	1/25/00		7 56	5	1	5	21								
003387	4/17/00		7 96	5	1	5	2								
003390	1/25/00	1/26/00	7 6	600	179	130									
003390	11/8/99	11/9/99	7 5	2300	570										
003390	2/27/00	2/28/00				130									
003391	1/26/00	1/26/00	6 67	27	88	5									
003392															
003394	2/10/00	2/11/00	7 54	100	146	30	18			0 684					
003394	1/31/00	2/5/00	6 77	20	160		22			0 263					
003394	1/26/00	2/5/00	6 16	27	57 1	16	17			0 339					
003400	2/21/00	2/23/00	7 4	17	320	4		0 05	0 2	1 2					
003401	1/25/00	1/25/00	7 21	33	110		22								
003401	2/16/00	2/16/00	7 32	9	67		12								
003404	1/25/00	1/26/00	6.84	4			27								
003404	1/25/00	1/26/00	6 94	4			27								

R0012604

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003404	5/25/00	5/26/00	6 2				22 4								
003404	5/25/00	5/26/00	5 83	63			29								
003406	1/25/00	1/26/00	7 07	26	67	2 6			0 0058	420	1 2	3 9			
003406	1/25/00	1/26/00	7 19	84	204	1 10			0 004	2900	2	3 8			
003406	1/25/00	1/26/00	7 16	79	94	4 2			0 0077	0 53	4 5	11			
003408	4/17/00	4/18/00	5 98	10	48	5	12	0 16						84	10
003408	4/17/00	4/18/00	6 85	5	47	5	6 8							88	10
003415	2/10/00	2/11/00	6 15	25	37	3									
003415	4/17/00	4/19/00	5 57	15	27										
003421	4/17/00	4/17/00	8 4	41	32	4 3			0 02	0 12				22	
003421	2/21/00	2/21/00	7 29		62					0 12				42	
003425															
003426	2/16/00	2/17/00	6 8	20	33	3 3									
003429	2/10/00		6 6	109	451	13				4 19	2 2	4 77			
003439	4/19/00	4/21/00	7 11	69	203	20 5			0 06	1 79				296	
003442															
003444															
003448															
003457	2/18/00	2/18/00	7 4	189	20	19									
003458															
003463															
003465	2/10/00	2/11/00	6 47	122	150	5									
003465	4/17/00	4/19/00	6 18	61	28	5									
003466															
003473	11/8/99	11/8/99	6 4	29	1110		490			2 47	2	5 7	0 1		
003473	2/10/00	2/10/00	6 7	30	93		34			0 2	0 7	1 67	0 11		
003483	2/16/00	2/19/00	7 07	950	130	30									
003486	1/25/00	1/25/00	7 4	94	395	14 2	52 1								
003486	1/25/00	1/25/00	8 7	200	2	6 6	2 5								
003486	2/16/00	2/16/00	8	4320	194	2 8	9								
003487															
003490															
003494															
003497	2/10/00	2/11/00	7 1	240	170	1	51	0 05	0 027	0 51			0 04	140	
003497	4/18/00	4/20/00	6 5	36	64	1	18	0 05	0 02	0 38			0 04	25	
003499															
003509															
003510															
003516															
003517	1/17/00	1/19/00	7 1	832	383		14 9		0 02	0 6					
003517	1/17/00	1/19/00	7 4	19	856		21 2		0 02	0 13					
003517	1/17/00	1/19/00	7 5	205	1473		163		0 08	1 55					
003517	1/17/00	1/19/00	8 1	118	398		30 4		0 02	0 42					
003517	1/25/00	1/29/00	8 5	20	1275		13 5	0 18					0 07		
003517	1/25/00	1/29/00	7 1	39	801		98 8	0 18					0 07		
003517	11/8/99	11/9/99	8 3		1137	6		0 18		0 21			0 07		
003517	11/8/99	11/9/99	8 3	24	1235	5		0 18		0 35			0 07		
003517	4/17/00	4/25/00				6		0 11		1 24			0 07		
003517	4/17/00	4/25/00				5		0 11		1 13				0 07	
003517	4/17/00	4/25/00				5		0 11		0 88			0 07		
003524															
003526	11/8/99	11/9/99	5 76	254	910		730								
003526	2/16/00	2/16/00	7 47	79	21		7 6								
003532	3/8/00	3/9/00	7 2	28	100	11									
003532	3/8/00	3/9/00	7 2	37	100	14									
003532	4/18/00	4/19/00	6 6	61	340	11									
003535	1/25/00		6 67	85	334	19		0 4	1 41	0 897	4 52	4 86		4 6	
003535	2/14/00							0 064	0 204	0 552	0 557	0 64			
003537	2/23/00	2/23/00	8 58	1940	199	28		8 57	5 47	19 9	66 6	166		1100	
003537	3/8/00	3/8/00	7 45	1030	401	3		2 8	3 18	9 04	28 1	67 8			
003539	4/17/00	4/18/00	6 2	28	97		21								
003545	2/23/00		5 05	270	783										350

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003545	4/19/00		4 69	215	916	77 4									7650
003552	1/25/00		4 5	68	19 3	5	59								
003552	4/17/00		6 3	187	89	5	74								
003553	2/15/00		7 9	38	5	5				0 07	0 1	0 04			
003554	2/14/00	2/15/00	6 5	26	0 064	18									
003555	1/25/00	1/28/00	6 86	120	299		46 3	0 058	0 084	0 938					
003557															
003560	1/17/00	1/18/00	7 9	34	1060										
003560	1/17/00	1/18/00	7 2	8	107										
003560	1/17/00	1/18/00	9 3	19	243	5									
003560	2/10/00	2/11/00	9	11	140										
003560	2/10/00	2/11/00	7 4	20	44										
003560	2/10/00	2/11/00	7 4	20	58										
003566															
003575	1/25/00	1/25/00	7 3		58										
003575	1/25/00	1/25/00	7 4		53										
003575	4/27/00	4/27/00	6 2	33	94										
003575	4/27/00	4/27/00	5 9	69	65										
003576															
003586															
003587	1/25/00		7 4	70	24	5	16								
003587	4/17/00		7	22	248	5	130								
003587	4/24/00		6 9	146	278	5	73								
003587	4/24/00		6 7	100	171	5	80								
003587	1/25/00		7 4	94	16	5	18								
003587	1/30/00		7 3	181	14	5	17								
003593	2/11/00	2/11/00	7 49	47			16			0 445					
003593	4/17/00	4/19/00	5 87	34			17			0 34					
003609	2/10/00	2/11/00	6 9	12	180	7		0 03			0 3	0 42			
003615	2/14/00	2/14/00	7	36	78	4									
003615	4/17.00	4/17/00	7 6	5	48	4									
003628	1/25/00	1/25/00	7 8	120	15300		33								
003628	1/25/00	1/25/00	7	26	169		17								
003628	1/25/00	1/25/00	6 9	74	1200		34	0 0214	0 1	0 678			0 0376		
003628	1/25/00	1/25/00	6 4	5	191		32	0 02	0 105	0 888			0 019		
003628	1/25/00	1/25/00	7 4	200	397		39	0 0608	0 105	1 34			0 0351		
003628	1/25/00	1/25/00	7 7	350	22400		14	0 02	0 1	0 485			0 066		
003628	1/25/00	1/25/00	7 5	76	315		31	0 152	0 143	1 43			0 066		
003628	1/25/00	1/25/00	5 1	62	373		24	0 02	0 1	0 678			0 0153		
003628	1/25/00	1/25/00	7	120	168		39	0 0612	0 1	0 623			0 01		
003628	1/25/00	1/25/00	8 8	19	2750		27								
003628	1/25/00	1/25/00	7 6	110	16700		6 7	0 02	0 1	0 628			0 019		
003628	1/25/00	1/25/00	8 1	150	41200		8 3	0 02	0 1	0 2			0 01		
003628	1/25/00	1/25/00	6 6	31	226		23	0 02	0 1	1 19			0 0115		
003628	1/25/00	1/25/00	6 8	340	89700		28	0 021	0 1	1 03			0 379		
003628	1/25/00	1/25/00	6 2	56	237		33	0 0331	0 1	0 78			0 0145		
003628	4/17/00	4/17/00	6 9	63	200		21	0 027	0 1	0 47			0 022		
003628	4/17/00	4/17/00	7 3	5	0 1		9 8								
003628	4/17/00	4/17/00	7 6	220	2800		12	0 0483	0 105	0 749			0 0225		
003628	4/17/00	4/17/00	6 8	98	100		7 6	0 031	0 1	0 477			0 0153		
003628	4/17/00	4/17/00	7 6	56	200		9 4	0 02	0 1	0 487			0 0148		
003628	4/17/00	4/17/00	7 5	114	200		13	0 0382	0 1	0 441			0 0168		
003628	4/17/00	4/17/00	7 4	90	200		20	0 0603	0 1	0 681			0 0156		
003628	4/17/00	4/17/00	6 3	72	400		94	0 0238	0 141	4 25			0 0593		
003628	4/17/00	4/17/00	8 2	290	300		26	0 0722	0 1	0 549			0 0355		
003628	4/17/00	4/17/00	7 9	130	46700		3 6	0 02	0 1	0 2			0 01		
003628	4/17/00	4/17/00	6 4	230	400		88								
003628	4/17/00	4/17/00	7 7	49	100		13	0 0224	0 125	0 645			0 0285		
003628	4/17/00	4/17/00	7 1	98	4 8		14								
003628	4/17/00	4/17/00	6 7	50	100		59	0 02	0 1	0 227			0 01		
003628	4/17/00	4/17/00	6 3	350	500		14	0 0865	0 1	0 846			0 0194		
003628	4/17/00	4/17/00	8 8	5	900		52								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003628	4/17/00	4/17/00	6 2	300	1100		144								
003628	4/17/00	4/17/00	6 7	63	400		71	0 02	0 128	3 14			0 0355		
003628	4/17/00	4/17/00	6 6	90	400		70	0 0227	0 1	2 21			0 023		
003628	4/17/00	4/17/00	6 7	88	200		11	0 0419	0 1	0 868			0 0167		
003629	1/23/00	1/26/00	7 2	70	670	2									
003629	1/25/00	1/26/00	6 4	388	130	10									
003629	2/23/00	2/28/00	7 1	475	52	19 6									
003629	2/23/00	2/28/00	7 1	38	45	3 2									
003631															
003632															
003637	1/17/00	1/17/00	8 6	190	620	16									
003637	2/10/00	2/10/00	8 3	37	350	5									
003642															
003672	2/21/00		6 2	24	112	5				0 25	0 4	0 42			
003674	2/10/00		7 8	10	40	5								36	6
003674	2/10/00		7 4	10	1000	8								210	43
003674	2/10/00		7 8	22	53	5								60	13
003676	2/10/00	2/11/00	6 9	20	27	4									
003676	3/6/00	3/7/00	8 2	4	35	4									
003678															
003681	1/25/00		8 8	20	62	4									
003681	2/10/00		6 7	99	39	4									
003681	4/17/00		6	150	980	13									
003683															
003685	2/15/00	2/24/00	4 6	12	62	5		0 06	0 25	0 46	0 1				
003685	2/15/00	2/24/00	5 18	8	49	5		0 06	0 25	0 36	0 09				
003686															
[illegible]	2/21/00	5/23/00	8 98	113	69	8 4		0 1	0 05	0 33					
003687	2/10/00	2/11/00	6 83	64						1 07					
003689	2/10/00	2/11/00	6 86	28						1 02					
003689	4/17/00	4/18/00	6 12	172						0 723					
003689	4/17/00	4/18/00	6 48	20						0 77					
003690	4/17/00	4/18/00	7 3	44	20	6									
003691	4/17/00	4/20/00		7790				0 01		0 52			0 05	322	
003691	4/17/00	4/19/00	5 82	14	88										
003705	1/25/00	1/25/00	7 3	12	94		12							100	
003705	1/25/00	1/25/00	6 6	39	43		18							130	
003705	1/25/00	1/25/00	7 5	42	710		58							240	
003711															
003712	11/8/99	11/12/99	6 14	440	440		54								
003716	2/21/00	2/21/00	8	40	15400				0 01						
003726	3/3/00		6 8	160	192	5				8 1	4	0 23			
003733															
003738	1/25/00		6 3	11	33	6				0 7	1 2	0 51			
003740															
003742															
003750	1/28/00		8 7	23	1500	5	8		0 051	0 11			0 013		
003750	2/11/00		4 2	62	2400	8 8	75	0 12	0 69	28			1 2		
003750	2/11/00		6 1	24	320	7 3	61	0 014	0 25	1 8			0 014		
003750	2/11/00		6 6	26	180	11	54	0 012	0 14	0 89			0 012		
003750	2/11/00		8 7	28	28	26	150	0 0084	0 057	0 62			0 0084		
003750	2/11/00		6 8	28	91	1 4	26	0 067	0 22	0 68			0 034		
003752	2/21/00	2/21/00	8 49	160	36	5 4		0 22	0 7	1 38					
003752	2/21/00	2/21/00	8 18	73	44	8 3		0 12	0 26	0 84					
003752	1/25/00	1/27/00	7 04	43	86	6 4	12 2		0 29	0 78					
003752	1/25/00	1/27/00	7 38	89	58	6 8	13 4		0 28	1 19					
003756	2/21/00		8	5	34	5	0			0 17	0 1	0 33			
003762															
003762															
003770	1/25/00		7 6	216	16	5	11								
003770	1/25/00		7 1	174	126	5	16								
003774	2/10/00	2/28/00	119	119	119	13 2	19 3			0 626	2 54				

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003774	2/10/00	2/28/00	6 67	65	67	10	9 55			0 51	1 14				
003774	2/10/00	2/28/00	6 74	229	160	10	11 6			1 51	2 97				
003774	4/18/00	5/1/00	6 18	33	106	10				0 389	0 189				
003774	4/18/00	5/1/00	6 28	393	143	24 5				0 564	1 88				
003781	2/12/00	2/11/00	6 87	78	58 8		11 5								
003781	1/25/00	2/9/00	6 67	156	605		71								
003785	1/25/00	1/25/00	7 12	27	71 6	10	34 6								
003785	2/20/00	2/21/00	7 36	64	9 96	10	8 33								
003787	1/25/00	1/28/00	6 09	10	310	2 9		0 356	0 584	1 26	1 97	6 85		66	
003787	1/25/00	1/28/00	5 78	146	145	2 2		0 125	0 241	0 906	3 08	6 78		180	
003787	1/25/00	1/28/00	5 78	85	158	1 9		0 202	0 406	1 16	1 17	4 23		150	
003787	1/25/00	1/28/00	5 89	32	16 6	1		0 006	0 025	0 271	0 229	0 474		16	
003787	1/25/00	1/28/00	6 27	141	164	2 3		0 4	0 7	1 42	2 61	8 59		250	
003791	4/17/00	4/18/00	7 01	15	168	16 7				0 31	0 12				
003793	1/25/00	1/25/00		30											
003803	2/14/00	2/15/00	7 1	41	61										
003803	4/18/00	4/19/00	6 6	110	200	24									
003826															
003829	3/8/00	3/8/00	6 53	11	22		2 5								
003834	1/25/00	2/28/00	6 07	12	54 5	7	7 5								
003852	1/25/00		5 7	37	98	5				7 12	1 9	2 56			
003852	1/25/00		3 8	43	106	6				1 29	1 5	2 21			
003855															
003857	1/17/00	1/17/00	6 7	46	270					4 46	0 78				
003857	2/11/00	2/11/00	5 7	32	40 3	6				0 96	1 19				
003860	4/17/00	4/17/00	6 15	10	64						0 26				
003860	2/14/00	2/14/00	6 11	10	100										
003860	1/25/00	1/25/00	7 26	15	74										
003860	11/8/99	11/8/99	6 43	33	810										
003861	2/10/00	2/11/00	8 3	360	57	1									
003861	2/10/00	2/11/00	8 2	30	24	1 7									
003864	11/16/99		5 2	8	12	10	74 3								
003864	3/21/00		5 3	7	11	10	74								
003874	2/10/00	2/11/00	6 17	44	171	9 6	42 6								
003876	1/21/00	1/31/00	6 74	85	94	5			0 06	4 9		1 7			
003876	1/25/00	1/31/00	6 66	66	110	5			0 07	2 9		3 8			
003876	1/25/00	1/31/00	6 07	25	50	5			0 03	0 1		0 5			
003876	4/18/00	4/24/00	6 63	25	47	5			0 13	2 8	1 5				
003876	4/18/00	4/24/00	6 71	38	220	5			0 05	0 22	1 2				
003876	4/18/00	4/24/00	5 75	5	74	5			0 02	1 2	0 28				
003879															
003901															
003909															
003914	4/14/00	4/20/00	6	22	68					1					
003914	2/16/00	2/18/00	6 25		29					0 54					
003920	2/10/00	2/10/00	6 89	138	28		11							24	
003920	2/10/00	2/10/00	7 25	85	40		8 4							100	
003920	4/17/00	4/17/00	6.34	75	33	3 8	40							160	
003920	4/17/00	4/17/00	588	28	33	3 9	34							150	
003925															
003926															
003927	11/8/99	11/9/99	6 38	852	1002	10									
003927	1/17/00	1/18/00	7 3	550	1000	200									
003929	2/10/00	2/11/00	7 2	37 1	129	8		0 02	0 07	0 19			0 01	101	
003932															
003939	2/23/00	2/23/00	7 34	83	0 65	70									
003939	2/10/00	2/11/00	7.6	70	640	26									
003939	2/10/00	2/11/00	6 89	134	380	59									
003939	2/23/00	2/23/00	7.08	63	0 77	16									
003940	1/25/00	1/25/00	6 9	138	82	13									
003940	1/25/00	1/25/00	6 7	32	79	4 5									
003943	12/15/99	12/16/99	7 3	295		86 5								1580	

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
003949															
003954															
003961	2/10/00	2/11/00	7 1	990	110	15	41								
003961	2/10/00	2/11/00	7	1030	190	4 5	31								
003961	11/8/99	11/8/99	6 4	66	358	3 5	120								
003961	11/8/99	11/8/99	6 6	407	423	12 5	160								
003963	1/25/00	1/28/00	8 1	5	50	1			1 25	2 15	0 4			21	
003966	1/25/00	1/26/00	6 5	34	89 2	0 5									
003966	2/10/00	2/11/00	6 5	50	43	1 2									
003967															
003970															
003983	1/25/00	1/25/00	7	12	100	3 2									
003983	1/25/00	1/25/00	7 1	41	92	5									
003983	2/10/00	2/10/00	7 2	45	460	2 5									
003983	2/10/00	2/10/00	7 2	15	556	3									
003988	4/17/00	4/20/00	7 05	48	476	1 2		0 008		0 583					
003990															
003993	2/14/00	2/14/00	6 7	202	561				0 17	8 66					
003998	4/17/00	4/17/00	7 13	135	313	43 4	0 5	0 293	1 11	0 817	1 37	2 33		324	
004003															
004004															
004010															
004011	1/25/00	1/25/00	7 04	41	699	0 58									
004011	4/16/00	4/18/00	6 38	105	215	0 62									
004012	4/17/00		10 98	140	0 58	7 6						2 28			
004024	2/10/00	2/10/00	6 2	161	446	10									
004024	2/10/00	2/10/00	6 9	178	238	10									
004024	4/17/00	4/17/00	7 3	171	150	6 3									
004024	4/17/00	4/17/00	6 8	171	380	5									
004027	4/17/00	4/20/00	7 4	9	587	4		0 05	0 11	0 55	0 52	0 62	1 94		
004027	4/17/00	4/20/00	7 6	2	595	4		0 05	0 05	0 28	0 3	0 28	0 49		
004033															
004050	1/25/00	1/25/00	6 31	55	40					0 52	1 2	2 2			
004050	11/8/99	11/8/99	6 13	164	300					4	4 5	9 3			
004071	1/24/00	1/25/00	7 16		62		14			0 11				36	1 9
004071	1/24/00	1/25/00	7 56	3 8	62		19			0 29				32 8	20 5
004071	1/24/00	1/25/00	7 5		70		14			0 25				43	4 1
004071	1/24/00	1/25/00	7 47	4 6	213		41			0 73				54	18
004071	1/24/00	1/25/00	7 76		135		26			0 23				34	16
004071	1/24/00	1/25/00	7 62		214		19			0 11				49	8
004071	2/10/00	2/10/00	7 2	40	40		7 7			0 089				34	2 8
004071	2/10/00	2/10/00	7 6	51	46		9 2			0 16				37	1 1
004071	2/10/00	2/10/00	7	11	70		11			0 32				26	3
004071	2/10/00	2/10/00	6 2	66	226		30			1 2				119	9
004071	2/10/00	2/10/00	6 6	273	6 6		18			0 84				116	11
004071	2/10/00	2/10/00	7 9	35	311		14			0 14				64	2 9
004074															
004079															
004081															
004086	2/14/00		7.97	47	0 24							2 95			
004088	2/16/00		6 85	16	0 29										
004092	1/25/00	1/25/00	6 38	69	37		9 7			1 5	2 1	2 4			
004092	2/10/00	2/11/00	7 47	15	63		4 5		0 02	0 92	0 88	0 58			
004101	1/25/00	1/27/00	6 9	13	40					0 27	0 5	0 7			
004101	2/16/00	2/17/00	7 1	44	38					0 26	0 8	1 2			
004103	1/1/00	1/1/00	7 4	46 5	204	1 03				0 16					
004103	1/1/00	1/1/00	7 25	697	253	2 46				1 29					
004103	1/25/00	1/25/00	7 43	214	200	1 23				0 59					
004103	1/25/00	1/25/00	7 39	87	340	0 56				0 28					
004105	1/25/00	1/25/00	7 42	39	140										
004105	1/25/00	1/25/00	7064	123	240	24									
004105	1/25/00	1/25/00	7 5	42	83										

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
004105	4/17/00	4/17/00	8 06	380	87										
004105	4/17/00	4/17/00	7 52	28	44	7									
004105	4/17/00	4/17/00	8 46	82	100										
004116															
004119	2/24/00	2/24/00	7 41	2420	340										
004119	3/8/00	3/8/00	7 93	610	220	16									
004124	1/25/00	1/25/00	8 9	77	333		77			0 49	4 95	6 84			
004124	1/25/00	1/25/00	8 8	6	352		19			0 57	0 76	1 53			
004124	2/14/00	2/22/00	1 8	73	10200		8			0 78	5 84	10 6			
004124	2/14/00	2/22/00	6 7	47	461		17			0 35	1 96	4 58			
004135															
004136															
004141	3/8/00	3/8/00	3 39	5	230										
004141	3/8/00	3/8/00	6 32		29										
004141	2/16/00	2/16/00	8 28	69	150	42									
004141	2/16/00	2/16/00	7 61	8	44										
004142															
004147															
004158	1/25/00	1/25/00	7 3	10	188										
004158	1/25/00	1/25/00	7 2	5	182										
004158	3/8/00	3/8/00	8 2	26	127	11 8									
004158	3/8/00	3/8/00	8		131	1 2									
004159															
004160															
004162	1/17/00	1/20/00	7 48	40	980		83		0 21	0 54					
004165															
[illegible]	4 17 00	4/18/00	7 36	192	280	11 7		0 29	0 36	0 37			0 06	232	
[illegible]															
[illegible]															
004196	4 17 00	4/18/00	9 14	81 6	211	12 4		0 08	0 02	0 42			0 02	163	
004191	2/10/00	2/17/00	7 8	18	71	4		0 046	0 2	0 4					
004191	4/17/00	4/18/00	7 2	58	190	5		0 027	0 2	0 5					
004193	1/18/00	1/19/00	7 3	64	680	15	20			0 26					
004193	1/25/00	1/25/00	7 7	11	460	5 7	17		20	0 06					
004193	2/10/00	2/10/00	7 3	20	330	5 8	7.7		0 03	0 06					
004196	1/25/00	4/3/00	6 52	33	90 5	10	21 9								
004196	2/21/00	4/3/00	6 15	2	29	10	6.98								
004197	2/10/00	2/11/00	7.6	2	141	10									
004197	4/17/00	4/17/70	7.7	8	143	10									
004207															
004211	3/8/00	3/8/00	6 89	7	74										
004211	3/8/00	3/8/00	6 91	9	21										
004211	4/17/00	4/19/00	5 6	64	21										
004211	4/17/00	4/19/00	5 09	33	94										
004213	2/16/00	2/18/00	6 26	33	94	10	8 26	0 1	0 044	2 95					
004213	2/20/00	2/25/00	6 21	11	116	10	31 7	0 1	0 015	0 107					
004214															
004215															
004223	2/16/00	2/18/00	6 8	43	38	5			0 49	1 3					
004226	4/17/00		5.9	10	90	5									
004228	2/16/00	2/18/00	6 8	43	38	5			0 49	1 3					
004228															
004229															
004235	2/14/00	2/15/00	7 46	472	517										
004235	3/8/00	3/9/00	7 19	43	80										
004249															
004250	2/14/00	2/15/00	7 19	89	150		51								
004252															
004254															
004257	11/8/99		7 6	120	98 3	18									
004257	1/25/00		7 5	46	17	5									
004259	1/25/00	1/27/00	9 1	4	20	4		0 71	0 3	1 4	93				

R0012610

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
004259	4/17/00	4/18/00	7.2	330	490	10		0.023	0.2	0.4	0.1				
004271	2/10/00		6.5	5	78	5				0.36	0.2	0.13			
004272	1/25/00		6.56	51	67.2	2									
004272	1/25/00		6.46	68	503	2.47									
004272	1/3/00		6.15	26	455	6.1									
004272	1/3/00		6.18	34	420	5.4									
004274	1/25/00	1/27/00	8.8	46	54	4									
004274	4/17/00	4/21/00	8	34	20	4									
004283	4/17/00	4/19/00	7.71	2	563	2									
004283	4/17/00	4/19/00	8.92	120	619	2.9									
004284	4/17/00	4/19/00	7.43	16	409	8.5									
004284	4/17/00	4/19/00	8.04	16	466	2									
004285	4/17/00	4/19/00	7.69	12	546	2									
004285	4/19/00	4/19/00	8.9	100	538	2									
004291	2/27/00	3/9/00	6.33	64	328	9.3		0.1	0.06	0.58	1.1			395	
004291	4/17/00	4/18/00	6.71	98	840	9		0.1	0.13	1.53	1.24			446	
004295	4/17/00	4/18/00	6.74	109			35			1.9		4.8			
004295	4/17/00	4/18/00	9.45	55			70			3.5		2.1			
004295	4/17/00	4/18/00	7.02	70			152			1.4		3.4			
004295	4/17/00	4/18/00	6.61	30			115			0.61		1.5			
004295	2/10/00	2/11/00	7.55	222			3			3.3		10			
004295	2/10/00	2/11/00	9.34	10			3			1.3		0.85			
004295	2/10/00	2/11/00	6.81	10			45			0.43		1.3			
004295	2/10/00	2/11/00	7.35	30			9.9			0.16		2.2			
004299	4/17/00	4/26/00	6.61	6	65	1		0.009		4.73					
004302															
004311	2/10/00	2/11/00	7.43	155	63	1									
004311	2/10/00	2/11/00	7.69	68	46	1									
004311	3/8/00	3/8/00	7.27	65	23	8.1									
004311	3/8/00	3/8/00	7.45	17	23	8.2									
004312	11/17/99	11/17/99	7.61	62	53	3.7	3.1								
004312	2/22/00	2/22/00	7.53	111	10000	0.5	25								
004312	2/23/00	2/24/00	7.53	738	22	0.5	3								
004312	3/4/00	3/6/00	7.56	127	28400	0.5	34								
004312	2/22/00	2/22/00	7.53	111	10000	0.5	25								
004312	11/17/99	11/17/99	7.61	62	53	3.7	3.1								
004312	3/4/00	3/6/00	7.56	127	28400	0.5	34								
004312	2/25/00	2/25/00	7.53	738	22	0.5	3								
004342	4/17/00	4/19/00	7.42	198	646	2									
004348	1/25/00	1/26/00	6.61	11	48	1	22.1								
004348	1/25/00	1/26/00	6.65	22	47	1	10.9								
004348	11/8/99	11/8/99	5.96	223	255	6	66.6								
004348	11/8/99	11/8/99	6.17	421	231	7	67.5								
004350															
004355	4/17/00	4/19/00	6.92	58	11	1									
004355	4/17/00	4/19/00	7.26	23	39	1									
004355	4/17/00	4/19/00	7.13	100	11	2									
004359	11/8/99	11/8/99	7.1	12	310	5				1.5	0.3	0.49			
004359	1/25/00	1/27/00	7.3	21	170	5				0.64	1	1.5			
004360	1/25/00	1/26/00	7	8		1.4								36	5.6
004361	1/25/00	1/26/00	6.8	49		2.2								92	11
004362															
004370	11/8/99		6.8	4	175	2	1								
004370	1/30/00		6.9	4	165	2	1								
004371															
004375															
004377															
004385															
004395															
004406	1/25/00	1/25/00	7.26	20	140		36								
004406	2/23/00	2/23/00	6.46	5	14		2								
004413															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
004437															
004450	1/25/00	1/25/00	8 65	556	210	5	11								
004450	1/25/00	1/25/00	7 66	51	360	5	1 3								
004450	2/16/00	2/18/00	8 24	1320	200	7	8 4								
004458	2/10/00	2/11/00	3 12	402	2300	5				360		339			
004458	2/10/00	2/11/00	3 86	728	5000	5				1900		1900			
004458	2/10/00	2/11/00	4 48	574	2800	5				600		740			
004458	4/17/00	4/18/00	3 67	1900	28000	11				2200		3200			
004458	4/17/00	4/18/00	5 43	280	2300	5				580		64			
004458	4/17/00	4/18/00	4 32	450	7800	9				1300		960			
004459	2/10/00	2/17/00	4 9	15	115	2 3									
004459	2/10/00	2/17/00	5.7	6	375	2 4									
004459	4/17/00	4/20/00	3 2	200	1176	13									
004459	4/17/00	4/20/00	6 4	342	189	12									
004462	4/17/00	4/17/00	6 4	100	66	5									
004467	1/25/00	1/26/00	7	100	378		48	0 03	0 04	0 16		3 6			
004467	1/25/00	1/26/00	7 8	30	167		22	0 01	0 02	0 09		2 39			
004467	1/25/00	1/26/00	7 3	580	485		104	0 15	0 14	1 01		20 4			
004467	2/10/00	2/10/00	7 7	50	108		10 6	0 01	0 01	0 07		1 65			
004467	2/10/00	2/10/00	8	50	71		7 3	0 01	0 01	0 09		2 21			
004467	2/10/00	2/10/00	7 3	120	241		67 2	0 02	0 02	0 22		2 73			
004470															
004473	1/7/00		6.72	54	230	2	0								
004473	3/8/00		9 54	160	83 8	52 3									
004474															
004482															
004489															
004497	1/25/00	1/25/00	7 3	40	61		11								
004497	11/8/99	11/9/99	6 2	34	150		55								
004506															
004514	2/16/00								5 53				6 03		
004514	2/16/00								4 42				4 64		
004515															
004516	2/10/00	2/11/00	7 02	111	42	3			0 03	0 65	1 7	2			
004516	2/10/00	2/11/00	7 16	392	52	3 7			0 04	0 57	2 2	2 6			
004517															
004518	1/25/00		6 9	9	63	5				0 11	0 3	0 13			
004518	2/16/00		7 3	18	17	5				0 53	0 4	0 56			
004519															
004520	4/17/00	4/20/00	6 38	21	222	1 2		0 011		1 07					
004521															
004526	2/10/00	3/2/00	6 23	16	45		7 06								
004526	4/17/00	4/28/00	5 62	6	104		35 5								
004532															
004533															
004539	2/14/00	2/18/00	6 34	5	28	5	7 7								
004539	2/14/00	2/18/00	6.62	53	44	5	10								
004539	2/14/00	2/18/00	6 75	5	61	5	10								
004539	4/18/00	6/2/00	6 15	27	420	5	170								
004539	4/18/00	6/2/00	6 14	11	450	5	150								
004539	4/18/00	6/2/00	6 2	14	420	5	200								
004552															
004553	2/17/00	2/22/00	6 78	5	120	5									
004553	2/17/00	2/22/00	6 9	5	120	5									
004554															
004574	1/25/00	1/25/00	7 7	180	310	5 5									
004574	2/10/00	2/11/00	7 2	46	170	2 7									
004578	1/25/00	1/26/00	7 1	56	510	19									
004578	2/11/00	2/16/00	6 7	69	280	1 9									
004578	4/18/00	4/18/00	7 63	300	140	5									
004578	4/18/00	4/18/00	6 86	14	52	5									
004578	4/18/00	4/18/00	6 8	22	160	5									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
004584															
004601															
004609	4/17/00	4/18/00	6 6	83	140	13									
004620															
004620															
004623	1/25/00	1/25/00	6 8	225	38	15	6 9	0 1	0 03	0 13		6 7	0 04	68	
004623	1/25/00	1/25/00	6 8	12	37	3	7 2	0 1	0 03	0 13		0 67	0 04	43	
004623	2/16/00	2/16/00	7 2	25	32	1 9	2 4	0 13	0 54	0 29		1 3	0 04	17	
004623	2/16/00	2/16/00	6 9	19	39	6 2	3 1	0 1	0 02	0 12		1 1	0 04	39	
004624	11/8/99	11/8/99	7 2	48	127	3 3		0 1	0 07	0 69		1 6	0 04	335	
004624	11/8/99	11/8/99	6 8	20	324	2 1		0 1	0 16	13		9	0 07	145	
004624	11/8/99	11/8/99	7 6	24	193	1 9		0 05	0 09	0 18		1	0 04	140	
004624	1/25/00	1/25/00	6 9	28	81	3		0 1	0 13	0 27		0 9	0 04	64	
004624	1/25/00	1/25/00	7 7	113	119	3		0 1	0 05	0 11		1 4	0 04	54	
004628	2/15/00	2/15/00	6 9	360	400	8									
004628	4/19/00	4/19/00	7 2	210	132	6 7									
004629	1/25/00	2/1/00	6 88	80	627	20									
004629	1/25/00	2/11/00	6 67	170	497	90									
004629	2/16/00	2/19/00	6 73	80	185	36									
004634	1/25/00	1/31/00	6 38	38	50 1		7 7								
004634	1/25/00	1/31/00	6 12	25	46 8		14								
004634	1/25/00	1/31/00	6 2	85	310		110								
004634	1/25/00	1/31/00	6 46	12	18 7		4 2								
004634	2/10/00	2/16/00	6 05	30	27 9		6 5								
004634	2/10/00	2/16/00	5 62	50	36		8 3								
004634	2/10/00	2/16/00	3 24	30	139		405								
004634	2/10/00	2/16/00	5 07	30	19 8		5 3								
004659															
004689															
004715	1/25/00	1/25/00	7 23	1365	1309	10 5	153								
004715	1/25/00	1/25/00	7 44	1622	289	10	171								
004715	1/25/00	1/25/00	6 51	391	2150	10	712								
004715	2/16/00	2/16/00	6 8	984	530	10	15 6								
004715	2/16/00	2/16/00	6 38	6530	2660	41 6	233								
004715	2/16/00	2/16/00	6 95	243	248	10	36 7								
004719	2/16/00	2/22/00	6 49	5	120	5									
004719	1/25/00	1/28/00	6 45	27	86	5									
004719	1/25/00	1/28/00	6 76	21	79	5									
004720	4/17/00	4/19/00	5 38	742	1740	4 5									
004735	2/10/00	2/10/00	5 91	20	140			0 011	0 062	0 34		0 43			
004735	2/10/00	2/10/00	5 89	1574	279			0 25	0 29	1 9		12			
004735	2/22/00	2/25/00				0 5									
004735	2/21/00	2/25/00				0 5									
004735	3/8/00	3/8/00	6 98	31	236	0 5		0 024	0 028	0 02		1 8			
004735	3/8/00	3/8/00	6 68	57	5	1 1		0 091	0 089	0 74		2 7			
004736	2/10/00	2/10/00	5 49	10	85			0 056	0 93	0 016		0 3			
004736	2/11/00	2/25/00				2 2									
004736	3/8/00	3/8/00	7 43	37	27	9 9		0 041	0 03	0 13		1 5			
004741	4/17/00	4/19/00	6 6	17	18 9		5 5								
004741	1/25/00	1/26/00	6 8	22	52 4		27 1								
004741	1/25/00	1/26/00	6 8	39	52 2		28								
004741	4/17/00	4/19/00	6 7	17	17 8		5 4								
004745	1/25/00	1/26/00	8 2	5	58	9	13								
004745	4/17/00	4/19/00	6 1	9	98	1	24								
004746															
004752															
004759	1/25/00		7 1	33	15	5	15	0 02	0 11						
004759	1/25/00		7 1	10	15	5	11	0 02	0 05						
004759	1/25/00		7	32	9	5	13	0 02	0 05						
004759	1/25/00		6 9	23	7	5	8	0 02	0 02						
004759	2/23/00		6 6	8	56	5	6	0 02	0 04						
004759	2/23/00		6 5	22	28	5	3	0 02	0 02						

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
004759	2/23/00		6 4	5	11	5	3	0 02	0 02						
004759	2/23/00		6 2	5	10	5	2	0 02	0 02						
004762															
004763	2/21/00	2/22/00	6 44	12 8	151	1 7		0 06	0 08	3 46			0 12	24 9	
004776															
004781	11/7/99		5 6	12	0 017	2									
004781	11/7/99		5 6	12	0 017	2									
004781	11/7/99		5 6	12	0 017	2									
004781	1/17/00		7 6	6	0 78	2 2									
004781	1/17/00		7 6	6	0 78	2 2									
004781	1/17/00		7 6	6	0 78	2 2									
004782															
004797	1/25/00	1/26/00	6 53	17	30	1	5 2			1 1					
004797	1/25/00	1/26/00	6 48	14	34	1	11 5			0 208					
004797	3/8/00	3/8/00	5 13	1	15	2	1 6			0 555					
004797	3/8/00	3/8/00	5 16	1	15	1	3 2			0 112					
004818	2/11/00	2/16/00	6 4	57	110										
004818	3/8/00	3/14/00	7 1	29	25	1 9									
004876															
004878	1/25/00	1/25/00	6 33	55	105	3	16 8								
004878	1/25/00	1/25/00	6 57	385	179	6	53 2								
004878	1/25/00	1/25/00	6 29	158	94	8	50 8								
004878	1/25/00	1/25/00	6 82	71	79	3	5								
004878	4/20/00	4/20/00	6 58	40	80	5	21 5								
004878	4/20/00	4/20/00	6 17	144	173	3	102								
004878	4/20/00	4/20/00	6 66	156	111	3	10								
004878	4/20/00	4/20/00	6 47	268	101	3	48								
004881															
004883	2/23/00	2/23/00	8 4	33	20	4									
004883	3/8/00	3/8/00	7 6	20	20	5									
004884	1/25/00	1/26/00	6 03	58	48	3			0 87	2 4	1 1	1 1			
004906															
004910	2/16/00	2/17/00	7 18	26	106	16		0 17	0 09	0 41			0 02		
004915	4/17/00	4/20/00	7 09	168		120	39								
004915	4/17/00	4/20/00	6 81	208	314	130	51								
004922	2/23/00		6 8	12	52	5				0 48	0 5	2 37			
004926	2/22/00	2/25/00	8 04	390	229	21	12								
004934															
004938	2/23/00	2/26/00	6 3	141	24 2	1									
004940	1/25/00	1/25/00	6 03	190	97		81							530	120
004940	4/17/00	4/19/00	5 33	1000	380		420							1600	760
004944	11/8/99	11/9/00	6 38	9 3	62					1 1					
004947	11/8/99	11/10/99	6 76	820	293	47									
004947	2/10/00	2/18/00	6 75	50	51 4	9									
004951	2/10/00	2/11/00	7 23	17	124		16 4			0 182	1 01				
004951	2/10/00	2/11/00	6 9	16	71		21 7			0 194	0 694				
004954	1/25/00	1/28/00	3 21	42	335		19 7								
004954	2/29/00	3/2/00	6 8	98	380		31								
004955															
004956		1/26/00	6 16	176	36 6	3 85									
004956		1/26/00	6 28	35	89 8	2									
004956		1/26/00	6.43		49 1	2									
004956		4/18/00	5 46		110	48 7									
004956		4/18/00	6 07		251	4 5									
004956		4/18/00	7		8470	33									
004957															
004958															
004963	2/23/00	2/23/00	7 68	39	67	5									
004963	4/17/00	4/17/00	7 07	64	280	5									
004967	2/10/00	2/11/00	6.4	18	166	6 3			0 05	0 17	0 73				
004967	4/18/00	4/20/00	6 1	26	190	6 6			0 09	1.12	1.14				
004968	2/10/00	2/10/00	8 73	25	84	6 3								67	

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
004968	2/16/00	2/18/00	6 93	5	83	0 5								38	
004970	4/17/00	4/21/00	6 38	7	42 1	1		0 017		1 9					
004974															
004977	1/25/00	1/26/00	7 22	159	1400	0 5	17								
004977	3/4/00	3/6/00	6 94	26	373	0 5	3								
004994	12/31/99	1/3/00	6	8	94		27							110	26
004994	2/20/00	2/21/00	5 8	8	27		2 1							18	3 6
004994	2/20/00	2/21/00	5 9	10	12		3							22	4 2
004995	11/8/99	11/9/99	6 9	10	141		27							95	9
004995	1/25/00	1/26/00	6 9	10	32									11	3
005001	1/25/00	1/25/00	7 7	45	950	8 6									
005001	2/10/00	2/11/00	8 1	290	580	14									
005011	11/8/99		6 4	14	250	13									
005011	11/8/99		8 3	21	670	10									
005011	2/10/00		9 3	51	1370	3									
005011	2/10/00		10 01	42	1260	3									
005012	11/8/99		6 67	172	315	3 79									
005012	11/8/99		5 86	98	107	1 4									
005012	11/8/99		7 34	522	301	2 37									
005012	12/31/99		6 78	68	105	1 4									
005012	12/31/99		7 35	470	117	1 4									
005012	12/31/99		7 87	426	292	1 4									
005013	1/25/00		7 6	1300	1031	3	82								
005013	1/25/00		7 8	6580	483	1	27								
005013	1/25/00		7 5	776	404	2	25								
005013	3/8/00		8 09	125	1332	4	29 3								
005013	3/8/00		7 78	345	1160	2	25 5								
005013	3/8/00		7 78	5700	804	3	36 6								
005019	4/17/00	4/18/00	7	36	150	5 8		0 0002	0 31	0 83			0 01		
005020	1/25/00	1/31/00	5 95	32	54 4	1									
005027	1/17/00	1/21/00	2 89	423	9560	17	240								
005027	1/17/00	1/21/00	7 11	853	587	10	236								
005027	2/10/00	2/11/00	7 19	271	98	10	16 6								
005027	2/10/00	2/11/00	6 79	140	106	10	14 4								
005035	2/10/00	2/11/00	8 9	32	310	7 2									
005063															
005064	2/16/00		5 6	60	130	2									
005072															
005079															
005091	4/17/00	4/18/00	7 2	45	110	12		0 016	0 14	0 96			0 01		
005093	2/10/00	2/14/00	6 54	19	80					0 039					
005093	2/10/00	2/14/00	6 6	69	100					0 034					
005096	11/8/99	11/8/99	6 6	10	290	6				0 67	0 7	0 69			
005096	1/25/00	1/26/00	7	12	52	5				0 12	0 5	0 64			
005098	2/10/00	2/17/00	6 41	65	181	5 6									
005131	3/5/00	3/7/00	7 1	64	179			0 07			2 7	3 6			
005131	3/5/00	3/7/00						0 07			2 3	3 4			
005131	3/5/00	3/7/00	7 05	53	174			0 07			1 9	3			
005131	3/5/00	3/7/00	7 18	78	349										
005132	2/11/00	2/11/00	8 08	180	738	39	340	0 084			4 7	6			
005132	2/11/00	2/11/00	7 33	145	245	10	42	88			3 8	4 2			
005133	1/26/00	1/26/00	7 12	490	182			0 05			2	2 4			
005133	1/26/00	1/26/00	7 35	97	401			0 05			3 3	3 2			
005133	1/26/00	1/26/00	7 36	138	480			0 21			15	15			
005133	1/26/00	1/26/00	7 37	1380	530			0 27			52	63			
005133	2/10/00	2/11/00	7	310	171			0 12			14	14			
005133	2/10/00	2/11/00	7 02	512	256			0 15			22	25			
005133	2/10/00	2/11/00	7 19	230	574			0 36			7	8 5			
005133	2/10/00	2/11/00	7 25	2 28	966			3 4			41	52			
005146	1/25/00	1/28/00	5 83	76	54	20 2									
005146	2/10/00	2/14/00	6 47												
005152															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
005153	1/25/00	1/26/00	6 68	30	65	4 3		0 003	0 018	0 286			0 02		
005178	11/8/00		7	200	365	18									
005178	1/25/00		5 6	206	655	6									
005178	1/25/00		7 3	198	121	8									
005179	11/11/99		7 86	21	303	1 9									
005179	11/11/99		6 94	7	881	2									
005179	2/10/00		7 91	78	62	4 4									
005179	2/10/00		7 47	4 2	1040	1 4									
005181	2/10/00	2/17/00	6 63	27	54 1	8		0 08	0 072	0 399				58	
005195															
005196	11/8/99	11/8/99	6 1	28	120	2	15	0 13	0 16	3		3 6	0 04	96	
005196	11/8/99	11/8/99	6 2	67	170	1 5	16	0 1	0 15	6 5		1 5	0 04	122	
005196	11/8/99	11/8/99	6 4	206	88	1 9	15	0 18	0 56	5 2		3 6	0 05	242	
005196	4/17/00	4/17/00	5 5	51	141	1 7	42	0 1	0 2	1 2		1 6	0 04	158	
005196	4/17/00	4/17/00	5 9	89	383	2 8	34	0 1	0 25	17		7 2	0 09	294	
005196	4/17/00	4/17/00	6 1	351	1060	4 8	24	0 1	0 59	8 1		9 7	0 18	940	
005228	4/17/00	4/17/00	6 12	59	285	5									
005228	4/17/00	4/17/00	6 53	69	96	9									
005229	2/21/00	3/1/00	6 26	137	99	0 5									
005229	2/21/00	3/1/00	5 95	12	69	0 5									
005229	2/21/00	3/1/00	6 28	73	68	0 5									
005229	2/21/00	2/22/00	6 28	73	68	0 5									
005229	2/21/00	2/22/00	5 95	12	69	0 5									
005229	2/21/00	2/22/00	6 26	137	99	0 5									
005266															
005317															
005321															
005336	11/15/99	11/16/99	6 22	1	223	5	1								
005336	11/15/99	11/16/99	6 26	1	244	5	1								
005336	3/8/00	3/8/00	6 69	2 1	18 8	5	2 7								
005336	3/8/00	3/9/00	6 73	1 6	25 2	5	2 2								
005351	1/25/00	1/25/00	7 33	14			48								
005353	1/25/00	1/27/00	6 3	60	66	1	18	0 05						28	
005353	1/25/00	1/27/00	6 4	26	84	1	13	0 18						47	
005353	4/17/00	4/18/00	5	10	56	1	7 2	0 05	0 024	1 3			0 04	25	
005353	4/17/00	4/18/00	5 4	16	66	1 4	6 7	0 05	0 02	0 33			0 04	25	
005405	1/25/00	1/31/00	6 86	6	59	5			0 06	0 21	0 31				
005405	1/25/00	1/31/00	6 92	5	59	5			0 06	0 23	0 32				
005419	11/8/99	11/9/99	7 85	32	442	5	400							950	
005419	2/10/00	2/11/00					570								
005428															
005432	2/14/00	2/29/00				5									
005432	2/23/00	3/8/00				5									
005435	4/17/00	4/21/00	6 97	6880	483	29	18								
005440	1/25/00	1/28/00	7 06	8			16 2			0 904					
005454	2/10/00	2/10/00	6 39	68	89		59								
005463	2/24/00	2/25/00	6 7	25	15	1	2 8								
005463	4/17/00	4/18/00	4 3	120	47	1	8 5								
005470	2/14/00	2/15/00	6 9	10	50	2 3									
005472	2/24/00	2/25/00	6 82	82	251		3 7			0 93					
005498	1/25/00		7	92	170	5									
005498	1/25/00		6 1	26	170	5									
005536	2/10/00	2/11/00	6 79	36	249		51 9								
005536	4/17/00	4/20/00	6 71	130	722		179								
005554															
005557	1/25/00	1/26/00	6 66	55	70	5				0 582					
005557	1/25/00	1/26/00	6 57	20	50	5				0 429					
005557	3/8/00	3/9/00	7 51	14	80	5				0 135					
005557	3/8/00	3/9/00	7 04	10	14 5	5				0 232					
005561	2/10/00	2/11/00	8 2	4900	434		44 2					276		102	
005561	2/10/00	2/11/00	8 5	1560	436		47 9					130		155	
005561	2/10/00	2/11/00	8 2	168	337		32 8					295		155	

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
005561	2/10/00	2/11/00	8 1	2400	681							169		955	
005561	2/10/00	2/11/00	8 9	13600	594		59 6					898		1750	
005561	4/17/00	4/19/00	7 1	1540	537		112					849		374	
005561	4/17/00	4/19/00	8	274	157		17 1					122		50 3	
005561	4/17/00	4/19/00	7 3	6240	326		47					160		132	
005561	4/17/00	4/19/00	8 2	2060	409		19 2					914		49	
005561	4/17/00	4/19/00	7 6	994	125		26 1					516		75 1	
005592	11/8/99	11/9/00	7	600	750	5	120								
005592	1/17/00	1/18/00	7 17	576	450	15	120								
005602															
005604	2/23/00	2/24/00	7 33	12	20		5 5								
005608	1/25/00	1/25/00	3 73	12	140	5				0 64					
005619															
005620	2/14/00	2/14/00	7 4	956	1000	8									
005620	3/8/00	3/8/00	8 4	152	0 269	19 2									
005647															
005692	9/21/99	9/22/99	5 82	10	180	1 3									
005692	9/21/99	9/22/99	8 55	22	2080	2 8									
005692	9/21/99	9/22/99	7 53	33	990	1 1	38								
005692	9/21/99	9/22/99	7 3	273	569	3 9		4 3							
005692	9/21/99	9/22/99	5 64	5	186	0 6									
005692	9/21/99	9/22/99	7 84	15	962	0 5	31								
005692	1/25/00	1/26/00	8 07	458	2140	1 5									
005692	1/25/00	1/26/00	8 23	343	583	2 1			0 102		16				
005692	1/25/00	1/26/00	7 49	704	612	2 7	27								
005692	1/25/00	1/26/00	6 9	308	252	0 7		20 5							
005692	1/25/00	1/26/00	6 69	19	170	0 4									
005692	2/15/00	2/15/00	8 01	231	369	1 1									
005692	4/17/00	4/18/00	7 78	384	155	0 9									
005692	4/17/00	4/18/00	7 49	296	1470	1 3	9 5								
005692	4/17/00	4/18/00	7 12	5510	580	0 7						4440			
005693	4/17/00	4/21/00	6 97	6880	483	29	18								
005693	4/17/00	4/21/00	7 34	4600	102	57	11								
005713	2/10/00	2/14/00	6 67	32	172	19 8		0 1	0 05	0 58				142	
005713	4/17/00	4/18/00	6 51	47	214	13		0 15	0 06	0 7				214	
005721	1/25/00		6 5	64	52	5	23	5	0 03	0 98			5		60
005750	2/16/00	2/18/00	6 67	30	80	5		0 071	0 05	0 217			0 05		
005750	2/16/00	2/18/00	6 01	47	110	5		0 05	0 495	1 06			0 05		
005750	2/16/00	2/18/00	6 11	10	91	5		0 05	0 105	0 909			0 055		
005750	2/16/00	2/18/00	6 23	39	110	5		0 05	0 688	1 89			0 05		
005750	2/16/00	2/18/00	6 74	10	110	5		0 05	0 05	0 05			0 05		
005750	2/16/00	2/18/00	5 74	10	32	5		0 05	0 05	0 05			0 05		
005750	2/16/00	2/18/00	3 08	46	380	5		0 05	0 156	0 439			0 05		
005750	2/16/00	2/18/00	5 72	10	33	5		0 05	0 05	0 05			0 05		
005750	2/16/00	2/18/00	5 91	14	70	5		0 05	0 152	0 522			0 05		
005750	2/16/00	2/18/00	6 06	255	140	5		0 162	0 521	1 88			0 05		
005750	2/16/00	2/18/00	6 04	21	90	5		0 05	0 197	0 803			0 05		
005750	2/16/00	2/18/00	6 22	10	15	5		0 05	0 096	0 328			0 05		
005750	2/16/00	2/18/00	6 28	44	49	5		0 05	0 096	0 561			0 05		
005750	2/16/00	2/18/00	6 05	10	55	5		0 05	0 057	0 459			0 05		
005750	2/16/00	2/18/00	6 25	10	100	5		0 05	0 153	1 32			0 05		
005750	2/16/00	2/18/00	6 28	13	65	5		0 067	0 126	0 767			0 05		
005750	2/16/00	2/18/00	6 37	47	65	5		0 055	0 44	1 75			0 05		
005750	3/8/00	3/9/00	5 67	10	74	5		0 05	0 078	0 853			0 05		
005750	3/8/00	3/9/00	6 48	10	66	5		0 05	0 065	0 631			0 05		
005750	3/8/00	3/9/00	6 24	10	25 5	5		0 05	0 055	0 588			0 05		
005750	3/8/00	3/9/00	6 15	97	27	5		0 05	0 05	0 299			0 05		
005750	3/8/00	3/9/00	6 04	11	60	5		0 05	0 051	0 575			0 05		
005750	3/8/00	3/9/00	6 45	10	76	5		0 05	0 064	0 273			0 05		
005750	3/8/00	3/9/00	6 48	43	81 8	5		0 05	0 275	0 769			0 05		
005750	3/8/00	3/9/00	6 46	22	44 2	5		0 05	0 136	0 841			0 05		
005750	3/8/00	3/10/00		19		5		0.05	0 083	0 163			0 05		

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
005775															
005776	4/17/00	4/18/00	7 5	18	24	3 2		0 002	0 005	0 031			0 02		
005776	4/17/00	4/18/00	7 08	53	120	4 8		0 002	0 005	0 077			0 02		
005776	4/17/00	4/18/00	8 09	84	354	6 5		0 002	0 02	0 118			0 173		
005777	1/25/00	1/26/00	7 35	28	157	1 7		0 002	0 014	0 085			0 02		
005777	1/25/00	1/26/00	7 78	523	439	1 5		0 002	0 02	0 111			0 02		
005777	1/25/00	1/26/00	7 6	118	339	0 8		0 002	0 006	0 061			0 02		
005786	1/25/00	1/26/00	8 2	3940	747	5	17 4	0 214				68		43 2	
005786	1/25/00	1/26/00	8 5	234	892	1 9	13 3	0 004				4 57		43 2	
005786	2/10/00	2/11/00	8 6	6730	467	5	45 2	0 334				145		650	
005786	2/10/00	2/11/00	9	108	563	5	13 3	0 011				10 2		650	
005797															
005806	11/8/99	11/10/99	7	34											
005806	4/17/00	4/20/00	7	8	37	3									
005810	1/28/00	2/2/00	7 96	175	0 86	5 3									
005817	2/16/00	2/17/00	7 38	150	58					0 05					
005839															
005840															
005842	4/17/00	4/18/00	6 92	55	220					0 83					
005861															
005878	11/8/99		8 21	100	6230		38								
005878	11/8/99		7 55	100	2730		94								
005878	2/10/00		8 04	100	282		4 9								
005878	2/10/00		7 24	100	527		6 8								
005899	3/8/00	3/9/00	6 91	6	15	5									
005899	3/8/00	3/9/00	6.91	5	20	5									
005899	4/17/00	4/17/00	7 14	30	130	5									
005899	4/17/00	4/17/00	7 02	42	130	5									
005903	2/16/00	2/22/00	5 51	52	56 6	5	4 36								
005903	3/8/00	3/9/00	5 76	6	22	5	2 58								
005905	2/16/00	2/18/00	2 15	6	4455	5	4 7								
005905	3/8/00	3/10/00	5 67	6	18	5	0 92								
005914	11/8/99	11/8/99	6 49	21	290	5				1 7	0 77	1 3			
005914	2/10/00	2/11/00	6 94	142	140	5				1 1	4 4	6 9			
005929	2/17/00	2/17/00	6.19	90	95 1	51 1	14								
005929	2/17/00	2/17/00	6 1	126	97 7	60 3	14								
005929	4/18/00	4/18/00	7	29	213	103	50								
005929	4/18/00	4/18/00	7	46	206	38	47								
005958															
005959	4/17/00	4/19/00	8 2	42 9	40	0 49									
005960	4/17/00	4/19/00	7 8	26 2	60	0 26									
005960	4/17/00	4/19/00	8 2	24 4	60	1.16									
005962	4/17/00	4/19/00	7 9	14 2	40	0 44									
005963	4/17/00	4/19/00	8 4	88 8	40	0 76									
005963	4/17/00	4/19/00		11 5		0 33									
005964	4/17/00	4/19/00	8.7	107	50	0 44									
005965															
005966	4/17/00		7 9	278	1540	0 41									
005968	4/17/00		8	17 2	10	0 7									
005968	4/17/00		8	16 8	10	0 53									
005996															
006003	1/25/00	1/25/00	7 8	23	59	4	27			0 5	2 55	2 7			
006003	1/25/00	1/25/00	7 7	53	120	4	1			0 8	0 469	0 5			
006003	1/25/00	1/25/00	7 7	17	54	4	18			0.8	0 295	0 6			
006003	4/17/00	4/17/00	5 9	39	120	4	45			1 1	2	1 8			
006003	4/17/00	4/17/00	7 6	14	51	4	8 7			0 6	1 2	0 5			
006003	4/17/00	4/17/00	7 5	14	48	4	9.7			0 9	2	0 5			
006004	1/25/00	1/27/00	6 49	167	128	5	43								
006004	11/8/99	11/9/99	5 88	153	150	5	46 9								
006014															
006041															
006061															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
006062															
006064															
006065															
006076	1/26/00	1/26/00	5 2	95	21 8		6 5								
006076	4/18/00	4/18/00	6	46	39		10 2								
006091	11/8/99	11/11/99	7 9	40	360	6 1		0 037	0 48	0 0044			0 066		
006091	11/8/99	11/11/99	10 3	26	440	44		0 037	0 48	4 1			0 067		
006091	1/25/00	1/26/00	7 2	51	130	0 9		0 013	0 169	1 44			0 033		
006091	1/25/00	1/26/00	9	37	130	0 5									
006120	2/16/00	2/21/00	7 63		2950	8			1 88	18 4					
006120	3/8/00	3/9/00	7 28		1470	38			1 33	17 9					
006143															
006146															
006150	11/9/00	11/12/00	6 5	107	53	2 5									
006150	2/16/00	2/28/00	7 7	5	21	3 5									
006157	1/25/00	2/2/00	6 2	54	330		18								
006157	2/10/00	3/6/00	2 9	39	1200		24								
006159	4/17/00	4/19/00	6 12	3	14	10	5 99								
006159	4/17/00	4/19/00	5 52	4	10	10	8 17								
006159	4/17/00	4/19/00	5 24	2	4	10	4 35								
006164															
006166	1/25/00	1/28/00	6 57	15	83	0									
006166	1/25/00	1/28/00	6 25	24	92	0									
006166	1/25/00	1/28/00	6 3	17	73	0									
006166	1/25/00	1/28/00	6 6	19	297	0									
006166	1/25/00	1/28/00	7 02	16	277	0									
006166	2/23/00	3/23/00	5 78	31	40	0									
006166	2/23/00	3/23/00	5 51	26	26	0									
006166	2/23/00	3/23/00	5 62	30	32	0									
006166	2/23/00	3/23/00	6 78	28	31	0									
006166	2/23/00	3/23/00	8 08	18	98	0									
006166	2/23/00	3/23/00	5 73	11	32	0									
006167	1/25/00	1/25/00	6 25	24	92	0 5									
006167	1/25/00	1/25/00	6 3	17	73	0 5									
006167	2/23/00	2/23/00	5 73	11	32	0 5									
006167	2/23/00	2/23/00	5 51	26	26	0 5									
006177	6/23/00	6/23/00	4 44	0	68	0									
006187	4/17/00		6 01	21	65	5 2		0 05	0.01	0 084			0.01		
006187	4/17/00		5 64	26 5	35	5		0 01	0 03	0 176			0 01		
006188	2/10/00	5/3/00	7 08	10	1 2		0 52	0 02	0 01	0 01		0.05			
006188	2/10/00	5/3/00	7 51	536	1330		65	0 22	0 09	0.74		20.1	0 04		
006189	2/10/00		7 68	41	351		19 3	0 02	0.03	0.12		5 05			
006189	4/17/00		7 78	262	202		30 9	0 03	0 06	0 31		20.2			
006189	2/10/00		7 4	10	1 67		0 72	0 02	0.01	0 01					
006189	4/17/00		5 86	10	1 19		0 5	0 02	0 01	0 01					
006190	2/10/00		8 13	1296	163		17 2	0 09	0 11	0.97		72 4	0.08		
006190	2/10/00		7 32	524	1694		54 4	0 03	0 04	0 18		25 8	0 05		
006190	2/10/00		7 65	1580	1211		18 3	0.04	0 1	1 4		68	0 11		
006190	4/17/00		8 22	7000	488		22 3	0 2	0 5	1 9		405	0 6		
006190	4/17/00		8 16	5640	1395		33 6	0 23	0 3	1 1		277	0 3		
006190	4/17/00		7 92	712	685		25	0 02	0 06	0 57		36 3	0 06		
006191	4/17/00		7 85	5440	1810		64 4	0 27	0 5	1 9		348	0 3		
006191	4/17/00		7 81	25760	1090		30	0 6	2 8	7 6		2510	2		
006191	2/10/00		6 71	10	1 37		0 5	0 01	0 01	0 01		0 06	0 02		
006191	4/17/00		5 5	10	2 63		0 66	0 01	0 01	0 02		0 05	0 02		
006191	2/10/00		7 36	336	1083		49 2	0 02	0 04	0 39		19	0 02		
006191	2/10/00		7 89	4270	1390		47.7	0 5	0 49	2 13		269	0 25		
006191	2/10/00		7 8	43640	1230		43 5	0 6	2 52	7 5		2480	1 7		
006191	4/17/00		7 45	120	577		61 8	0 01	0 03	0 22		6 64	0 02		
006192	2/10/00		7 85	1152	536		22 3	0 06	0 08	0 57		22 3	0 12		
006192	2/10/00		7 63	76150	3340		120	1 4	2 2	10 7		120	3 7		
006192	2/10/00		8 32	2327	1362		52 3	0.1	0 18	8 7		52 3	0 23		

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
006192	2/10/00		7 85	1300	2050		72 4	0 05	0 1	1 06		72 4	0 17		
006192	4/17/00		8 05	2390	356		18 4	0 07	0 1	0 6		18 4	0 2		
006192	4/17/00		7 67	25140	1931		100	0 26	1 5	4 8		100	2 1		
006192	4/17/00		7.61	808	494		19 3	0 02	0 05	0 44		19 3	0 08		
006192	4/17/00		7 94	2025	885		35 2	0 07	0 13	0 63		35 2	0 19		
006193	4/17/00	4/18/00	8 53	12980	1690		84 6	0 9	0 81	3 2		794	0 47		
006193	4/17/00	4/18/00	5 51	10	3 2		0 89	0 01	0 01	0 03		0 25	0 02		
006194	4/17/00		7 15	600	199		48 8	0 07	0 07	0 42		31	0 42		
006194	2/10/00		7 57	10	5 35		2 17	0 02	0 01	0 02		0 06	0 02		
006194	2/10/00		7 85	377	109		20	0 06	0 13	0 8		19 1	0 07		
006194	2/10/00		7 43	282	371		82 6	0 04	0 05	0 33		13 8	0 03		
006194	2/10/00		7 69	4444	360		78	0 51	0 27	1 41		171	0 3		
006194	4/17/00		5.61	10	1 94		0 75	0 02	0 01	0 03		0 05	0.02		
006194	4/17/00		7 3	440	302		39 8	0 08	0 23	1 22		19 1	0 07		
006194	4/17/00		7 29	392	266		84 2	0 04	0 08	0 43		15 8	0 04		
006198	1/25/00	1/26/00	8	88	810		16 2								
006207															
006212	2/23/00	3/7/00	7	42	610	3		0 08	0 05	0 77	0 467	1 1		83	8
006213	2/12/00	2/16/00	7 41	215	576	43	59 2	0 52	0 24	2 24	4 06	19 1		410	
006213	2/16/00	2/22/00	7 12	69	560	25	74	0 144	0 104	1 2	1 4	5 08		340	
006214	3/8/00	3/9/00	6 91	49	193	6	14 2	0 0608	0 04	0 502	1 89	3 7		67	
006214	2/14/00	2/14/00	7.24	14	298	1	16	0 0445	0 0418	0 503	0 981	1 58		62	
006216	1/25/00	1/26/00	7.86	22	1160	4	60	0 0288	0 0906	0 358	0 639	3 35		270	
006216	2/10/00	2/11/00	6 89	7	1120	2	79 5	0 015	0 039	0 29	0 159	7 03		240	
006217	1/25/00	1/28/00	7 77	143	1580	21	102	0 343	0 425	2 08	4 61	14 5		460	
006217	2/16/00	2/18/00	7 4	48	848	10	56	0 135	0 0973	0 98	1 03	4 66		260	
006217	3/13/00	3/13/00	6 8	40	790	9	50	0 093	0 075	1 51	0 837	4 11		210	
006218															
006218	1 17 00	6/16/00	77	35	27	5									
006257	1 25 00		9 8	180	0 34										
006258															
006262															
006263															
006285															
006288															
006303	4/17/00	4/19/00			82										
006303	4/17/00	4/19/00		60	530	4 1									
006303	4/17/00	4/19/00		72	640	10									
006307	4/17/00	4/18/00	7 25	71			18					1 61		67	
006307	4/17/00	4/18/00	6 63	103			17					1 23		85	
006307	4/17/00	4/18/00	7 34	42			18					0 803		62	
006307	4/17/00	4/18/00	7 09	48			18					0 522		60	
006307	4/17/00	4/18/00	7 23	108			13					2 63		65	
006310	1/25/00	1/25/00	7.2	140	32	9 3		0 047	0 039	0 48	3	5 1			56
006310	1/25/00	1/25/00	7.8	85	110	4 7		0 011	0 021	0 2	1 2	1 7			72 5
006319															
006322	4/17/00	4/18/00	6 3	29	130	1 4								66	1 6
006323	1/25/00	1/25/00	6 9	33	31	2 8									13
006326															
006333															
006334	1/25/00	1/25/00	7 6	16	92	2 6									37 2
006341	2/10/00	2/11/00	6	23	92	2 6									21 4
006341	2/10/00	2/11/00	6 7	37	39	3									20
006342	2/10/00	2/11/00	7 1	47	60	1 5									18 2
006342	2/10/00	2/11/00	7.8	37	70	3 7									21
006343	1/25/00	1/25/00	7	49	62	2 5									26 5
006344	4/17/00	4/18/00	6.7	340	390	4 1									164
006347	11/8/99	11/8/99	6	28	580	1 7									66
006347	11/8/99	11/8/99	5 9	18	400	1 5									16
006347	11/8/99	11/8/99	6.4		190										12
006348	11/8/99	11/9/99	6 8	78	380	8 7									76
006355															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
006357															
006358															
006359															
006361	11/8/99	11/8/99	6 1	26	242				0 16	3 34					
006370															
006378															
006379															
006381															
006389	11/8/99	11/8/99	6 6	15 5	372	2 5	95					1 06			
006389	1/25/00	1/25/00	7 7	29 4	286	4 7	40 6					1 38			
006390															
006391	11/8/99	11/8/99	7 3	78 7	1501		16 8					3 8			
006391	11/8/99	11/8/99	7	58 4	533		11 5					10			
006391	11/8/99	11/8/99	7 5	24 3	1614		14 7					1 68			
006391	11/8/99	11/8/99	7.4	114	523		14 2					4 5			
006391	11/8/99	11/8/99	7 8	82 1	665		19 6					8 82			
006391	1/15/00	1/17/00	6 6	26 5	299	2 4	127					1 1			
006391	1/15/00	1/17/00	6 4	27 6	297	2 5	127					1 07			
006391	1/15/00	1/17/00	6 4	27	289	3 5	127					1 02			
006391	1/15/00	1/17/00	6 4	27 7	297		125					1 02			
006391	1/15/00	1/17/00	6 6	22 9	296		124					1 39			
006393	1/25/00	1/25/00	6 6	24 9	268		13 8					0 967			
006393	3/8/00	3/8/00	7.4	7 7	266		6 42					0 6			
006394	11/8/99	11/9/99	6 2	5 5	791		37 9								
006394	1/25/00	1/26/00	7 5	309	279	8 6	33					9 13			
006408															
006409	1/25/00	1/26/00	1 86	74	7500			0 017	0 02	6 6					
006409	1/25/00	1/26/00	6 56	20	83			0 008		3 9					
006411															
006416															
006424															
006425															
006429															
006439	1/25/00	1/26/00	7 04	86	57			0 008	0 03	0 68					
006446															
006448	4/18/00	4/21/00	6 36	150	44			0 05	0 03	0 51					
006450															
006466															
006468															
006469															
006470															
006471															
006493	11/16/00	11/22/00	6 76	172	0 51	22 3									
006493	11/16/00	11/22/00	5 49	46	0 32	0									
006493	11/16/00	11/22/00	6 42	37	87 1	15									
006493	11/16/00	11/22/00	6.74	189	0 53	0									
006493	4/17/00	4/21/00	5.76	86	940	0									
006493	4/17/00	4/21/00	6.33	384	2950	0									
006493	4/17/00	4/21/00	6 67	66	450	0									
006493	4/17/00	4/21/00	7 48	124	1980	0									
006512															
006549															
006551	11/8/00	11/10/00	6.9	60	490		180								
006551	11/8/99	2/1/00	6 7	30	150	9 4	55								
006582															
006586															
006665	11/8/00	12/9/00	6 33	23 6	155	5	50 4			1 3	1 2	3 4			
006665	2/10/00	3/10/00	6 85	111	118		32.7								
006724															
006751	1/25/00	6/5/00	5.64		64 4		6 53								
006751	2/10/00	6/5/00	5.5		113		20.1								
006757	1/25/00	2/1/00	6.16	17	20	5									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
006757	1/25/00	2/1/00	6 22	10	30	5									
006757	1/25/00	2/1/00	6 73	10	50	5									
006757	1/25/00	2/1/00	6 7	27	160	5									
006759	11/8/99	11/8/99	6 04	158	480	14									
006759	11/8/99	11/8/99	6 41	92	420	31									
006759	11/8/99	11/8/99	6 78	53	365	12									
006759	11/8/99	11/8/99	7 59	70	585	25									
006759	4/17/00	4/18/00	5 9	200	1030	18 1									
006759	4/17/00	4/18/00	6 1	132	961	17 2									
006759	4/17/00	4/18/00	6 6	60	510	5 9									
006759	4/17/00	4/18/00	7.4	154	586	34 3									
006759	4/17/00	4/18/00	5 9	200	1030	18 1									
006760	2/10/00	2/23/00	6 48	255	540	15 4									
006760	2/10/00	2/23/00	6 64	106	185	15 4									
006760	2/10/00	2/23/00	6 55	256	400	175									
006761	4/17/00	4/18/00	7.7	75	116	32 3									
006764	4/17/00	4/18/00	7 7	75	116	32 3									
006764	4/17/00	4/18/00	7 2	86	222	24 1									
006764	4/17/00	4/18/00	6 9	14	113	1 9									
006764	4/17/00	4/18/00	7 5	1020	192	128									
006764	4/17/00	4/18/00	7 1	34	309	5 5									
006764	4/17/00	4/18/00	7 7	134	294	3 6									
006764	4/17/00	4/18/00	8.8	852	641	241									
006764	4/17/00	4/18/00	8 3	122	395	27 8									
006818	1/25/00		6 5	105	32	5	3 5	0 02	0 11						
006818	1/25/00		7 1	23	48	5	3 4	0 02	0 02						
006852	2/16/00	2/16/00	8 35	36	73	3									
006852	2/16/00	2/16/00	8 75	12	89	3									
006852	2/16/00	2/16/00	7 01	6	30	3									
006852	4/18/00	4/18/00	6 14	30	24	30									
006852	4/18/00	4/18/00	7 37	77	85	77									
006852	4/18/00	4/18/00	6 15	45	61	45									
006866	11/8/99	11/18/99	5 83	61	520										
006866	1/25/00	1/26/00	7 09	32	17										
006885	4/17/00	4/17/00	7	80	418	2 5									
006885	4/17/00	4/17/00	5 8	105	325	4 5									
006903															
006935	3/8/00	3/14/00	6 97	92	42	11									
006935	2/21/00	3/2/00	8 51	24	43		3 6							22	
006936															
006948	2/10/00	2/17/00	6 81	170	96		9 2								
006948	2/10/00	2/17/00	6 07	60	74 4		12								
006948	2/10/00	2/17/00	6 27	110	25		6 4								
006948	11/8/99	11/11/99	6 57	26	210	21	35								
006948	11/8/99	11/11/99	6	325	170	20	62								
006948	11/8/99	11/11/99	6 12	365	90	22	17								
006953	1/25/00	2/2/00	6 32	22	194	0									
006953	1/25/00	2/2/00	6 13	94	197	0									
006953	2/14/00	2/23/00	6 89	96	60 6	0									
006953	2/14/00	2/23/00	7 27	33	148	0									
006953	2/14/00	2/23/00	6 36	10	99 1	0									
006958	1/25/00	1/27/00	7 78	21	32	1 95									
006958	1/25/00	1/27/00	7 33	6 2	3	0 51									
006958	1/25/00	1/27/00	7 06	8 8	80	0 56	69								
006958	2/10/00	2/11/00	7 69	14 6	41	0 82	7 9								
006958	2/10/00	2/11/00	7 28	3 5	31	1 64	5 8								
006958	2/10/00	2/11/00	7 23	1 8	27 5	0 62	3 6								
006958	2/10/00	2/11/00	6 84	8 9	34 9	1 13	3 7								
006958	2/10/00	2/11/00	7.07		31.1	1									
006958	1/25/00	1/27/00	7 88	21 4	36	0 51									
006962															
006966	4/17/00	4/17/00	8.6	34	136	10									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
006966	1/25/00	1/26/00	7	23	104	10									
006973	1/25/00	1/25/00	7 1	9	34	6									
006973	2/16/00	2/16/00	6 8	6	72	6									
006976	1/25/00	7/14/00	6 05	0	124	0									
006982	11/8/99	11/30/99	6 4	130	150	0									
006982	4/17/00	5/5/00	5 7	65	67	11									
006987	2/10/00	2/14/00	9 53	316	340				0 05	0 65	5 3	10 1		323	
006987	4/17/00	4/18/00	8 18	650	1190	25 8			0 11	1 05	4 91	9 39		1360	
006988															
006997	1/25/00	1/26/00	5 7	12	45				0 09	3	0 31				
006997	1/25/00	1/26/00	6 1	0 7	45					0 54	0 7				
006997	3/8/00	3/9/00	5 9		21				0 03	0 53					
006999															
007000	11/8/99	11/8/99	4 21		79										
007000	1/25/00	1/27/00	6 54	432	27	9 8								106	
007019	11/8/99	11/17/99	7	140	70	0	8 7								
007019	11/8/99	11/17/99	6 9	88	140	0	18								
007019	11/8/99	11/17/99	7 1	21	190	4 2	29								
007019	2/10/00	2/23/00	6 7	220	190	4 6	24								
007019	2/10/00	2/23/00	7 2	120	77	4 8	23								
007019	2/10/00	2/23/00	7 8	260	58	1 7	8 5								
007024															
007029	1/25/00	1/28/00	5 3	12			6 6								
007029	1/25/00	1/28/00	5 4	64			5								
007034															
007042	2/10/00	2/10/00	7 5	78	40	7	11								
007042	4/17/00	4/17/00	7 2	110	89	11	39								
007080	1/25/00		7 21	179	166	6 4	37 9								
007080	1/25/00		7 44	167	194	16 4	5 02								
007080	2/12/00		8 26	462	116	2 9									
007080	2/12/00		7 52	28	1730	0 7									
007080	2/12/00		7 62	28	94 1	2 1									
007080	2/12/00		7 28	70	123	2 6									
007106	1/25/00	1/25/00	7 74	177	270	34			0 21	0 2					
007106	1/25/00	1/25/00	7 85	186	280	49 6			0 25	0 3					
007106	1/25/00	1/25/00	8 98	134	1390	66			0 16	0 44					
007106	4/18/00	4/18/00	7 39	157	137	7			0 21	0 26					
007106	4/18/00	4/18/00	7 64	115	380	15 3			0 09	0 09					
007106	4/18/00	4/18/00	7 09	124	130	15 6			0 09	0 03					
007108															
007109	4/17/00		10 99	221	1 37	18 3						6.44			
007113															
007120															
007121															
007122															
007131	4/18/00	4/19/00	6 98	133	230										
007131	2/17/00	2/17/00	8 13	71	134										
007149	1/25/00		8 25	142	121	5									
007149	1/25/00		7 91	236	778	5									
007149	1/25/00		8	364	529	5									
007150															
007151															
007152															
007153	1/25/00		7 91	236	778	5									
007154	1/25/00		8	364	529	5									
007188	4/17/00	4/18/00	6 16	5	35	5									
007196	1/25/00	1/25/00	6 56	34	94 5	0 53									
007196	1/25/00	1/25/00	6 82	52	98 3	1 48									
007196	1/25/00	1/25/00	6 78	60	81 3	0 54									
007196	3/4/00	3/4/00	6 87	42	303	1 3									
007196	3/4/00	3/4/00	6 91	190	272	1 6									
007196	3/4/00	3/4/00	6 98	153	186	3									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
007202	4/17/00	4/18/00	7	9	36	6								120	
007204															
007206															
007209	2/21/00	2/21/00	7 28	23	64	23 8		0 22	0 4			1 16		136	
007211															
007214	11/8/99	11/8/99	6 74	15	200	9 2								165	
007214	1/25/00	1/27/00	6 85	15	220	7 5								236	
007219	1/25/00	1/25/00	7 6	7	28	4			0 2	0 5	0 1	0 5			
007219	2/16/00	2/16/00	6 7	4	50	4			0 2	0 6	2	0 5			
007220	1/25/00	1/28/00	7 1	215	356	5									
007220	1/25/00	1/28/00	7	15	232	5 2									
007220	1/25/00	1/28/00	7 2	37	441	5									
007223															
007226															
007231															
007234	1/25/00	2/2/00	6 2	37	370	12									
007234	4/17/00	4/25/00	6 7	65	45	0									
007242	2/14/00	2/15/00	6 66	23	55	11 1								52	
007242	2/14/00	2/16/00	6 95	10	41	0 5								40	
007243	2/10/00	2/19/00	6 54	60	59 7	20									
007254	3/8/00	3/9/00	7 25	96	58	5						5 4			
007254	2/10/00	2/15/00	5 85	102	100	5						3 2			
007257	3/4/00	3/9/00	8 1	6	970	2 4	7 6	0 0225	0 122	1 07			0 057		
007282															
007284	2/10/00	2/12/00		30	461		61								
007284	3/8/00	3/9/00		10	192		14								
007310	4/17/00	4/18/00	6 6	160	360	15		0 074	1 4	2 3					
007310	4 17 00	4/18/00	6 6	150	350	4 5		0 23	3 5	2 1					
007310	4 17 00	4/18/00	7	59	390	6 8		0 14	2 7	1 3					
007310	4 17 00	4/18/00	6 3	180	840	5 1		0 079	3 2	3 5					
007310	4 17.00	4/18/00	6 6	120	500	2 6		0 035	1 8	1 5					
007310	11/8/99	11/8/99	7 2	14	210	8 2		0 19	1 2	2 5					
007310	11/8/99	11/8/99	6 5	120	220	2 4		0 034	1 8	1					
007310	11/8/99	11/8/99	6 4	24	290	1 9		0 024	1 1	3 1					
007310	11/8/99	11/8/99	6 3	100	580	6 7		0 11	3 3	2 4					
007310	11/8/99	11/8/99	6 5	10	1500	4 2		0 053	3 8	2					
007316															
007317															
007321	4/17/00	4/19/00	6 7	10	27	0 5									
007321	2/10/00	2/11/00	8	200	89	5 4									
007331	11/8/99	11/17/99	7 03	16	178	15	38		0 186						
007331	2/10/00	2/15/00	6 66	78	183	8	32		1 2						
007332	1/26/00	1/28/00	6 5	5	210	1									
007332	1/26/00	1/28/00	6 9	10	190	0 9									
007332	1/26/00	1/28/00	580	12	580	6 6									
007332	1/26/00	1/28/00	7	20	1100	11									
007332	1/26/00	1/28/00	6 3	31	570	13									
007332	2/10/00	2/11/00	7 4	2	160	0 7									
007332	2/10/00	2/11/00	7 6	2	170	0 9									
007332	2/10/00	2/11/00	2	2	6500	20									
007332	2/10/00	2/11/00	7 3	2	180	0 9									
007332	2/10/00	2/11/00	7 3	2	180	3 3									
007332	2/10/00	2/11/00	7 3	3	190	10									
007343	2/10/00	2/15/00	6 9	100	120										
007344	2/4/00	2/21/00	6 8	6 8	150	4 5									
007344	2/4/00	2/21/00	6 9	7 6	100	5 8									
007344	2/4/00	2/21/00	6 8	16	110	2 8									
007345	2/10/00	2/15/00	6 61	10	103	1								78	
007345	3/6/00	3/7/00	6 4	14	43	10 5								13	
007346	11/8/99	11/9/99	6 48	77	142	13 1								281	
007352	1/25/00	1/25/00	7 61	35	120	5			0 02	0 1					
007352	1/25/00	1/25/00	7 06	13	180	9			0 02	1 1					

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
007352	4/18/00	4/18/00	6 39	8	73	17			0 02	0 58					
007352	4/18/00	4/18/00	7 02	80	94	5			0 02	0 57					
007353	3/1/00	3/1/00	6 93	79	82	5									
007353	3/14/00	3/14/00	7 13	15	86	10									
007359	3/7/00		7 2	21	7	5	1 6								
007359	3/7/00		6	10	7	5	1 2								
007359	4/17/00		6 6	76	34	5	3 8								
007359	4/17/00		6 4	99	56	5	6 1								
007362	2/10/00		7 6	15	109	9	23						0 02		
007362	2/10/00		7	5	75	10	15						0 02		
007362	4/17/00		5 6	51	74	5	23						0 08		
007362	4/17/00		5 9	71	198	5	49						0 07		
007362	4/17/00		6 3	29	158	5	43						0 11		
007362	4/17/00		5 8	26	112	5	53						0 09		
007362	4/17/00		6 5	14	128	5	36						0 02		
007362	4/17/00		6 7	47	100	5	34						0 1		
007362	4/17/00		6 9	5	176	5	62						0 02		
007362	4/17/00		6 9	35	74	5	27						0 11		
007371	1/25/00	1/25/00	6 69	28	145	4 1									
007371	1/25/00	1/25/00	6 63	42	283	16									
007371	2/16/00	2/16/00	6 34	130	78	0 5									
007371	2/16/00	2/16/00	7.51	54	88	0 5									
007371	3/8/00	3/8/00	8 52	49	35	2 6									
007371	3/8/00	3/8/00	8 61	15	65	6 1									
008000	1/25/00	1/27/00	7	58	210	5			0 03	2 4					
008000	4/17/00	4/19/00	6 6	180	240	5			0 08	17					
008004															
008006	2/10/00	2/11/00	7 4	69	77	1 5									
008006	1/25/00	1/25/00	6 9	20	78	2									
008007	2/10/00	2/18/00				1									
008007	2/10/00	2/18/00				1									
008007	2/10/00	2/18/00				1									
008007	4/17/00	4/20/00	6 63	61	520	5	151								
008007	4/17/00	4/20/00	7 18	58	105	3	6 4								
008018	1/25/00	1/25/00	8 25	24	61	5	6 1								
008018	1/25/00	1/25/00	7 77	27	200	5	58								
008019	1/25/00	1/25/00	7 1	22	110	3 3									
008019	1/25/00	1/25/00	7 1	12	120	3 5									
008019	2/10/00	2/10/00	7 1	29	120	3 4									
008019	2/10/00	2/10/00	6 8	64	120	3 6									
008028															
008031	4/17/00	4/17/00	6 9	300	160	5 1									
008031	4/17/00	4/17/00	7 1	610	490	6 7									
008031	4/17/00	4/17/00	7 3	190	370	12									
008195	11/8/99	11/8/99	7.9	488	425	42	25								
009006	11/8/99	11/9/99	7 1	29	65	4									
009006	4/17/00	4/18/00	6 3	140	330	5									
009008															
009017	1/25/00	1/25/00	7 05	130	115	6									14
009017	3/3/00	3/3/00	6 37	66	44	2									42
009017	4/17/00	4/17/00	7 43	413	156	6									147
009019	11/8/99	11/9/99	6 05	70	183	44									
009019	11/8/99	11/9/00	6 65	46	212	13									
009019	1/25/00	1/26/00	7 74	18	65	2									
009019	1/25/00	1/26/00	7 48	68	62	1									
009021	1/26/00	1/26/00	7 6	6	798	5									
009021	1/26/00	1/26/00	7 28	192	958	1									
009021	2/14/00	2/14/00	6 38	1	66	1									
009021	2/14/00	2/14/00	6 68	3	141	2									
009023	1/25/00	1/25/00	6 9	58	420	5		0 22	1	3 2	2 3	1 4		360	
009031															
009045															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
009054															
009056	1/25/00		7 3	10	9 8	20	5 8								
009056	4/17/00		7 3	17	34	5	33								
009057	11/8/99	11/9/99	6 04	24	270	7 7				1 92	1 4	0 9		129	
009057	1/17/00	1/17/00	7 17	74	351	9 5				1 33	2 48	3 34		437	
009058															
009069	1/25/00	1/25/00	8 06	174	109		20								
009069	1/25/00	1/25/00	2 27	484	3810		13								
009069	1/25/00	1/25/00	2 2	2210	4670		20								
009069	2/10/00	2/11/00	668	130	68		23								
009069	2/10/00	2/11/00	5 88	104	35		11								
009069	2/10/00	2/11/00	4 61	43	82		6 8								
009076	2/10/00	2/10/00	6 8	31	50	4									
009076	2/10/00	2/10/00	7 3	30	49	4									
009077	2/21/00	2/22/00	7 1	79	33	1 9									
009079	2/10/00	2/10/00	8 14	30	204	0 2									
009079	1/25/00	1/25/00	7 26	13	208	1 7									
009085															
009176															
009197	1/25/00	1/26/00	7 03	25	226	0 5									136
009197	3/8/00	3/8/00	7 25	18	19	0 5									5
009247	1/25/00	1/27/00	6 9	43	197	25 6									301
009247	2/10/00	2/11/00	6 55	595	323	24 8						301			623
009299	1/25/00	1/27/00	6 88	10	77	5									
009299	1/25/00	1/27/00	5 73	104	360	5									
009299	2/10/00	2/10/00	5 81	37	280	5									
009299	2/10/00	2/11/00	6 54	12	36	5									
009301	11/8/99	11/8/99	5 4	34	320										
009301	11/8/99	11/8/99	8 1		300										
009301	1/31/00	1/31/00	8 2		280										
009301	1/31/00	1/31/00	7 2		110										
009304															
009305															
009307															
009313	11/8/00	7/14/00	5 38	12	42 5	0									
009313	2/15/00	2/24/00	6 38	138	430	6			3	3 2	4 1				
009313	2/15/00	2/24/00	6 25	296	410	5			18	3 5	3 4				
009313	2/15/00	2/24/00	6 6	34	400	5			3 6	1 4	1 1				
009314	1/25/00	1/27/00	7 64	25	124									76	
009314	2/16/00	2/18/00	7 09	33	104	14 8								76	
009315	2/10/00	2/10/00	5 7	65	85	46	54	0 02	0 05	1 36			0 29		
009315	2/16/00	2/16/00	6 1	240	47	15	94	0 05	0 15	1 38			1 02		
009320															
009321	2/10/00	2/10/00	6 7	1370	429		120								
009321	4/17/00	4/17/00	5 4	40	372		30								
009322	1/25/00		7 37	818	610	27	9 3								
009322	2/11/00		7 48	1980	1000	140									
009355	4/17/00	4/18/00	5 9	34	350		110								
009355	1/25/00	1/26/00	6 8		67		13								
009376	1/25/00	1/26/00	7 1	20	140		58								
009376	4/17/00	4/19/00	6 95	6	38		12								
009383	2/10/00	2/25/00	6 9	130	62	7 5	21								
009383	4/17/00	4/18/00	7 1	45	14	2 5	4 2								
009384	2/10/00	2/11/00	7 1	10	44	11	10								
009384	4/17/00	4/18/00	6 9	30	682	5 8	120								
009388	1/25/00	1/26/00	8 52	184	280		17								
009388	3/8/00	3/8/00	9 08	80	100		5 7								
009393	2/11/00	2/11/00	6 6	18	320		27								
009393	1/25/00	1/25/00	6 4	29	69		9 5								
009398	2/12/00	6/13/00	7 9		1300	17									
009398	2/12/00		7 6	480	1150	18									
009398	4/18/00		7 2	515	1050	19 2									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
009398	4/18/00		7 4	487	1230	21 2									
009398	2/10/00	2/11/00	6 71	33	40		9 4								
009415	1/26/00	1/27/00	7 26	137	188	7 7				0 8	69	16			
009415	1/26/00	1/27/00	8 47	355	139	54				5 5	40	100			
009415	1/26/00	1/27/00	7 25	69	134	9				2 7	2 5	5 4			
009415	4/17/00	4/18/00	8 27	168	404	28				1 2	4 2	9 6			
009415	4/17/00	4/18/00	9	150	185	9				1 1	1 6	3 4			
009415	4/17/00	4/18/00	7 08	188	97	7 1				10	1 2	3 4			
009464	3/3/00	3/4/00	7 86	112	168										
009464	3/3/00	3/4/00	8 16	147	184	0 78									
009464	3/3/00	3/4/00	8 11	107	185										
009464	4/17/00	4/17/00	7 16	76	182										
009464	4/17/00	4/17/00	7 47	160	121	1 5									
009464	4/17/00	4/17/00	7 54	56	189										
009468															
009469	3/6/00	6/23/00	6 5	5	203	3									
009469	4/14/00	6/23/00	6 5	5	203	3									
009470	3/3/00		6	5	150	5				1 17	1 8	0 41			
009474															
009477	1/25/00	1/31/00	6 53	94	32										
009477	1/25/00	1/31/00	6 88	445		1									
009477	1/25/00	1/31/00	6 65	1030	96										
009477	1/25/00	1/31/00	6 38	72	72										
009477	1/25/00	1/31/00	6 42	296	0 7										
009477	3/8/00	3/8/00	8 17	302	23	0 71									
009477	3/8/00	3/8/00	7 42	360	54	3 6									
009477	3/8/00	3/8/00	7 32	134	30										
009477	3/8/00	3/8/00	7 25	17	18										
009477	3/8/00	3/8/00	6 99	26	24										
009477	3/8/00	3/8/00	8 59	252	30	0 75									
009484															
009486	9/23/99	9/24/99	6 53	74	450										
009496															
009518	1/25/00		4 3	35	18	7				0 24	0 7	1 48			
009519	1/25/00	1/26/00	6 87	12	70					0 58					
009519	1/25/00	1/26/00	6 92	13	70					0 17					
009519	4/17/00	4/18/00	6 88	16	26	6 9				0 1					
009519	4/17/00	4/18/00	7 16	26	35	9 3				0 32					
009523															
009526	11/8/99	11/9/99	5 85	50	190					5 4					
009532	2/10/00	2/11/00	7 41	32	70					0 017					
009533															
009543															
009546	11/8/99	11/8/99	6 17	281	1600	19	600								
009546	11/8/99	11/8/99	6 36	93	1600	8	490								
009549															
009550															
009555															
009566	1/19/00	1/21/00	7 6	35	1150	17	250								
009566	2/15/00	2/17/00	6 77	77	381	44	82								
009566	2/15/00	2/17/00	7 65	107	636	35	62								
009566	4/17/00	4/20/00	9 52	268	1200	97	249								
009566	4/17/00	4/20/00	9 62	86	4150	114	587								
009579	1/25/00	1/26/00	7	216	60	32	7 7								
009579	1/25/00	1/26/00	6 9	28	60	6	6 7								
009580															
009581	2/10/00	2/11/00	7.98	854	510		45							1000	
009582															
009585	4/17/00	4/24/00	6	121	73	2									
009599															
009602	2/21/00	2/21/00	6 2	21	28										
009602	2/21/00	2/22/00	6.7		19	12									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
009609	9/23/99	9/23/99	6 5	69	1300	4 9			0 058	5 2			0 19		
009609	4/17/00	4/17/00	8 5	57	65			0 011					0 09		
009611	2/23/00	2/25/00	7	8 4	6	2 3						0 52			
009613															
009615	1/25/00	1/25/00	7 6							0 65					
009615	4/17/00	4/18/00	7 1	9		4			0 025						
009618	3/8/00	3/8/00	7 9	43	11 82										
009620	2/10/00	2/16/00	5 7	11	110	4				0 7					
009620	4/17/00	4/21/00	7 6	41	100	4				0 3					
009620	4/17/00	4/21/00	7 8	32	96	6				0 2					
009620	2/10/00	2/16/00	6 9	14	120	11				0 3					
009623															
009626	2/16/00	2/16/00	6 7	52	148	28				1 92		1 18			
009640	2/3/00	2/17/00	6 5	16	81	2		0 064	0 06				0 012		
009640	3/8/00	3/9/00	5 5	4	45	40		0 064	0 011				0 012		
009647	4/18/00	4/25/00	7 71	96	0 89	2		0 00276					0 00242		
009647	4/18/00	4/25/00	7.73	36	129	0 7		0 00201					0 00198		
009648	1/25/00	1/25/00	7 1	408	69	16 6				0 98				290	
009648	2/16/00	2/17/00	7 11	582	57	13 9				1 17				495	
009653	2/10/00	2/11/00	6 4	50	200	15 4									
009653	2/10/00	2/11/00	7 1	820	210	19 1									
009653	3/8/00	3/8/00	2 2	5	4000	10									
009653	3/8/00	3/8/00	2 4	290	290	10									
009657	1/25/00	1/26/00	8	23	21	2 5				1 02					
009657	1/25/00	1/26/00	7 9	38	24	2 5				1 04					
009657	1/25/00	1/26/00	7.7	27	20	2 5				1 02					
009657	1/25/00	1/26/00	7 6	24	20	2 5				1					
009657	1/25/00	1/26/00	7 4	28	19	2 5				1 03					
009657	1/25/00	1/26/00	7 2	21	30	6 7				1					
009657	4/17/00	4/18/00	8 5	25	7	2 7				0 17					
009657	4/17/00	4/18/00	7 7	25	6 8	4				0 17					
009657	4/17/00	4/18/00	7 3	20	7	6 2				0 22					
009657	4/17/00	4/18/00	7	15	25	10				0 45					
009657	4/17/00	4/18/00	6 9	15	26	2 5				0 45					
009657	4/17/00	4/18/00	6 9	13	26	11 2				0 45					
009668	2/14/00		7 5	40	690	27	538								
009668	3/8/00		8 3	44	720	36 5	56 7								
009682	4/17/00	4/18/00	7 23	90	910	1 1									
009684	4/18/00	4/18/00	8 16	28	130				0 02	0 26			0 02		
009687															
009695															
009697	2/16/00	2/16/00	7 07	12	40	4 6									
009697	2/16/00	2/16/00	7 51	16	86	8 9									
009698	2/21/00		7 4	39	333	5	5 2								
009698	2/21/00		7 5	23	260	5	21 4								
009698	2/21/00		8 1	10	20	5	5 2								
009698	2/21/00		7 4	14	395	5	6 5								
009698	1/25/00		10 6	18	276	5	14								
009698	1/25/00		7 7	18	123	5	17								
009698	1/25/00		7 8	19	118	5	12								
009698	1/25/00		7 3	18	157	5	19								
009704	2/16/00	2/18/00	6 43	100	125										
009704	2/28/00	2/28/00	7 3	28	336										
009715															
009716	2/14/00	2/21/00	7	15	9C 1										
009716	2/14/00	2/21/00	5 6	487	604										
009716	2/21/00	2/23/00	7	15	96										
009721	1/17/00	1/17/00	6 89	86	69	7 4	101								
009721	2/10/00	2/10/00	7 46	128	129	6 9	34								
009723	2/21/00	2/28/00	6 3	480	64		3 2								
009723	2/21/00	2/28/00	6 4	16	73		9 3								
009728	2/10/00	2/16/00	6 42	41	73						0 684				

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
009728	2/10/00	2/16/00	6 31	56	84						2 21				
009728	2/21/00	2/22/00	6 66	25	30						0 486				
009728	2/21/00	2/22/00	6 4	24	38						1 11				
009738	1/25/00	1/25/00	6 9	110	69										
009768	1/25/00	1/28/00	6 46	49	159	2 4		0 019		0 466					
009768	1/25/00	1/28/00	6 7	40	126	1 4		0 011		0 292					
009778	1/25/00	1/26/00	8 6	110	1710	1 8		0 03	0 2	2 1			0 04		
009778	3/8/00	3/10/00	8 4	61	1260	0 6		0 8	0 13	0 8			0 08		
009780															
009781	3/8/00	3/10/00	7 3	56	57	5	8 1								
009784															
009790	2/10/00	2/10/00	7 9	796	767	22	107 8								
009790	2/10/00	2/10/00	7 8	636	74	109	19								
009790	2/10/00	2/10/00	8	340	334	18	146 7								
009790	11/8/99	11/8/99	7 3	396	107	3	15								
009790	11/8/99	11/8/99	7 9	488	425	42	25								
009790	11/8/99	11/8/99	7 4	2300	617	42	2001								
009807															
009812															
009820	1/25/00	4/17/00	6 17	28	54 4		8 2								
009820	4/17/00	4/20/00	6 6	11	15 8		4 6								
009824	1/25/00	1/26/00	6 67	38	170	16									
009824	1/25/00	1/26/00	6 71	40	170	14									
009824	2/16/00	2/16/00	7 55	12	230	10									
009824	2/16/00	2/16/00	8 17	11	300	5									
009841															
009847	1/25/00	1/25/00	7 9	36	120	10									
009847	1/25/00	1/25/00	4 3	430	590	10									
009855	11/9/99	11/9/99	5 5	16	250		78 6								
009855	11/9/99	11/9/99	5 9	68	120		17 6								
009855	4/18/00	4/18/00	6	50	603										
009864	2/16/00	2/25/00	6 4	24	90	2									
009864	1/25/00		5 8	44	100	2									
009864	1/31/00	2/1/00	6 2	4	160	2									
009867	1/25/00	1/26/00	7 3	7	2280	2									
009867	11/8/00	11/9/00	7 2	591	960	4 5									
009871	11/8/99		6 3	8	50 7	5				0 65	0 58	0 43			
009880	2/23/00	2/24/00	6 58	20	40		13								
009882	2/10/00	2/11/00	7 7	120	200	8									
009882	2/10/00	2/10/00	7 1	110	140	9									
009882	2/10/00	2/11/00	7 2	120	160	9									
009882	4/17/00	4/18/00	7 1	110	390	8									
009882	4/17/00	4/18/00	7 2	200	290	5									
009882	4/17/00	4/18/00	6 9	58	660	4									
009885	2/10/00	2/15/00	7 8	280	120	24		0 51	0 5	1 2		16			120
009885	4/17/00	4/19/00	6 9	110	150	10		0 22	0 3	0 8	1 8	3 6			180
009899															
009917	4/17/00	4/17/00	3	34	1600	3 1	19								
009917	1/25/00	1/25/00	3 2	31	660	5	12								
009927	2/12/00		6 9	62	244	5	19 1	0 02	0 04	0 96					
009927	2/12/00		7 1	22	420	5	16 4	0 02	0 06	0 64					
009927	2/12/00		8 2	64	160	5	15 6	0 02	0 04	0 97					
009927	2/23/00		8 1	214	432	5	10	0 06	0 04	0 61					
009927	2/23/00		8 2	55	369	5	8	0 02	0 02	1 11					
009927	2/23/00		8	37	360	5	5	0 02	0 12	0 84					
009970	3/1/00	3/3/00	9	103	10	10		0 25	0 25	0 25			0 25	2000	
009974															
009976															
010027	11/8/99	11/8/99	6 19	17	400		140								
010027	2/10/00	2/10/00	7 13	56	170		61								
010028	1/25/00	1/31/00	6 71	270	800	5		0 1	0 11	0 14			0 1		
010028	1/25/00	1/31/00	7 01	21	1100	10		0 1	0 13	0 13			0 1		

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
010028	1/31/00	1/31/00									0 01				
010028	1/31/00	1/31/00									0 08				
010028	4/18/00	4/26/00	6 67	140	118	36 6		0 1	0 12	0 45			0 1		
010028	4/18/00	4/26/00	6 67	31	37 9	5		0 1	0 09	0 06			0 1		
010028	4/18/00	4/26/00	6.54	70	76 1	5		0 1	0 09	0 17			0 1		
010028	1/25/00	1/25/00	6 97	84		5		0 1	0 13	0 22			0 1		
010045															
010049	4/17/00	4/24/00	6 6	25	52	2 5									
010049	4/17/00	4/24/00	6 6	25	55	2 7									
010049	1/25/00	2/2/00	9 2	33	114	4									
010049	1/25/00	2/2/00	7 6	132	168	4									
010049	1/25/00	2/2/00	7 8	20	39	4									
010049	4/17/00	4/24/00	6 7		49	2 5									
010089															
010107															
010111															
010116	2/10/00	2/10/00	7 81	37	190	10	7 91								
010116	1/17/00	1/17/00	8 5	38	800	12	118								
010120															
010129	3/9/00	3/31/00	7 18	1867	407	16 1	90 4	0 1			3 16	3 28			
010129	1/21/00	1/21/00	150 1	160 2	120 1	413 1	415 1	200 7			200 7	200 7			
010135															
010138															
010139	1/26/00	2/15/00	6 33	37 1	122	22 9		0 1	0 09	0 89			0 04		
010143	4/20/00	5/3/00	6 1	25	109	60		0 079	0 124	1 29					
010151															
010162	2/21/00	2/21/00	7 19	157	32	17		5	1	0 19				134	
010165	2/25/00	2/25/00	6 4	35	150	7 2	63								
010175															
010176															
010185															
010194	2/15/00	2/28/00	7 1	214	205	14		0 1	0 092	0 28					
010197															
010206															
010215															
010226															
010244															
010269															
010270	2/11/00	2/22/00	6 38	7			3 6								
010270	2/26/00	2/26/00	6 17	36	51		6 6								
010271	2/16/00	2/22/00	6 6	42	88	0 5	20								
010285	4/19/00	4/21/00	7 24	49	37	9 2		0 05		0 39				33	
010286	6/12/99	6/23/99	6 14												
010286	2/21/00	2/21/00	1 81	18	9900	5									
010294	1/30/00	1/31/00	7 47	2	165		33 4								
010294	2/20/00	2/22/00	7 4	119	95		7 3								
010298	1/25/00	1/25/00	6 55	17	41		5 3								
010298	1/25/00	1/25/00	6 49	13	38	6 18									
010298	1/25/00	1/25/00	6.44	13	38	4 99									
010298	1/25/00	1/25/00	6 42	14	41	4 99									
010298	2/16/00	2/16/00	6 48	10	31	5									
010298	2/16/00	2/16/00	6 44	23	32	5									
010298	2/16/00	2/16/00	6 36	12	32	5									
010298	2/16/00	2/16/00	6 53	6	44 9	5									
010301															
010302															
010306	4/3/00	4/6/00	150 1	160 2	120 1	1664	415 2								
010307	1/25/00	1/25/00	6 9	65	1050	9	880								
010315	1/25/00	1/26/00	7 28		128	34 7		0 05	0 67	1 19				457	
010315	1/26/00	1/27/00	6.68	106		28 2		0 05	0 08	0 59				294	
010315	4/17/00	4/24/00	7.09	59	64	17 6		0 05		0 28				102	
010315	4/17/00	4/24/00	7.17	172	92	20 9								162	

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
010322															
010327															
010335															
010336															
010339	2/23/00	2/23/00	7.3	33	33		4 3								
010348	1/25/00	2/16/00	8 25	142	121	5									
010355															
010364	2/10/00	2/10/00	9 19	758	357	13 6									
010364	11/8/99	11/8/99	6 73	407	1620	43 3				12 7					
010364	11/8/99	11/8/99	7 04	302	624	8 9				1 26					
010371															
010372	4/17/00	4/18/00	7 25	310		530			0 05	11	3	11			
010372	4/17/00	4/18/00	6 96	282											
010372	4/17/00	4/18/00				23			0 29	1 8	3 7	9			
010372	4/17/00	4/18/00				4			0 24	4 2	1 4	5 1			
010372	4/17/00	4/18/00	6 95	120											
010378															
010380	11/9/99	11/17/99	7 4	10	51	7 2	28 5			0 396	0 1	0 42			
010385	2/2/00	2/2/00	6 2		21	2									
010385	2/25/00	2/25/00	5 51		45 5	2	5 4								
010385	4/17/00	4/17/00	6 18		20 5	5 4	8 5								
010385	4/17/00	4/17/00	5 62		12 5	3 8	5 6								
010385	4/17/00	4/17/00	5.52		11 8	6 9	4 6								
010385	2/25/00	2/25/00	5 71		48 9	2	3 7								
010385	2/25/00	2/25/00	5 61		44 6	2	5 9								
010388															
010390	4/17/00	4/17/00	5 98		216	27									
010397	11 8 99		6 08	113	0 54										
010401	2 24 00	3/14/00	7 16	71	202	8 4									
010402	4 22 00	4/24/00	7 7	40	180	7		0 045	0 2	0 5					
010403	6 2/99	6/2/99	6 9	32	380	16		1 8	0 2	0 9					
010410															
010419	1/31/00	2/23/00	6 52	68	42	5		0 24	0 72	4 6					
010422															
010424															
010426															
010435															
010436	4/17/00	4/17/00	7	140	2300	4 2									
010442															
010447	1/25/00	2/25/00	9 1	15	39	4									
010447	4/17/00	6/15/00	7 4	85	37	4									
010454															
010454															
010481															
010485															
010489															
010494	2/16/00	2/17/00	7 37												
010494	2/16/00	2/18/00			73										
010494	2/16/00	2/22/00		15						0 05					
010506															
010510	2/23/00	2/23/00	7 41	16	34 7	5									
010511															
010539															
010542															
010563	1/25/00	2/3/00	5 79	188	140	1 7									
010563	4/17/00	4/17/00	6 45	137	612	2 1									
010577															
010580	11/8/99	11/19/99	6 41	259	576	9 7									
010584															
010593															
010594															
010600															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
010606	2/11/00	6/5/00	6 72	66	70	5	8 16								
010606	2/11/00	6/5/00	6 72	66	70	5	8 16								
010606	3/8/00	6/5/00	6 74	20	35	5	2 67								
010612	1/25/00	1/27/00		25	54					180					
010613															
010619	2/11/00	2/11/00	1	87	109	5									
010624															
010625															
010628	1/25/00	2/25/00	7 45	42 6	185	5									
010628	3/8/00	3/8/00	7 81	10	940	5									
010635															
010644															
010651	1/25/00	2/7/00	7 12	22	150	5			0 2	0 73					
010657	2/21/00	2/21/00	6 4	48	11	5	12								
010666	2/10/00	2/24/00	6 99	23	80	6 9				0 14	0 5	1 37		54	
010669															
010670	12/31/99	1/3/00	7 28	54	135	15		0 079	0 092	0 379					
010680															
010695	2/10/00	2/18/00	6 7	72	20	1 4									
010696	2/10/00	2/10/00	7 7	36	130	5									
010703	4/17/00	4/17/00	6 66	50	142		28								
010708	2/23/00	2/24/00	6 5	10		5		0 008	0 014	23			0 019		
010710	1/26/00	1/26/00	6 4	42	46	3 5									
010716															
010721	4/19/00	4/19/00	6 22	68		1									
010727															
010733															
010740															
010744															
010745															
010749	2/10/00	2/10/00	8 6	76	37 1	9 23	13								
010759	4/17/00	4/25/00	7 46	156	28	1		0 015		2 43					
010766															
010773	1/25/00	1/25/00	7 8	48	78	5									
010774															
010791	4/18/00	4/19/00	7 59	26	337			0 192			6 56	9 75			
010800	1/25/00	2/14/00	7 51	7	830										
010804															
010807	1/25/00	2/2/00	7 56	134	88		18								
010814	4/18/00	4/18/00	6 5		31	10			0 48						
010824	11/10/99	11/11/99	6 3	20	150	0 6									
010824	11/10/99	11/11/99		82	346										
010838															
010842															
010844															
010849															
010854															
010856															
010864	4/17/00	4/19/00	7 37	510	102	62			0 003	0 002					
010873	1/25/00	2/9/00	7 03	29	403	15				2500					
010873	1/25/00	2/9/00	2 71	16	962	4 4				200					
010873	4/17/00	5/15/00	7 08	20	44	5				270					
010873	4/17/00	5/15/00	6 96	30	56	7 5				960					
010874															
010877															
010880	1/25/00	2/14/00	7 51	7	830	0									
010880	11/8/99	11/8/99	7 47	5	5800	0									
010894	1/26/00	1/27/00					14								
010894	1/25/00	1/26/00	8	304	251	20	64			3 34					
010894	1/26/00	1/27/00					64								
010894	2/14/00	3/2/00	8 2	115	426	5	21			1 56					
010894	2/15/00	2/15/00					2 4								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
010894	2/15/00	2/15/00					38								
010907	1/15/00	2/19/00	6 26	420	38 5	30									
010907	1/25/00	1/31/00	6 6	5	32	5									
010907	1/25/00	1/31/00	6 55	7	37	5									
010907	1/25/00	1/31/00	6 47	40	145	5									
010907	1/25/00	1/31/00	6 4	9	52 1	5									
010907	11/8/99	11/12/99	6 22	30	137	68									
010907	11/8/99	11/12/99	6 53	160	237	85									
010907	2/15/00	2/19/00	6 28	380	36 5	20									
010907	4/17/00	4/20/00	6 73	65	72 7	60									
010907	4/17/00	4/20/00	6 74	71	21 3	60									
010907	4/17/00	4/20/00	6 83	52	24 8	55									
010907	4/17/00	4/20/00	6 93	84	16 2	60									
010914	4/17/00	4/25/00	5 5	45	72	2 5	22								
010914	1/25/00	1/25/00	7	0 3	56	7 2	22								
010933	11/8/99	11/9/99	6	8	602	10									
010954	11/8/99														
010960	2/10/00	2/23/00	6 7	1420	0 132	2 2									
010960	2/10/00	2/23/00	8 4	36	0 344	5 6									
010960	11/8/99	2/23/00	5 4	47	0 22	8									
010960	11/8/99	2/23/00	5	40	0 097	16 8									
010966	2/14/00	2/17/00	7 5	350	2500	4 2	350								
010966	2/10/00	2/11/00	7 6	430	1500	3 7						8 5			
010966	2/10/00	2/11/00	7 5	350	2500	4 2									
010982	5/25/00	5/25/00	7 2	80	180	2 5									
010982	1/31/00	2/7/00	7 8	68	138	5									
010992	1/25/00	1/25/00	6 73	34 9	188	0 8		0 02	0 02	1 9				11 8	
010993	1/25/00	1/26/00	6 6	1500	2100	22									
010993	1/25/00	1/28/00						0 15	0 21	0 7	31	43			
010993	11/8/99	11/11/99		230				0 1	0 33	5 2	5 4	9 1			
010994															
010996	2/10/00	2/11/00	6 8	36	58	11						6 1			
010996	4/17/00	4/24/00	8 4	30	54	4						1 8			
011004	2/14/00	2/15/00	7 69	76	1354	0	0								
011004	1/25/00	1/26/00	6 86	60	798		34								
011004	2/16/00	2/17/00	7 41	56	1160	0	0								
011008	2/16/00	3/6/00	7 01	6	46		8 8			0 45					
011008	1/25/00	2/2/00	6 93	37	59		20			1 2					
011008	3/8/00	3/21/00	7 02	9	34		4 8			0 43					
011021	1/25/00	2/25/00	8 8	13	73	5				0 1					
011033	4/17/00	4/25/00	5 91	0			5	0 007	0	0 2					
011036															
011040															
011041															
011047	1/26/00	1/26/00	6 78	14	42	6 4									
011047	11/8/99	11/8/99	5 71	14	254	0									
011047	1/26/00	1/26/00	6 37	432	555	10									
011053	11/8/99	11/10/99	6 7	49	290	6									
011053	2/10/00	2/15/00	7 3	130	270	4									
011062															
011085	4/17/00	4/27/00	6 8	48	0 26	7									
011085	4/17/00	4/27/00	6 6	86	0 236	7									
011085	11/8/99	11/23/99	6 7	218	0 197	2									
011085	11/8/99	11/23/99	6 6	178	0 186	7									
011088	4/17/00	4/17/00	7 11	71	227	6									
011088	4/17/00	4/17/00	6 75	0	153	3									
011088	11/8/99	11/8/99	6 42	4	181	1									
011088	11/8/99	11/8/99	6 09	5	316	1									
011092	4/19/00	4/27/00	5 38	52	123		28			1 02	0 409	0 66			
011116	1/25/00	2/14/00	5 7	114	102	0									
011116	1/25/00	2/14/00	6 4	43	113	0									
011116	1/25/00	2/14/00	7 2	0	215	0									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
011116	1/25/00	2/14/00	6 2	120	55	0									
011116	1/25/00	2/14/00	6 2	99	80	0									
011116	1/25/00	2/14/00	6	24	94 8	0									
011116	2/14/00	3/2/00	6 4	63	86 1	0									
011116	2/14/00	3/2/00	7	243	168	5 2									
011116	2/14/00	3/2/00	6 1	18	233	5 9									
011116	2/14/00	3/2/00	6	14	61 8	0									
011116	2/14/00	3/2/00	6 1	84	58 2	0									
011116	2/14/00	3/2/00	6 1	20	446	0									
011119	4/17/00	4/19/00	6 6	19	160				0 02	0 15					
011119	2/10/00	2/14/00	6 9	80	190										
011119	4/17/00	4/19/00	6 9	22	160		22		0 02	0 15					
011119	2/10/00	2/14/00	7	52	140		22		0 02	0 27					
011119	2/10/00	2/18/00					18								
011122	4/17/00	4/24/00	6 79	157	163	17 8						8 37		206	62
011122	1/25/00	1/25/00	7 92	687	159	38						25 4		724	100
011128	5/1/00	4/18/00	5 9	33	0 06		3								
011128	4/17/00	4/18/00	4	6	91		107								
011128	4/17/00	4/18/00	5 7	27	77		3								
011128	1/25/00	1/26/00	6 6	38	140		11								
011128	1/25/00	1/26/00	6 8	182	140		17								
011128	1/25/00	1/26/00	6 6	966	180		50								
011128	4/20/00	4/24/00					107								
011128	4/24/00	4/24/00					36								
011137															
011153															
011157	2/24 00	2/24/00	9 5	213	165	0						8 48			
011162	2/24 00	2/24/00	9 5	213	165	0						8 48			
011162	2/24 00	2/24/00	9 5	213	165	0						8 48			
011167															
011171	2/16/00	2/22/00	5 34	134	21 9	99									
011171	2/16/00	2/22/00	4 89	61	35 2	0									
011171	2/16/00	2/22/00	4 98	0	33 4	0									
011171	3/8/00	3/14/00		0	51 4	5 4									
011171	3/8/00	3/14/00		0	41 4	3 2									
011171	3/8/00	3/14/00		0	21 7	2 5									
011179															
011180															
011184															
011194	2/10/00	2/11/00	7 4	85	150		12							110	24
011194	4/17/00	4/18/00	7 3	13	56	5								56	1
011199															
011202															
011216															
011219															
011226	1/25/00	1/26/00	7 6	22	42	6									
011226	2/10/00	3/2/00	6	3	39	3									
011229	2/24/00	2/24/00	9 5	213	165	0						8 48			
011230	2/16/00	2/18/00	6 63	66	118	19			1.07	0 894			0.351		
011230	2/16/00	2/18/00	6 27	2	27	2			0 15	2 3			0 08		
011230	3/8/00	3/10/00	6 49	2	42	1			0 0986	3 33			0 0436		
011230	3/8/00	3/10/00	7 65	1	822	1			0 164	0 185			0 0896		
011238	2/22/00	2/26/00	6 34	5	29 5	1		0 006		0 262					
011245															
011247	11/8/99	11/9/99	6 8	130	260	330									
011247	11/8/99	11/9/99	6 7	64	120	10									
011247	11/10/99	11/10/99				0									
011247	11/15/99	11/15/99		10											
011247	1/25/00	1/25/00	7 6	100	60	13									
011247	1/25/00	1/25/00	6 24	0	177	0									
011247	1/25/00	1/28/00		14											
011247	1/27/00	1/28/00				4 82									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
011247	1/27/00	1/28/00				4 83									
011247	1/25/00	1/25/00	7 4	97	39	18									
011247	1/28/00	1/28/00		100											
011247	1/25/00	1/25/00	6 24	12	177	4 82									
011247	1/25/00	1/25/00				4 83									
011247	1/28/00	1/28/00		0											
011247	1/25/00	1/25/00	7 4	14	39	18									
011247	1/27/00	1/27/00		97											
011248	1/25/00		6 7	22	47	4 8									
011249	1/25/00	1/25/00	6 9	310	110	9 1									
011249	11/8/99	11/9/99	6 8	80	170	6 6									
011250	4/17/00	4/19/00	8 4	36	101										
011250	4/17/00	4/24/00		0											
011250	4/17/00	4/24/00		86											
011250	4/17/00	4/19/00	5 5	130	800										
011251	11/8/99	11/12/99	7	120	250	8 5									
011251	1/25/00	1/26/00	7 86	0	221	0									
011251	1/25/00	1/25/00	7.2	32	61	5 2									
011251	1/25/00	1/30/00				4 87									
011251	1/25/00	1/30/00				4 8									
011256															
011261	1/25/00	2/2/00	7 47	29	92		26								
011261	11/8/00	11/24/00	7 02	74	1600		660								
011262	2/14/00	2/15/00	8 5	620	280		9					0 6			
011262	1/25/00	1/26/00	4 07	87	748		11 2								
011272	1/25/00	1/25/00	6 45	160	366		122	0 084	0 182	0 712					
011273	4/17/00	4/17/00	7 13	316	474	52 1		0 18	0 58	3 28				882	
011273	2/11/00	2/14/00	6 66	250	79	168		0 22	0 53	1 54				395	
011274	4/17/00	4/19/00	5 5	22	37		11 3			0 44					
011274	2/23/00	2/28/00	6 9	75	54		3 2			0 06					
011278	1/25/00	1/25/00	6 8	30	268	0									
011278	11/8/99	11/11/99	6 8	20	180	29									
011282	3/1/00	3/1/00	6 89	200	100	15								120	
011282	2/16/00	2/16/00	6 36	63	80	54 2								211	
011284	2/10/00	2/10/00	6 9	160	480	8 6	180								
011284	3/8/00	3/10/00	6 9	15	58	9 1	13								
011311															
011320	2/23/00	2/25/00	6 76	38	35	0 5									
011320	4/14/00	4/18/00	6 76	12	49	0 5	3 4								
011326	1/25/00	1/25/00	9 8	180	0.34	0						8 69			
011339	11/19/99	11/22/99	6 83	30	318	49	177								
011339	1/18/00	1/21/00	7 9	162	312	11	31								
011359	11/8/99	11/8/99	6 42	30	185	9		3							
011359	2/21/00	2/22/00	6 64	5	55	0 5		1 09							
011369	11/8/99	11/15/99	8 07	29	751	11 3				0 11	0 2			44	
011369	2/10/00	2/11/00	6 26	48	130	7 3				11 4	2 7			62	
011370															
011377															
011378															
011379															
011385	12/31/99	6/8/00	7 31	5	327		4 73								
011385	2/12/00	6/8/00	7 15	7	340		2 82								
011385	2/12/00	6/8/00	7 09	5	340		1 95								
011385	12/31/99	6/18/00	7 1	7	348		4 01								
011387	3/4/00	3/6/00	6 96	29	404	0	0								
011387	3/8/00	3/9/00	7 01	0	420	0	17								
011391	4/17/00	4/18/00	7 3	5	23	4		0 051	0 2	1 2					
011398															
011403															
011404	4/17/00	4/24/00	6 9	46	855		99								
011409	1/25/00	1/31/00	6 24	12	100		6								
011411															

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
011417															
011419	4/17/00	4/17/00	7 1	63	471	14		0 048	0 093	0 834					
011427	2/10/00	2/11/00	6 35	258	117	8 2	102								
011427	2/10/00	2/11/00	6 35	278	116	0 59	0								
011427	2/10/00	2/11/00	6 33	266	113	8 2	102								
011429															
011431	3/9/00	3/6/00	6 3	11	70	2									
011431	11/12/99	11/12/99	5 4	95	700	2 2									
011431	3/9/00	3/9/00	6 3	11	70	2									
011434															
011438	5/15/00	5/23/00	7 42	8	592	1 1	12								
011438	4/18/00	5/8/00	6 5	35	52	1 2	7 9								
011438	4/18/00	5/8/00	6 33	39 7	22	31	2 6								
011438	5/15/00	5/15/00	7 16	6	579	1 5	14								
011439															
011442	2/10/00	2/11/00			58										
011444															
011452	4/18/00	4/18/00	6 5	208	683		111								
011452	1/25/00	1/25/00	6 7	132	548		158								
011454	1/25/00	1/26/00	7	35	89	5									
011454	2/16/00	2/17/00	7	15	42	5									
011463															
011476															
011484	4/19/00	4/19/00	6 24	13	15	9 7									
011484	1/25/00	1/26/00	5 52												
011484	1/25/00	1/26/00	5 75												
011484	1/25/00	1/31/00		96											
011484	1/25/00	1/31/00		396											
011484	1/25/00	1/27/00			123										
011484	1/25/00	1/27/00			131										
011484	1/25/00	2/1/00				7 6									
011484	1/25/00	2/1/00				64									
011484	2/1/00	2/1/00				9 2									
011485															
011486	2/10/00	2/15/00	8 31	41	79	0	0		0	0 1				50	
011487	2/23/00	2/24/00	4 35	3970	810	5								11	
011487	2/23/00	2/28/00	7 15	1100	330	5								115	48 8
011487					1400										
011487	1/25/00	1/26/00	2 92	546		18 8									90
011487	1/25/00	1/26/00	4 34	408		571									40 5
011487	1/25/00	1/26/00	7 9	168											9
011487	1/25/00	1/26/00	7 86	136											2
011487	1/25/00	1/26/00	7 89	440											
011487	2/18/00	1/28/00				91 8									
011487	2/18/00	1/28/00				92 6									
011487	2/18/00	1/28/00				0									
011487	2/18/00	1/28/00				0 3									
011487	2/18/00	1/28/00				95 9									
011487	2/23/00	3/2/00	7 07	640	300	5								69	24 2
011487	2/23/00	3/2/00	7 19	16	80	5								7	3 2
011487	2/23/00	3/2/00	8 23	29900	510	5								31	19 8
011487	2/23/00	3/2/00	4 35	3970	810	5								11	0 2
011487	3/6/00	3/6/00		0	1 3	0								0	0 31
011487	3/6/00	3/6/00	81 4												
011487	3/2/00	3/6/00	7 35		810										19 87
011487	3/2/00	3/6/00	8 95	1003										97	126 5
011487	3/1/00	3/6/00												98	
011487	3/1/00	3/6/00												101	
011487	3/1/00	3/6/00												0	
011487	3/1/00	3/6/00												98	
011487	2/28/00	2/28/00		1003	810										
011487	2/28/00	2/28/00		1024	1 3										

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
011487	2/18/00	1/28/00	6 788	934											0 34
011487	2/18/00	1/28/00	8 983	911											116 7
011487	3/6/00	2/25/00	7 35												
011487	3/6/00	2/25/00	8 95												
011502	2/14/00	2/14/00	7 8	20	142	0 5		0 05	0 07	0 01					
011507	2/10/00	2/14/00			73										
011507	2/10/00	2/10/00	7 7	160	2000	5									
011507	2/10/00	2/10/00	6 7			0									
011507	2/10/00	2/15/00		10											
011507	2/10/00	2/10/00	9 18	26	689	4 93									
011507	2/10/00	2/13/00				4 93									
011507	2/10/00	2/13/00				5 26									
011507	1/28/00	1/28/00		0											
011507	1/25/00	1/25/00	6 91	52	317										
011507	1/25/00	1/28/00		0											
011507	1/25/00	1/28/00		0											
011507	1/25/00	1/29/00				0									
011507	1/25/00	1/29/00	5 37		140	5 44									
011507	1/25/00	1/25/00	6 4	34		2 8									
011507	2/10/00	2/10/00	6 7	26	2000										
011507	1/25/00	1/25/00	6 3		47	1 2									
011513	1/26/00	2/14/00	7	38	78	0			0 04	0 56					
011515	2/10/00	2/16/00	6 9	49	320	17		0 029	0 2	2 7					
011520															
011527															
011528															
011535															
011537															
011558	2/10/00	2/11/00	6 78	15	101	1		0 1	0 05	0 34				90	
011558	4/17/00	4/18/00	6	13	39	8 1		0 1	0 02	0 25				50	
011559	1/25/00		7 3	80	419	0 8									
011559	3/8/00		6 8	180	250	9 7									
011566	4/17/00	4/18/00	8	170	150	11		0 13	0 13	0 8	1 7	6 1		94	
011568															
011574															
011578															
011580															
011597	11/8/99	11/8/99	5 98	353	166	19 4									
011597	11/8/99	11/8/99	6 15	66 7	250	5									
011597	4/17/00	4/17/00	4 83	27	156	55 7									
011597	4/17/00	4/17/00	5 75	171	173	5									
011602	4/17/00	4/18/00	6 4	12	0 281	7	84								
011602	4/17/00	4/18/00	5 8	158	0 043	5	12								
011610	1/25/00	1/26/00	7 7	10	42	4 4									
011610	2/16/00	2/17/00	6 66	41	59	1		0 1	0 05	0 17					
011618	3/8/00		7.13	990	346	10	31 3	0 01			3 81	3 64			
011618	1/17/00		6 63	298	1190	45 5	279	0 1			5 4	7 4			
011620															
011621	2/10/00	2/11/00	7 9	7	37	6					0 22				
011641	3/8/00	3/10/00	8 12	10	415									138	
011642	1/25/00	1/25/00	8 7	116	103	0 6									
011642	1/25/00	1/25/00	7 7	128	96 7	7 1									
011642	3/13/00	3/13/00	7 2	14	25	2 8									
011642	3/13/00	3/13/00	7 5	146	44	6 5									
011645															
011647															
011648	1/17/00		8 3	22	454	5	48								
011648	1/25/00		8 1	55	24	9	18								
011652	1/30/00	2/3/00	6 69	67	399	8 3		0 1	0 21	0 57				207	
011652	2/15/00	2/17/00	6 71	292	190	11 5		0 1	0 1	0 41				272	
011655	2/10/00		6.4	99	540	5									
011655	2/10/00		7 1	40	28	5									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
011655	3/3/00														
011655	3/3/00														
011667															
011671	4/17/00	4/19/00	6 2	170	670		7 2								
011671	4/17/00	4/19/00	6 1	490	290		17 6								
011671	4/17/00	4/19/00	7 1	1000	780		30 6								
011671	4/17/00	4/19/00	7 3	1200	280		6 3								
011674	2/10/00	2/11/00	6 56	24	50	5									
011674	2/10/00	2/11/00	6 61	13	68	5									
011674	5/25/00	5/26/00	6 43	5		10	120								
011681	3/8/00	3/15/00	6 01	96	24	0 5				0 09	6 55	0 1			
011681	1/25/00	1/25/00	7 37	49	28 9	0 5				0 91	0 6	0 85			
011686															
011697															
011697															
011704	2/16/00	2/22/00	7 8	930	310	15									
011704	3/6/00	3/8/00	7 5	1300	150	14									
011711	1/25/00	1/27/00	7 37	15	43 4	18									
011712	4/17/00	4/20/00	6 6	160	197	7 2		0 1			1 4	3 15			
011712	5/24/00	5/30/00	6 8	220	724	62		0 1			2 8	4 45			
011729	4/17/00	4/19/00	7.3	1200	280		16 7								
011736	4/21/00		7.6	152	200		100								
011736	4/21/00		7.1	67	134		70								
011736	4/21/00		6 9	75	143		162								
011736	4/21/00		8 1	377	3940		2775								
011743															
011749	1/25/00	1/27/00	5 71	20	104	17		0 073	0 127	1 99					
011751	1/25/00	1/25/00	6 6	116	51	5									
011751	2/15/00	2/15/00	6.7	200	54	7 5									
011766															
011782	2/10/00	2/11/00	7 4	100	110	1 9									
011783	1/25/00	1/26/00	7 2	10	87	1 3									
011788															
011793	1/25/00	1/26/00	6 8	12	110	1									
011807															
011816															
011819	4/12/00	4/17/00	6 98	86	108	3 9	9 6								
011825	1/25/00	1/26/00	6 77	6	78	5									
011825	2/13/00	2/18/00	6 95	11	24	9									
011831															
011846	4/17/00	4/21/00	6 8	32	311	28		0 102	0 054	0 868					
011855	3/8/00	3/9/00	7 36	19	139	8 8									
011858	4/17/00	4/18/00	5 7	61	198	10	54								
011862	1/25/00		7 38	0 05	22 6	0									
011862	1/25/00		7 31	0 05	104 2	0									
011862	1/25/00		6 87	0 05	22 4	0									
011862	1/25/00		7 31	0 05	104 3	0									
011862	3/8/00		6 88	0 05	23 7										
011862	3/8/00		7 05	0 05	24 8										
011862	3/8/00		7 1	0 05	15 7										
011862	3/8/00		6 88	0 05	22 9										
011870															
011879															
011886															
011903															
011907	2/10/00	2/16/00	6			1		0 102		1 2					
011929															
011930	1/25/00	1/26/00	7 63	10	242	12 4		0 1	0 05	0 08				51	
011953															
011955	2/10/00	2/10/00	7 52	95	168	30 8								428	
011955	4/17/00	4/18/00	7 45	81	154	9 2								281	
011957	1/25/00	1/25/00	7	705	107	1					3 8			554	

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
011957	4/17/00	4/24/00	7 11	27	49	1					0 14			38	
011966	2/10/00	2/28/00	6 42	48	365	19 3		0 05	0 04	0 58				97	
011972															
011974	1/25/00	1/28/00	8 9	53	42	4									
011974	4/17/00	4/18/00	6 8	49	61	4									
011976															
011984	1/18/00	1/25/00	7	10	62	21									
011984	2/16/00	3/2/00	6 6	124	72	8									
011986	4/17/00		7	22	40	5				0 19	0 4	0 18			
012007															
012010	2/10/00	2/10/00	6 51	137	158		43								
012010	2/10/00	2/10/00	6 72	33	104		35								
012010	4/17/00	4/17/00	6 59	83	77		37								
012010	4/17/00	4/17/00	7 04	66	213		65								
012013	1/25/00	1/25/00	7 35	46	86	0 51		0 002							
012013	1/25/00	1/25/00	7 43	35	87	0 5		0 002							
012013	11/8/99	11/8/99	7 75	30	175	0 5		0 002							
012013	11/8/99	11/8/99	7 76	14 8	155	0 5		0 002							
012020															
012022															
012024															
012036	2/10/00	2/18/00	7 34	58	88	1		0 1	0 05	0 17				64	
012036	3/8/00	3/8/00	7 12	37	46	10 6		0 1	0 05	0 08				52	
012038															
012040	1/25/00	1/26/00	6 08	82	285	1									
012040	11/8/99	11/10/99	4 37	34	158	8									
012046	1/25/00	1/25/00	7 7	1	117	1	12	0 014	0 16						
012046	1/25/00	1/25/00	7 64	1	74 9	1	12	0 018	0 26						
012046	11/8/99	11/8/99	6 76	11	352	1	55	0 07	0 42						
012046	11/8/99	11/8/99	6 5	7 2	346	1 5	78	0 07	0 56						
012047															
012052	11/8/99	11/8/99	5 61	84	137	6 9		0 5						61	
012052	2/10/00	2/14/00	5 54	50	41	1		0 1						12	
012052	2/10/00	2/14/00						0 25							
012053	1/25/00		6 4	11	7		8 3	0 02	0 02	0 13			0 02		
012053	4/14/00		6 5	25	26	5	13 8								
012054															
012059															
012067	2/10/00	2/11/00	7 2	130	140	11	50								
012073															
012074	12/31/99		9 1	78	280		13								
012074	12/31/99		9 1	14	170		6 8								
012074	1/25/00		9 6	35	390		7 9								
012074	1/25/00		9 6	40	180		6 2								
012078															
012079															
012082	1/26/00	1/28/00	7	600	570		100								
012082	1/26/00	1/28/00	7 2	620	620		81								
012082	1/26/00	1/28/00	7 2	120	350		56								
012082	2/14/00	2/15/00	6 7	130	570		110								
012082	2/14/00	2/15/00	7 1	210	600		90								
012082	2/14/00	2/15/00	7 1	23	390		24								
012082	2/14/00	2/15/00	6 8	98	330		170								
012083	2/23/00	2/23/00	7 42	27	43	5 5						0 79		43	
012083	2/29/00	2/29/00	6 56	14	41	1						0 34		10	
012092															
012100	1/25/00	1/25/00	7 5	68	80	3 8									
012100	1/25/00	1/25/00	7 5	24	120	2 7									
012100	1/25/00	1/25/00	7 3	65	46	2 9									
012100	4/17/00	4/17/00	8	300	65										
012100	4/17/00	4/17/00	7 4	2170	280										
012100	4/17/00	4/17/00	7 3	1440	1770										

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
012108	2/10/00	2/16/00	7 1	95	72	7									
012108	2/10/00	2/10/00	7	81	63	10									
012108	4/17/00	4/19/00	6 8	160	180	12									
012108	4/17/00	4/19/00	6 5	90	190	5									
012110															
012115	1/25/00	1/25/00	7 3	35	120	87		0 032					0 048		
012115	1/25/00	1/25/00	7 9	26	56	5		0 015					0 021		
012115	1/25/00	1/25/00	7 7	42	75	5		0 033					0 042		
012137	2/14/00	2/14/00	7 62	46	177	8 3		0 05	0 06	0 01				124	
012145	1/25/00	1/25/00	7 7	410	270		130								
012145	2/10/00	2/11/00	7 2	31	120		27								
012148	2/10/00	2/11/00	6 9	89	320	0 6						3 4			
012148	2/10/00	2/11/00	7	24	100	0 4						0 9			
012148	2/23/00	2/24/00	7 4	24	26	0 08						0 99			
012148	2/23/00	2/24/00	7 4	22	47	0 2						0 97			
012154															
012155															
012156															
012160															
012162															
012167	3/6/00	3/7/00	6 8	11	45	1									
012171															
012180															
012188	2/10/00	2/11/00	5 87	10	526	0 5									
012188	2/10/00	2/11/00	5 69	26	476	0 5									
012188	4/17/00	4/17/00	6 61	25	64	0 5									
012188	4/17/00	4/17/00	6 71	24	66	0 5									
012204	12/21/99	1/5/00	7 74		1010	1	3 8								
012204	12/21/99	1/5/00	7 89		2080	1	8 6								
012204	2/23/00	2/25/00	7 88		540	1	4 9								
012204	2/23/00	2/25/00	7 93		1110	2	13 5								
012204	4/17/00	4/19/00	7 93		1100	1	12 2								
012204	4/17/00	4/19/00	8 1		2430	1	15 9								
012206	4/18/00	4/18/00	6 7	40	55	14									
012209															
012217	1/25/00	1/26/00	7 06	24	126	5									
012217	1/25/00	1/26/01	6 98	27	135	4									
012217	2/12/00	2/12/00	6 3	52	92	3									
012219	1/25/00	1/25/00	7 09	143	257	1									
012219	4/26/00	4/26/00	6 87	26	270	40									
012229															
012232															
012239															
012243	2/11/00	2/11/00	7 07	278	44		22 3								
012245	11/16/99	11/16/99	6 2	20	334	4		0 1			0 29	2 2			
012245	1/25/00	1/28/00	6 6	20	174	2 5		0 1			0 2	0 7			
012250	11/8/99	11/10/99	7 02	24	240		38								
012252	2/12/00	2/24/00	7 07	13	67	5			0 02	0 34		0 64			
012252	2/12/00	2/24/00	7 31	19	170	5			0 02	0 1		1 6			
012252	2/12/00	2/24/00	7 33	53	200	5			0 02	0 17		3 1			
012256															
012257	4/17/00	4/18/00	6 46	61	182	7 7									
012258															
012268	1/25/00	1/26/00	6 92	78	74	0 5									
012270	1/25/00	1/31/00	6 67	237	210	5			0 11	1 2	5 3				
012270	3/8/00	3/9/00	6 21	147	510	9			0.23	2 4	5 2				
012278															
012279															
012281	1/31/00	2/2/00	6 04	47	180	1 6									
012293	1/25/00		7.17	55	38 2	10	110								
012293	1/25/00		6 98	60	26 5	10	50 8								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
012293	2/14/00		6 53	32	28	10	7 33								
012293	2/14/00		6 4	53	21	10	6 34								
012295	2/21/00	2/22/00	6 9	10	88		14	0 005	0 04	0 47					
012297															
012310	1/25/00	1/31/00	7 47	13	200	5									
012310	1/25/00	1/31/00	6 68	10	110	1									
012310	1/25/00	1/31/00	7 14	43	160	5									
012310	1/25/00	1/31/00	6 5	45	110	7									
012310	11/8/99	11/8/99	6 15	175	44	6	12 8								
012310	11/8/99	11/8/99	6 47	73	107	6	25 2								
012310	11/8/99	11/8/99	6 67	6	170	1	10 2								
012310	11/8/99	11/8/99	9 61	3	118	1	37 4								
012315	1/25/00	1/25/00	7 43	15	190	5									
012315	2/10/00	2/11/00	6 81	816	110	11									
012316	1/25/00	2/2/00	6 9	65	541	4									
012325	2/23/00	2/24/00	6 44	23	106	5 7				0 1	0 43	0 55	0 4	37	
012325	3/8/00	3/8/00	7 68	10	80	6 2					0 5	0 26	0 1	167	
012343	1/26/00	1/26/00	7 4		150										
012358	2/25/00		6 53	12	58 7	5	4 18								
012358	2/4/00		5 76	232	947	5	487								
012361															
012366	1/25/00	1/26/00	7 35	28	120	5	12	0 58							
012366	1/25/00	1/26/00	4 34	7	73	5	6 6	4 4							
012366	1/25/00	1/26/00	6 63	9	60	5	7 2	0 83							
012366	1/25/00	1/26/00	6 74	8	110	5	11	0 12							
012366	2/20/00	2/23/00	6 82	9				2 4							
012366	2/20/00	2/23/00	7 06	13	56	5		3 6							
012366	2/20/00	2/23/00	7 41	20	46	5		0 33							
012366	2/20/00	2/23/00	6 87	6	47	5		0 14							
012366	2/20/00	2/23/00	8 86	6	68			0 07							
012366	2/20/00	2/23/00	7 25	213	200			3 2							
012378															
012383															
012393	2/10/00	2/11/00	7 21	176	1260	3 1		0 059		0 6	1 68	3 52			
012394	11/9/99	11/23/99	6 14	70	76	5	15								
012397	4/17/00	4/18/00	6 8	42	27	1									
012399	2/10/00	2/25/00	8 4	75	180										
012405	1/27/00	2/17/00	6 36	25	100		17 6								
012407	4/18/00	4/26/00	5 4	5	67	1									
012407	4/18/00	4/26/00	5 03	28	56	33									
012410	11/18/99	11/18/99	6 9	26	337	9									
012412															
012413															
012428	3/3/00	3/24/00	6 68	8		5									
012429															
012432	2/22/00	3/14/00	7 07	5	31	5	1 8								
012441	11/8/99	11/12/99	6 86	13	127	12 9									
012446															
012449	2/10/00	2/10/00	6 7	160	290	3 1									
012450	1/31/00	1/31/00	6 9	8	233	0 2									
012450	1/31/00	1/31/00	7 1	3	33										
012450	1/31/00					0 1									
012461	1/25/00	1/27/00	8 05	430	159	3 8	17								
012461	4/17/00	4/24/00	6 62	29	107	4	21								
012468	2/10/00	2/10/00	4 46	105		35									
012473	1/25/00	1/26/00	6 32	12					0 03						
012473	1/25/00	1/26/00	5 89	34					0 036						
012481															
012490	1/17/00	1/18/00	6	240	1000	30									
012495															
012498	2/16/00	4/6/00	8	13	52	4									
012504	4/17/00	5/16/00	5 4	76	150	5									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
012509															
012512	2/10/00	2/10/00	5 69	100	107	2				0 533					
012519	12/8/99	12/9/99	8 4	1						0 01			0 005	5	
012519	5/16/00	5/17/00	8 25	1						0 079			0 04	23	
012521	3/8/00	3/9/00	6 9	29	30	5				0 23	0 8	0 79			
012521	4/17/00	4/21/00	6 4	50	110	5				0 86	1 4	2 1			
012530	2/16/00	2/17/00	7 15	4	865										
012530	3/10/00	3/13/00	7 62	28	296										
012531	1/25/00	1/26/00	6 7	8	140										
012535	2/10/00	2/10/00	6 9	190	23	1 8									
012541															
012542															
012543	1/25/00	1/28/00	10 21	280	2260	9 8								214	
012543	2/10/00	2/14/00	6 71	35	38	0 5								43	
012549	1/25/00	1/25/00	7 3	39	150									100	
012549	11/8/99	11/9/99	6 6	61	300									270	
012552															
012553	4/17/00	4/18/00	6 42	214	192	151				6 6	5 6	22 3			
012553	4/17/00	4/18/00	6 56	90	350	69				3 8	2 3	51 6			
012553	4/17/00	4/18/00	6 69	80	79	26				1 2	3 6	24 1			
012555	1/25/00	1/25/00	7 18	175	200	11									
012556															
012562	11/8/99	11/11/99	6 3	34	291		104								
012562	11/8/99	11/11/99	10	44	311		38 4								
012562	11/8/99	11/11/99	6	5	186		63 1								
012562	4/19/00	4/19/00	5 6	114	63		23								
012562	4/19/00	4/19/00	5 8	54	60		20								
012562	4/19/00	4/19/00	6 1	74	135		23								
012565															
012575	11/8/99	11/24/99	6 5	32	254		70		0 18				0 1		
012581	2/10/00	2/14/00				23									
012581	4/17/00	4/17/00	7 32	772	2250	108									
012584															
012587	11/9/99	11/12/99	6 56	100	147	20	27								
012588															
012591	11/8/99	11/8/99	6 3	64	440	6 5									
012598	4/17/00	4/17/00	6 7	30	32	1 1		0 1			0 67	0 98			
012599	2/10/00	2/14/00	6 89	61	84 9	5									
012599	4/17/00	4/21/00	7 46	72	77 7	5									
012599	4/17/00	4/21/00	7.85	62	43	5									
012600															
012603	2/10/00	2/10/00	6 1	25	410	13	220								
012605	1/25/00	1/27/00	6 5	20	140	7 1									
012606	1/25/00	1/28/00	6 8	18	80	5			0 02	1					
012606	4/17/00	4/21/00	6 5	53	70	5			0 02	2 1					
012608	1/25/00	2/1/00	6 38	5	67	0 5								11	5
012608	2/13/00	2/17/00	6 6	5	36	0 5								16	5
012612															
012614	1/25/00	5/15/00	7 8	6	200	1 5									
012614	1/25/00	5/15/00	7 8	8	177	0 05									
012614	1/25/00	5/15/00	8	12	129	1 5									
012614	1/25/00	5/15/00	7 1	12	37 5	0 2									
012620	1/26/00	1/26/00	6 3	80	0 13	32									
012620	11/8/99	11/8/99	6 8	50	0 225	2									
012624															
012650															
012652	1/25/00		6 57	7 6	51	1 9									
012654	6/19/00	6/19/00	6 36	60	45	0 5		0 05	0 07	0 47					
012666	1/24/00	1/24/00		37	32 3	1								27	
012666	3/8/00	3/8/00		23	8 81	1								16	
012671	2/14/00	2/15/00	6 1	1	39	5	11								
012671	2/14/00	2/15/00	7	18	55	5	9 3								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
012671	2/14/00	2/15/00	7 2	22	89	5	9 5								
012671	2/14/00	2/15/00	6 2	1	35	5	5 4								
012672															
012682	3/10/00	3/10/00	6 47	26	131	10		0 1	0 05	0 05					
012686	1/25/00	1/25/00	6 74	20	72	10			0 35	0 8			0		
012686	2/10/00	2/10/00	7	0 01					0 86	1 2			0		
012688	2/11/99	2/19/00	6 17	165	108	13 7		0 1	0 05	0 25				136	
012702	1/25/00	1/25/00	7 5	10	0 3	2	64								
012702	2/16/00	2/16/00	5 8	8	0 791	10	61								
012707	4/17/00	4/24/00	6 66	5	988	5									
012709	4/17/00	4/17/00	6 11	30	35 2	11									
012714	2/11/00	2/11/00	6 68	45	42	0 5									
012715	2/10/00	2/17/00	7 15	10	78	14									
012715	2/10/00	2/17/00	6 78	42	25	14									
012722															
012725															
012727															
012731	4/17/00	4/19/00	7	10		5 2									
012731	11/8/99	11/8/99	6 8			10									
012731	1/25/00	1/26/00	6 39	19		10									
012731	2/10/00	2/11/00	6 32	9		5 2									
012731	3/8/00	3/8/00	5 83	23		5									
012739															
012740															
012753	2/15/00	2/15/00	6 64	5	85	5	23								
012753	2/14/00	2/15/00	6.52	10	66	5	19								
012755	12/31/99	6/28/00	7 62	10	69 6	15 3									
012759	2/14/00	2/15/00	6 82	10 3	208	5 5		0 02	0 09	1 71			0 03		
012761															
012775															
012779	2/10/00	2/14/00	7 6	84	0 292	13									
012779	2/10/00	2/14/00	7 4	72	0 295	19									
012779	2/21/00	2/28/00	7 3	142	0 074	37 7									
012779	2/21/00	2/28/00													
012791	1/28/00	1/28/00	7.1	56	41		3 9								
012791	1/28/00	1/28/00	7 1	18	29		4 4								
012823	4/17/00	6/15/00	5 92	46	130	1	3 4								
012852	1/8/99		7 5												
012852	2/10/00		7 5												
012855															
012857	2/14/00	2/17/00	6 25	20	30 7	1	4 9								
012915															
012916															
012926	2/14/00	2/15/00	8 29	5	45	5		0 05	0 01	0 01				5	
012927															
012932	1/17/00	1/18/00	6 45	10	202	10									
012932	2/16/00	2/17/00	6 57	1	77	10									
012943	11/8/99	11/10/99	6 6	184	459	38									
012943	11/8/99	11/10/99	7 6	15	697		19 5								
012943	11/8/99	11/10/99	6 8	6	477		38								
012943	4/17/00	4/19/00	5 5	46	18		2 3								
012943	4/17/00	4/19/00	6 6	96	320		34 2								
012943	4/17/00	4/19/00	6 8	178	479		27 5								
012951	2/10/00	2/16/00	7	180	41	16									
012951	4/17/00	4/19/00	7 3	110	29	14									
012975	1/25/00	1/27/00	6 72	30			11							70	
012975	1/25/00	1/27/00	6 1	123			6 9							140	
012975	2/14/00	2/17/00	7 11	30	50 1		15								
012975	2/14/00	2/17/00	7 36	42	135		11								
012981	1/17/00	1/17/00	7 31	200	533	13 5					2 14			341	
012981	11/8/99	11/8/99	7 8	51	310	10					0 1			230	
012994	1/26/00	2/7/00	8 38	111	1830										

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
012997	2/14/00	2/16/00	8 07	95	283										
013000															
013005															
013030	1/25/00	1/26/00	7 48	135	75	2 2		0 007	0 03	0 386			0 02		
013031	1/25/00	1/26/00	7 73	31	240	2 8		0 002	0 03	0 181			0 02		
013070	1/25/00	1/28/00	5 6	28	20		3 4								
013070	2/10/00	2/11/00	6.4	32	51		19								
013101	3/6/00	3/7/00						0 078	0 32	2 1			0 013		
013101	5/11/00	5/12/00						0 36	0 28	2 4			0 028		
013119	2/13/00	2/14/00	5 2	200	410	5									
013119	1/25/00	1/26/00	6 1	260	550	5									
013122	1/31/00	2/1/00	7 4	220	240	41				0 67	6 7	6			
013122	2/16/00	2/17/00	7 1	110	200	9				0 39	2 6	3 6			
013127															
013128	2/10/00	2/18/00	7 61	34	77 1	5								18	
013129	11/8/99	11/9/99	7 07	91	374	12		0 1	0 13	4 02				579	
013129	1/25/00	1/27/00	7 49	71	129	13 2		0 2	0 06	1 99				129	
013131	1/25/00	1/26/00	5 85	57	151	4			0 059	1 32					
013131	1/25/00	1/26/00	5 78	134	440	6			0 16	1 97					
013131	1/25/00	1/26/00	6 29	48	226	3			0 074	2					
013142	2/16/00	2/17/00	8 5	130	140	21									
013142	2/16/00	2/17/00	7 6	140	180	13									
013142	2/23/00	2/24/00	7 7	49	75	6 6									
013142	2/23/00	2/24/00	7 9	44	93	12									
013144	1/25/00	1/26/00	6 4	28	150	11									
013144	2/21/00	2/28/00	7	395	71	8 7									
013149	1/25/00	1/25/00	7 2			26									
013149	11 8 99	11/9/99	6 9	17	1260	11									
013149	2/11 00	2/11/00	7 2			17									
013149	2 21 00	2/23/00	7 2			4 9									
013149	4.17/00	4/18/00	6 9			5 6									
013166															
013167	1/25/00	1/25/00	6 95	116	105	18 8		0 1	0 08	0 37					
013173	1/25/00	1/27/00	6.76	48	130	5	30		0 13	0 47					
013173	2/21/00	2/23/00	6 79	5	84	5	16		0 02	0 24					
013178															
013179	2/23/00	2/25/00	5 9	6	16 2	5	1 52								
013179	2/23/00	2/25/00	5 6	6	24 5	6	1 66								
013179	2/23/00	2/25/00	5 6	8	19 9	5	1 39								
013179	2/23/00	2/25/00	5 4	6	12 4	5	2 25								
013179	2/23/00	2/25/00	5 8	16	20 6	5	1 29								
013179	4/17/00	4/20/00	5 3	6	42 3	5	15 2								
013179	4/17/00	4/20/00	5 4	9	31	5	5 35								
013179	4/17/00	4/20/00	5 9	12	25	5	4 42								
013179	4/17/00	4/20/00	5 9	12	38 2	5	9 36								
013179	4/17/00	4/20/00	6 1	6	25	5 2	5 87								
013180	4/17/00	4/18/00	5 66	18	43	5									
013180	4/17/00	4/18/00	6 14	5	43	5									
013184															
013188	2/10/00	2/14/00	5 4	45	70 5	52		0 026	0 067	0 357					
013189	2/10/00	2/14/00	6 58	88	67 8	35		0 046	0 094	0 439					
013190	2/10/00	2/14/00	6 12	86		75		0 088	0 09	0 664					
013198	1/25/00	1/28/00	6 4	34	150		9 5								
013198	1/25/00	1/28/00	6 5	120	94		14								
013198	2/23/00	2/25/00	6 3	6	33		4 4								
013198	2/23/00	2/25/00	6 6	8	35		3								
013204	1/25/00	1/25/00	6	25	39	5	3 5								
013204	1/25/00	1/25/00	6 9	100	100	5	8 9								
013204	1/25/00	1/25/00	4 75	28	31	5	3								
013204	2/11/00	2/11/00	6.64	136	31	5	7 1								
013204	2/11/00	2/11/00	6 65	5	24	5	3.4								
013204	2/11/00	2/11/00	6.57	39	48	5	9.4								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
013215															
013216	5/10/00	5/10/00	7 05	229	535	31 8									
013221															
013225	11/8/99	11/11/99	5 95	22	471	5	130								
013225	12/31/99	1/6/00	6 18	348	157	10	29								
013228	11/8/99	11/9/99		5	5		1								
013228	11/8/99	11/9/00	9 1	38	280		37								
013229															
013230	1/25/00	1/26/00	5 95	228	410	27						5 2		700	
013230	11/11/99	11/22/00	4 19	298	1900	35						11 2		2800	
013231															
013235	1/25/00		6 6	174	1936	5	16	0 02	0 03	0 1			0 02		
013235	2/10/00		6 4	54	1100	5	9	0 02	0 27	0 06			0 06		
013251	11/8/99	11/10/99	8 4	200	120	2 9	18					3 3			
013251	11/8/99	11/10/99	8 6	390	150	2	18					24			
013251	11/8/99	11/10/99	6 2	67	130	2 1	42					2 5			
013251	11/8/99	11/10/99	6	58	99	2 3	35					1 9			
013251	11/8/99	11/10/99	5 8	44	180	4 1	65					1 1			
013251	11/8/99	11/10/99	5 7	38	170	3 5	64					1 2			
013255															
013262	2/10/00	2/17/00	6 28	50	97 6	2									
013262	4/17/00	4/20/00	7 33	13	40 5	2									
013272	2/10/00	2/11/00	7 2	37	41	2									4 2
013272	2/10/00	2/11/00	7 2	59	38	5 3									4
013279															
013296	2/10/00	2/16/00	7 1	17	170	15		0 038	0 2	0 3					
013296	4/17/00	4/21/00	8	14	46	4		0 027	0 2	0 4					
013297	11/8/99	11/8/99	6 29	126	800	5	210								
013297	11/8/99	11/8/99	5 88	183	1400	5	170								
013297	1/25/00	1/26/00	6 71	18	23	5	6 3								
013297	1/25/00	1/26/00	6 12	23	43	5	15								
013342															
013344															
013345															
013347															
013348															
013359	2/16/00	2/16/00	6	280	27	2	3 5								
013359	2/16/00	2/16/00	6 2	5	20	2	3 9								
013359	5/10/00	5/10/00	7 1	13	500	2	410								
013359	5/10/00	5/10/00	4 9	180	1200	2	490								
013369															
013370	4/17/00	4/20/00	6 46	60				0 233	0 062	7 42			0 016	240	
013377	2/10/00	2/15/00	5 84	90	55	2						3 95			
013378															
013389															
013392	2/10/00		6 7	98	237	12				1 62	2	4 43			
013393															
013394	1/25/00	1/26/00	7	46	56		12 6								
013394	1/25/00	1/26/00	6 8	34	71		14 8								
013394	1/25/00	1/26/00	6 8	21	150		11 5								
013394	1/25/00	1/26/00	6 9	43	46		12 8								
013394	1/25/00	1/26/00	6 5	49	46		9 8								
013394	4/17/00	4/19/00	6 6	110	680		22 3								
013394	4/17/00	4/19/00	6 5	240	2400		25 4								
013395	1/25/00	1/26/00	7	46	56		12 6								
013395	1/25/00	1/26/00	6 8	34	71		14 8								
013395	1/25/00	1/26/00	6 8	21	150		11 5								
013395	1/25/00	1/26/00	6 9	43	46		12 8								
013395	1/25/00	1/26/00	6 5	49	46		9 8								
013395	4/17/00	4/19/00	5 5	30	210		11 5								
013406															
013418	1/25/00	1/27/00	6 58	59	425	37	49								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
013418	1/25/00	1/27/00	6 34	111	149	12	25								
013418	1/25/00	1/27/00	6 06	76	166	19	32								
013418	1/25/00	1/27/00	6 09	2850	15000	535	505								
013418	1/25/00	1/27/00	6 26	53	59 2	9	13								
013418	2/16/00	2/21/00	6 35	5	5 6	6									
013418	2/16/00	2/21/00	6 49	8	64 5	8	7 7								
013418	2/16/00	2/21/00	6 51	230	640	42	30								
013418	2/16/00	2/21/00	6 7	5	7 65	6	8 4								
013418	2/16/00	2/21/00	6 98	130	175	8	9 8								
013420	1/25/00	1/26/00	8	88	810		16 2								
013420	1/25/00	1/26/00	8 1	1300	1700		32 6								
013420	1/25/00	1/26/00	7 7	170	610		13 5								
013420	1/25/00	1/26/00	7 5	150	330		10 7								
013423															
013427	1/25/00	1/28/00	6 28	12	120		30								
013427	4/17/00	4/20/00	5 91	98	140		60								
013433	1/17/00	1/19/00	6 46	15		4									
013433	2/10/00	2/12/00	6 24	64		3									
013436	1/25/00	1/25/00	6 69	28	99	10									
013436	4/17/00	4/18/00	7 5	82	800	10									
013438	2/16/00	2/24/00	6 96	49	180	9 2									
013438	2/16/00	2/24/00	7 03	52	190	12									
013438	3/8/00	3/14/00	7 16	8 6	85	3 2									
013438	3/8/00	3/14/00	7 19	12	85	2 1									
013455	12/31/99	1/3/00	6 8	170	280		28				4 6	3 7			
013455	2/10/00	2/10/00	8 1	150	97		8 9				3 9	6 6			
013457															
013462	2/10/00	2/10/00	7 6	90	1760	12									
013462	2/16/00	2/17/00	7 8	460	9120	33									
013470	2/15/00	2/16/00	5 75	320	47 1	8 3									
013470	1/24/00	1/28/00	5 64	123		2									
013476															
013533	1/25/00	1/25/00	7 37	7	50	5									
013533	2/10/00	2/11/00	6 23	15	240	11									
013533	3/7/00	3/9/00	8 13	5	25 3	5									
013540	2/9/00	6/28/00	6	158	193	8	11			1 33	4 55	7 67			
013540	2/9/00	6/28/00	6 6	134	187	2	9 2			1 35	2 67	4 72			
013540	2/9/00	6/28/00	6 7	109	237	2	8 8			1 13	3 06	5 49			
013540	3/14/00	6/28/00	6	44	102	2	9 2			1 56	1 51	2 92			
013540	3/14/00	6/28/00	7 1	50	354	3	5 8			0 94	2 85	5 89			
013540	3/14/00	6/28/00	7 1	588	108	9	19			1 43	9 49	16 4			
013577	2/14/00	2/18/00	6 3	7	186										
013577	2/14/00	2/18/00	5 33	7	186										
013577	2/21/00	2/24/00		40		5 3									
013596															
013605	1/25/00	4/7/00	6 4	32	57										
013605	1/25/00	4/7/00	6 5	28	31										
013605	1/25/00	4/7/00	6 6	56	77										
013605	2/16/00	4/7/00	5 2	33	41										
013605	2/16/00	4/7/00	5 6	20	43										
013605	2/16/00	4/7/00	5 7	36	38										
013606															
013622	1/25/00		6 92	53		13			0 1	0 91				366	
013655															
013688	4/18/00	4/19/00	5 39	5		5	6 9								
013693	1/25/00	1/26/00	7 28	144	440	12		0 13	0 33	0 85	1 9	12		390	
013693	1/25/00	1/26/00	7 21	22	260	5		0 03	0 2	0 63	0 37	2 4		220	
013694	1/28/00		6 95	42	388	2									
013697	2/10/00	2/14/00	6 27	55	120	5									
013697	2/10/00	2/14/00	6 63	195	82	5 9									
013697	4/17/00	4/18/00	6 6	24	266	3 1									
013697	4/17/00	4/18/00	7 2	88	92 2	4 7									

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
013706															
013708															
013713	1/25/00	1/26/00	6 02	2	47 2	2									
013713	1/25/00	1/26/00	7 06	10	108	2									
013721															
013726	1/26/00		7 33	186	27 8										
013726	1/26/00		7 01	317	29 6										
013726	2/26/00	2/29/00	6 15	56	94 4										
013726	2/26/00	2/29/00	5 95	34	76 3										
013729	1/25/00	1/26/00	6 61	192	109	6 8								55	310
013729	4/17/00	4/18/00	6 31	133	83	13 1								261	32
013745	2/10/00	2/14/00	7 83	46	128	1				0 27					
013745	4/17/00	4/18/00	6 88	31	59	6									
013746															
013779	1/25/00	1/27/00	8 6	33	110	11									
013779	4/17/00	4/19/00	6 8	57	180	8									
013803	2/11/00	2/11/00	6 2	277	155	5									
013803	4/17/00	4/17/00	6 7	56	128	3 7									
013843															
013866	4/11/00		6 45	129	990	159		0 07	0 12						
013881	1/31/00	2/5/00	6 54	30	68 6		11			0 213					
013881	1/31/00	2/5/00	6 4	20	118		20			0 154					
013881	1/31/00	2/5/00	6 74	40	167		23			0 096					
013881	2/16/00	2/18/00	6 54	30	80 7		23			0 181					
013881	2/16/00	2/18/00	6 98	290	90 4		12			0 594					
013881	2/16/00	2/18/00	6 71	30	86 1		21			0 161					
013881	2/16/00	2/18/00	6 98	60	95 7		9 6			0 567					
013881	1/31/00	2/5/00	6 46	30	100		17			0 101					
013891	2/16/00		6 22	32	162	20	49								
013891	2/16/00		6 47	56	639	105	268								
013893	4/17/00		7 32	52	202	15	75								
013893	4/17/00		7 56	46	625	155	492								
013943	1/25/00	1/26/00	7 8	80	170	8 6									
013943	1/25/00	1/26/00	8 2	100	66	5									
013943	11/8/99	11/9/99	7 2	160	200	5									
013944	1/25/00	1/26/00	8 2	100	66	4 72									
013944	11/8/99	11/9/99	6 8	47	360	5									
013951															
013959															
013961															
013968															
013969															
013989	1/17/00	1/17/00	8 1	42	230	11	50								
013989	9/21/99	9/22/99	7	260	1300	55									
014013															
014039	11/8/00	6/15/00	4 47	50 5	415	5									
014039	11/8/99	6/15/00	4 16	106	466	5									
014039	4/17/00	6/15/00	4 56	146	253	5									
014039	4/17/00	6/15/00	4 77	184	240	5 8									
014070	2/21/00	2/22/00	8 03	148	322	17		0 18	0 09	0 42				178	
014070	2/21/00	2/22/00	6 97	27	868	0 5		0 05	0 01	0 1				167	
014070	3/8/00	3/16/00	5 73	47	70	7 9		0 05	0 04	0 13					
014070	3/8/00	3/16/00	6 92	60	229	11 3		0 05	0 04	0 09					
014165															
014172	11/9/99	11/9/99	5 64	17	530		180								
014184	1/25/00	1/25/00	6 3	101	82 9	5				0 8	1 43	5 6			
014184	11/8/99	11/8/99	6 3	49	159	5				1 31	1	4 91			
014186	2/11/00	2/11/00	7 14	50	0 36	16 9				0 18	0 01	1 47			
014186	4/17/00	4/18/00	7 88	77	121	5	18			0 24	0 01	2 42			
014209															
014214	1/25/00	2/1/00	8 2	22	260					2	2 3	19			
014224	1/26/00		7 2	620		10	0.05								

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Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
014224	2/14/00		7 4	411		10	0 05								
014224	2/21/00		7 1	460	10	0 05									
014224	4/18/00		6 9	568		10	0 05								
014234	4/17/00	4/20/00	6 29	90	255	2								140	
014288															
014308															
014325	1/25/00	1/27/00	7 7	300	250	7									
014325	11/9/99	11/10/99	7	2100	300	530									
014347	2/23/00	2/23/00	6 5	10		5		0 008	0 014	23			0 019		
014350	3/8/00	3/9/00	6 9	32	110	5			1 1	0 22	0 9	0 79			
014350	4/17/00	4/21/00	6 2	37	110	7			2 2	0 76	0 8	1 5			
014397															
014410															
014415	1/25/00	1/25/00	6 57	9	78	0 5									
014431	4/17/00	4/20/00	7 03	16	218	2 4		0 011	0 03	0 13	0 18	1 64		63	
014500															
014532	2/10/00	2/16/00	7 1	9	63			0 014	0 2	0 2					
014532	4/17/00	4/20/00	6 5	43	98	4		0 077	0 4	0 1					
014568	1/25/00	1/27/00	7.73	555	680	5									
014568	2/10/00	2/15/00	6 26	390	21	5									
014585															
014588															
014613															
014615															
014638	11/8/99	11/10/99	6 9	14	140	4									
014638	2/10/06	2/15/00	6 6	34	130	4									
014642	1/25/00	1/25/00	6 02	10		0 5								43	
014642	1/25/00	1/25/00	6 13	10		0 5								53	
014642	1/25/00	1/25/00	6 25	10		0 5								50	
014642	1/25/00	1/25/00	6 63	78		0 5								102	
014642	1/25/00	1/25/00	6.17	10		0 5								54	
014642	1/25/00	1/25/00	6 68	90		0 5								88	
014642	1/25/00	1/25/00	6 22	26		0 5								59	
014642	1/25/00	1/25/00	6 27	32		0 5								59	
014642	2/14/00	2/14/00	5 6	9		5								16	
014642	2/14/00	2/14/00	5 89	34		10								16	
014642	2/14/00	2/14/00	6 21	66		5								36	
014642	2/24/00	2/24/00	6 71	218		18								40	
014645	2/17/00	2/17/00	7 04	72	323	0 5									
014645	3/8/00	3/8/00	7 19	14	106	0 5									
014646	2/10/00	2/11/00	7.4	74	200		49								
014646	2/10/00	2/11/00	7 5	98	190		47								
014646	2/10/00	2/11/00	7 4	21	240		78								
014646	2/10/00	2/11/00	7 5	84	210		55								
014646	2/21/00	2/22/00	6 9	10	40		4 5								
014646	2/21/00	2/22/00	6 9	16	28		3 4								
014646	2/21/00	2/22/00	6 9	34	30		3 6								
014646	2/21/00	2/22/00	7	10	46		4 6								
014661	4/17/00	4/21/00	6 5	134	82	1 9					2 16			120	
014673															
014674															
014701	3/8/00	3/9/00		11	20	9 3								5	
014701	4/18/00	4/18/00	6 12	56	655	7 5								672	
014703															
014707	2/21/00	2/22/00	7.15	110	200		17	0 061	0 07	0 82					
014713	1/25/00	1/25/00	7.1	15	35	1 8									
014722	11/8/99	11/8/99	6	104	125	10									
014743	2/11/00	2/14/00		35	277	9 2		0 05	0 11	1 86				240	
014743	2/15/00	2/15/00	7 1	5	63	0 5		0 05	0 01	0 08				13	
014767	1/25/00	5/25/00	7 31	41	3865	5									
014767	2/10/00	5/25/00	5 92	34	170	11									
014775	4/17/00	4/17/00	8 33	201	245	81					3			141	

R0012648

Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
014775	4/17/00	4/17/00	7 95	342	835	23					5 8			551	
014777		5/19/00	5 4	11	111	5									
014777		5/19/00	5 53	65 2	55.1	5									
014777	2/17/00	3/7/00	6 51	33	86	5									
014777	2/17/00	3/7/00	5 11	142	165	5									
014783	2/10/00	2/16/00	6 8	153	156	10				0 83	2 3	1 17			
014802	2/24/00	6/28/00	5 75	105	657	7 3									
014802	4/17/00	6/29/00	6 19	55	85 3	5									
014824	1/26/00	1/27/00	6 37	48	555	12 9		0 05	0 09	0 57					
014824	3/15/00	3/15/00	6 63	20	64	11 5		0 05	0 01	1 33					
014835	2/10/00	2/15/00	5 6	180	130	24		0 34	0 2	2 1	5 4			880	
014835	4/17/00	4/21/00	7 8	51	31			0 079	0 2	0 7	0 84	2 4		29	
014837	2/10/00	2/15/00	5 8	170	160	32		0 12	0 2	0 6	1 6	3 8		236	
014837	4/17/00	4/21/00	7 8	51	31			0 079	0 2	0 7	0 84	2 4		29	
014854															
014885	2/10/00	2/16/00	6 1	130	300	40		0 87	0 8	5 6	13	0 5		590	
014885	4/17/00	4/20/00	6 2	93	1700	9		0 87	1 2	17	13	7 1		2100	
014891	1/25/00	1/26/00	7 56	104	165	4	59							190	32
014891	1/25/00	1/26/00	7 58	168	212	6	42							180	47
014891	2/23/00	2/24/00	8 29	152	59	3								54	
014891	2/23/00	2/24/00	8 86	76	50	3								52	
014899	1/25/00	1/25/00	7 13	22		3	16 2								
014907	1/25/00	1/26/00				3	15 8		0 0461						
014907	1/25/00	1/27/00				2	13		0 0257						
014908															
014945	3/8/00	3/10/00	6 4	8	36	6		0 032	0 054	0 1	0 23	0 4			
014946	3/8/00	3/10/00	5 8	14	30	10		0 022	0 063	0 61	0 37	1 1		39	
014968	2/10/00	3/6/00	5 84	513	162 9		20 1								
014968	3/6/00	3/6/00	5 73	107	98 8		31 3								
014985															
014986	12/31/00	1/6/00	5 95	80	335	19		0 109	0 245	2 31					
014989															
014990	1/25/00	2/5/00	6 18	21	67 9	5		0 026	0 044	0 327					
014999															
015003	1/25/00	1/25/00	6 8	10	100	5	35								
015003	4/18/00	4/18/00	6 5	49	280	5	150								
015006															
015045	2/13/00	2/24/00	6	5	150	2									
015045	2/21/00	2/24/00	6 4	1	100	2									
015045	4/26/00	4/26/00	5 8	1	70	2									
015054	2/10/00	2/18/00	6 25	3040	960	230		0 527	0 347	2 77					
015062															
015074															
015076															
015082															
015083															
015088	2/10/00	2/10/00	6 8	5	32	5				0 14	0 1	0 08			
015089	1/25/00	1/25/00	6 93	8	90	5									
015089	1/25/00	1/25/00	7 08	6	70	5									
015089	1/25/00	1/25/00	6 62	6	50	15 3									
015089	1/25/00	1/25/00	7	11	70	6 6									
015089	1/25/00	1/25/00	7 57	8	170	5									
015089	4/17/00	4/17/00	5 06	154	148	5									
015089	4/17/00	4/17/00	5 41	24	300	5									
015089	4/17/00	4/17/00	5 5	58	92 2	5									
015089	4/17/00	4/17/00	5 77	24	240	5									
015089	4/17/00	4/17/00	5 9	66	186	5									
015092															
015100	1/25/00	1/26/00	7 39	58	43	5	3								
015100	1/25/00	1/26/00	6 88	83	20	6	8 4								
015100	4/17/00	4/20/00	6 2	22	300	12	95								
015100	4/17/00	4/20/00	6 47	55	230	5	150								

R0012649

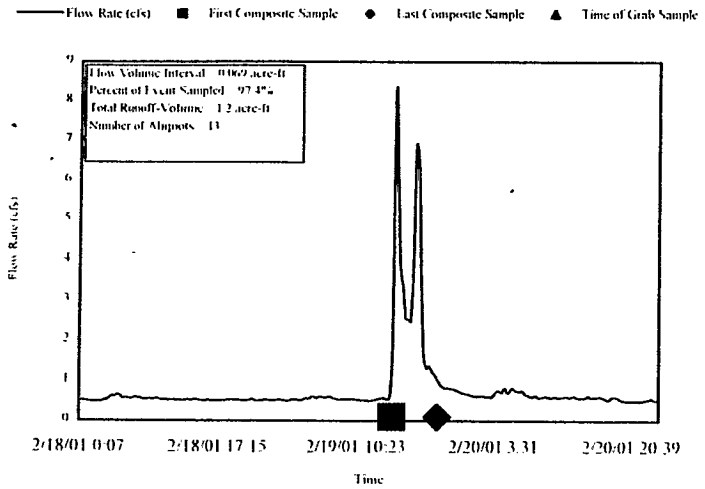
Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
015124	1/25/00	1/26/00	6 88	86	110					0 94					
015128															
015136	4/17/00	4/18/00	6 3	130	970	15	48								
015136	4/17/00	4/18/00	6 7	250	1500	19	77								
015136	4/17/00	4/18/00	6 7	75	50	8 2	6 9								
015141															
015147	1/25/00	2/24/00	6 65	93	410	6 7	30								
015147	2/23/00	2/25/00	6 8	130	300	9 3	23								
015171	2/16/00	2/17/00	6 8	9	30	5 2		0 1	0 05	0 29			0 1		
015171	2/16/00	2/17/00	6 7	8	29	6 3		0 1	0 05	0 13			0 1		
015171	4/18/00	4/20/00	6 9	80	60	10		0 1	0 05	0 31			0 1		
015171	4/18/00	4/20/00	7 1	85	27	17		0 1	0 05	0 3			0 1		
015180															
015186	2/10/00	2/10/00	6 08	209	258	4	25								
015186	4/17/00	4/18/00	7 28	1	57	1	2 7								
015189	1/24/00	1/26/00	6 87	31	58		11								
015189	11/8/99	11/8/99	6 5	32	155		33 2								
015200	1/25/00	1/31/00	6 69	29	82	1		0 031		0 347					
015266	2/27/00	2/28/00	6 47	56 2	200										
015266	4/17/00	4/24/00	5 7	38	587										
015277															
015278	4/17/00	4/17/00	7 7	120	210	40			0 15		1 5	2 7			
015287	1/25/00	1/26/00	7	78	150	21									
015287	11/8/99	11/9/99	4 9	460	3200	170									
015289	1/25/00	1/25/00	7 2	15	84	5									
015289	2/10/00	2/10/00	7	29		5									
015290															
015340															
015340															
015340															
015348	11 8 99	11/8/99	5 44	44	334	1		0 1				2 3			
015348	11.8.99	11/8/99	5 19	59	212	1		0 1				1 6			
015348	2/16/00	2/16/00	6 55	21	55	0 5						0 44			
015348	2/16/00	2/16/00	6 63	31	35	1						1 2			
015348	2/16/00	2/16/00	6 88	16	48	0 5						0 31			
015348	2/16/00	2/16/00	6 76	15	18	1		0 05				0 5			
015355															
015356															
015403	3/4/00	3/7/00	8 2	31	52	4		0 009	0 2	0 2					
015403	4/15/00	4/20/00	7.4	4	27	4		0 0076	0 2	3 2					
015404	1/25/00	1/25/00	7 3	5	325	0 5				0 64					
015404	1/25/00	1/25/00	7 21	5	446	0 5				0 7					
015404	1/25/00	1/25/00	7 49	46	131	0 5				1 29					
015404	1/25/00	1/25/00	7.69	18	129	0 5				1 3					
015404	11/8/99	11/9/99	6.18	10	123	1				1 99					
015404	11/8/99	11/9/99	6 2	18	78	1				3 46					
015404	11/8/99	11/9/99	6 22	20	232	1				3 86					
015404	11/8/99	11/9/99	6 54	187	134	1				3 44					
015421															
015421															
015422	11/8/99	11/9/99	7	16	250	5		0 028	0 1	0 78	0 92		0 013		
015422	3/8/00	3/8/00		16	46	5		0 046	0 037	0 36	1 8		0 019		
015432	4/17/00	4/18/00	6 7	19	25	1									
015448															
015468															
015475															
015476															
015482	11/8/99	11/8/99	6 3	17	4 2	5	7 7								
015482	2/11/00	2/14/00	6 5	10	54	1 3	7.8								
015488	2/21/00	2/21/00	8.69	32	952	0 5					0 53	1 4			
015488	2/21/00	2/21/00	8 76	449	592	5					11	17			
015488	4/18/00	4/18/00	7 12	23	819	0 5					0 72	1 2			

R0012650

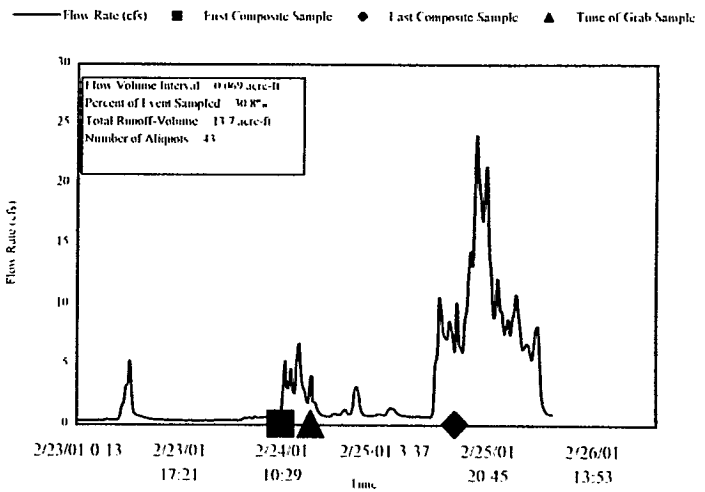
Facility Sequence ID	Date of Storm	Date Analyzed	pH	TSS (mg/L)	SC (umhos/cm)	O&G (mg/L)	TOC (mg/L)	Pb (mg/L)	Cu (mg/L)	Zn (mg/L)	Al (mg/L)	Fe (mg/L)	Ni (mg/L)	COD (mg/L)	BOD (mg/L)
015488	4/18/00	4/18/00	7 26	10	347	0 5					0 1	0 54			
015516	1/25/00	1/28/00				71		0 433	0 281	1 52	3 42	10 5		210	
015516	4/17/00	4/22/00	6 7	5	1310	136		0 417	0 316	4 71				1200	
015533															
015539															
015540															
015549															
015554	4/17/00	4/20/00	7 6	110	35	4		0 005	0 2	1 5					
015556	2/16/00	2/17/00	7 09	61	350	10									
015556	3/14/00	3/14/00	7 4			4 2	35								
015569	4/17/00	6/19/00	5 79	167	253	0 5		0 05	0 07	2 18					
015576															
015579															
015609	5/25/00	5/25/00	6 43	96	1565	23 8									
015615															
015626															
015627															
015632	2/10/00	2/11/00	8 6	280	500	39		0 052	0 064	0 34	2 2	3 6			
015632	2/10/00	2/11/00	8 4	160	290	11		0 013	0 034	0 32	1 7	2 5			
015632	2/16/00	2/17/00	7 8	16	108			0 006	0 2	0 1	0 1	0 5			
015640															
015641															
015654	1/25/00	1/25/00					7 9								
015654	2 16/00	2/17/00	5 9	6	57	5									
015655	2 10-00	2/10/00	6 9	37	120	7				0 5	1 5	2 9			
015655	4 17 00	4/18/00	6 8	130	340	4				1 1	2	4			
015662															
015663															
015670															
015673															
015674															
015698	4/17/00	4/20/00	7 6	57	20	4		0 036	0 2	0 3					
015699	4/17/00	4/21/00	7 5	8	24	4		0 012	0 2	5 3					
015700															
015710															
015716	3/6/00	3/9/00	7	110	340	4						5 1			
015717															
015732	2/23/00	2/23/00	6 77	8	63		6 8								
015732	4/18/00	4/18/00	6 76	30	66		11								
015737	4/17/00	4/20/00	7 1	140	180	4		0 094	0 2	0 9					
015747															
015767															
015779	4/17/00	4/20/00	7 5	44	150	4		0 029	0 2	0 4					
015794															
015798															
015827															
015840															
015853															
015854	1/25/00	1/25/00	7 1	19	83	5									
015854	1/25/00	1/25/00	6 6	32	21	0 5									
015854	11/8/00	11/8/00	6 7	18	180	4 2									
015868															
015915															
015915	3/8/00	3/10/00	7 09	30	55	1		0 001		0 101					

R0012651

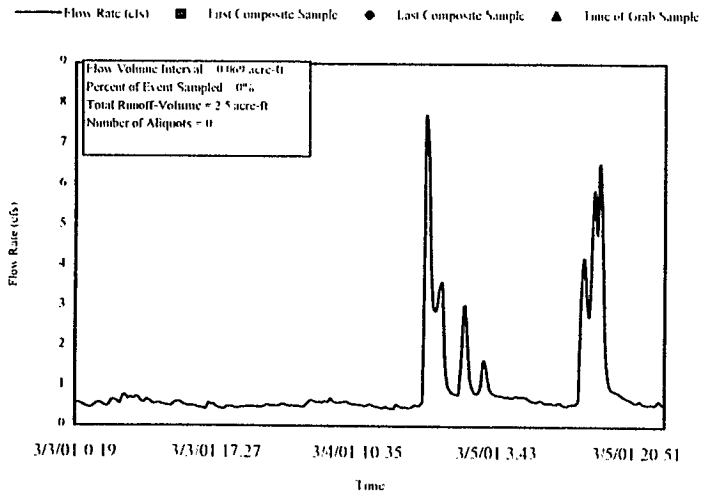
Station 27, Storm 9 (2/19/2001)



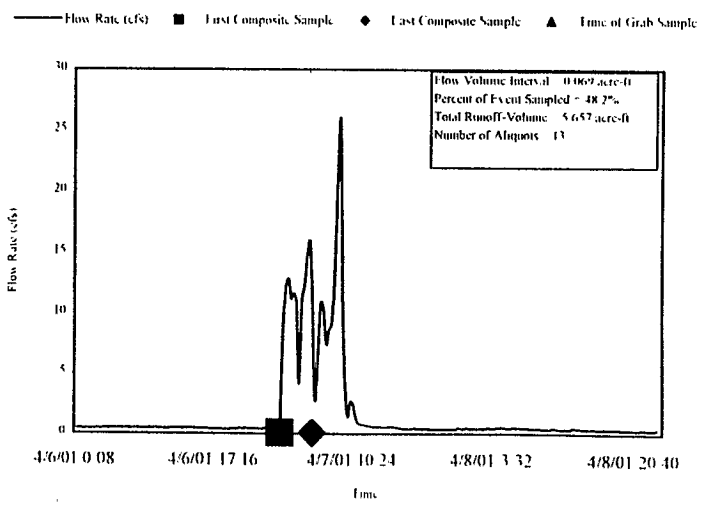
Station 27, Storm 10 (2/24/2001)



Station 27, Storm 11 (03/04/2001)

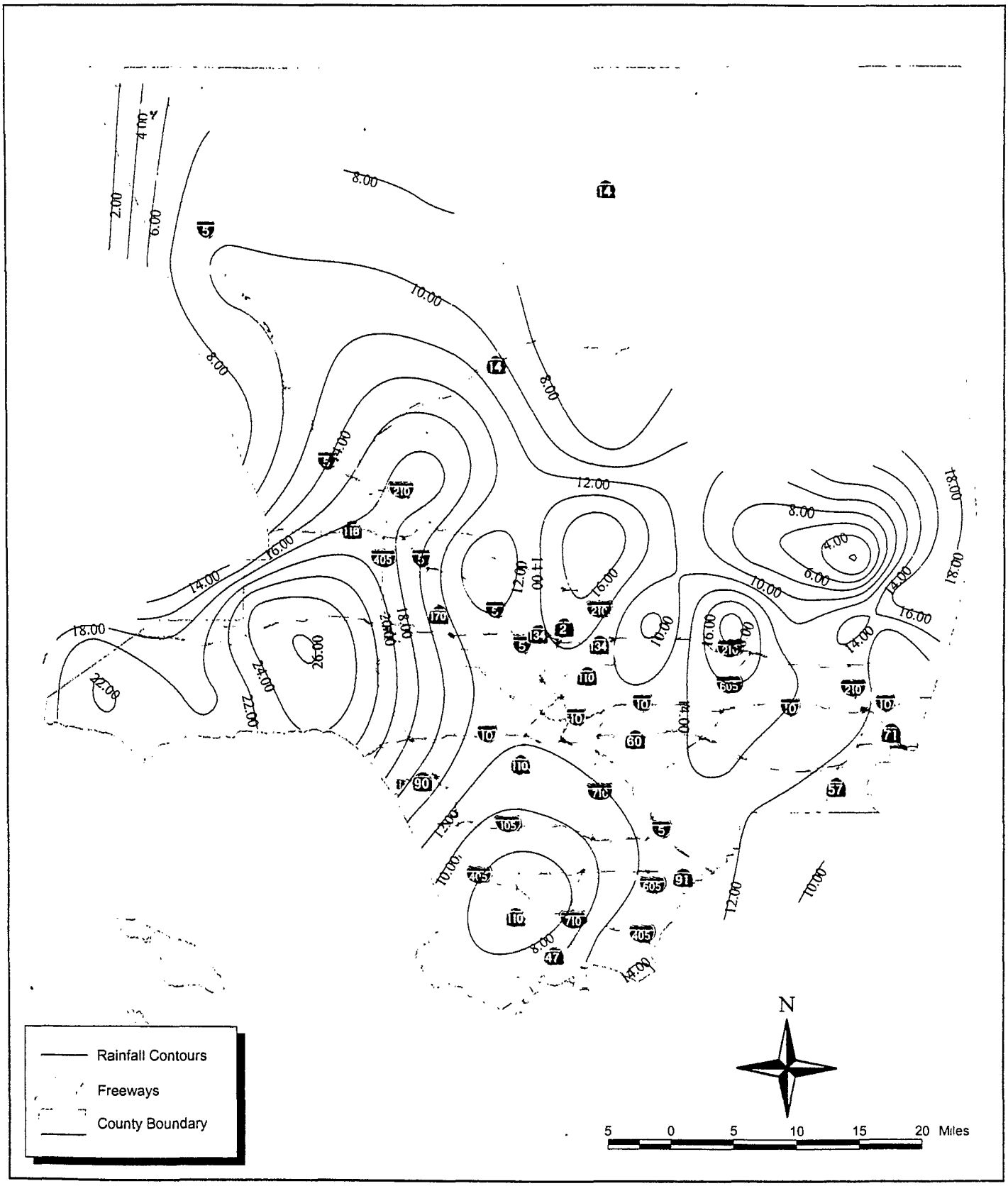


Station 27, Storm 12 (04/07/2001)



R0012652

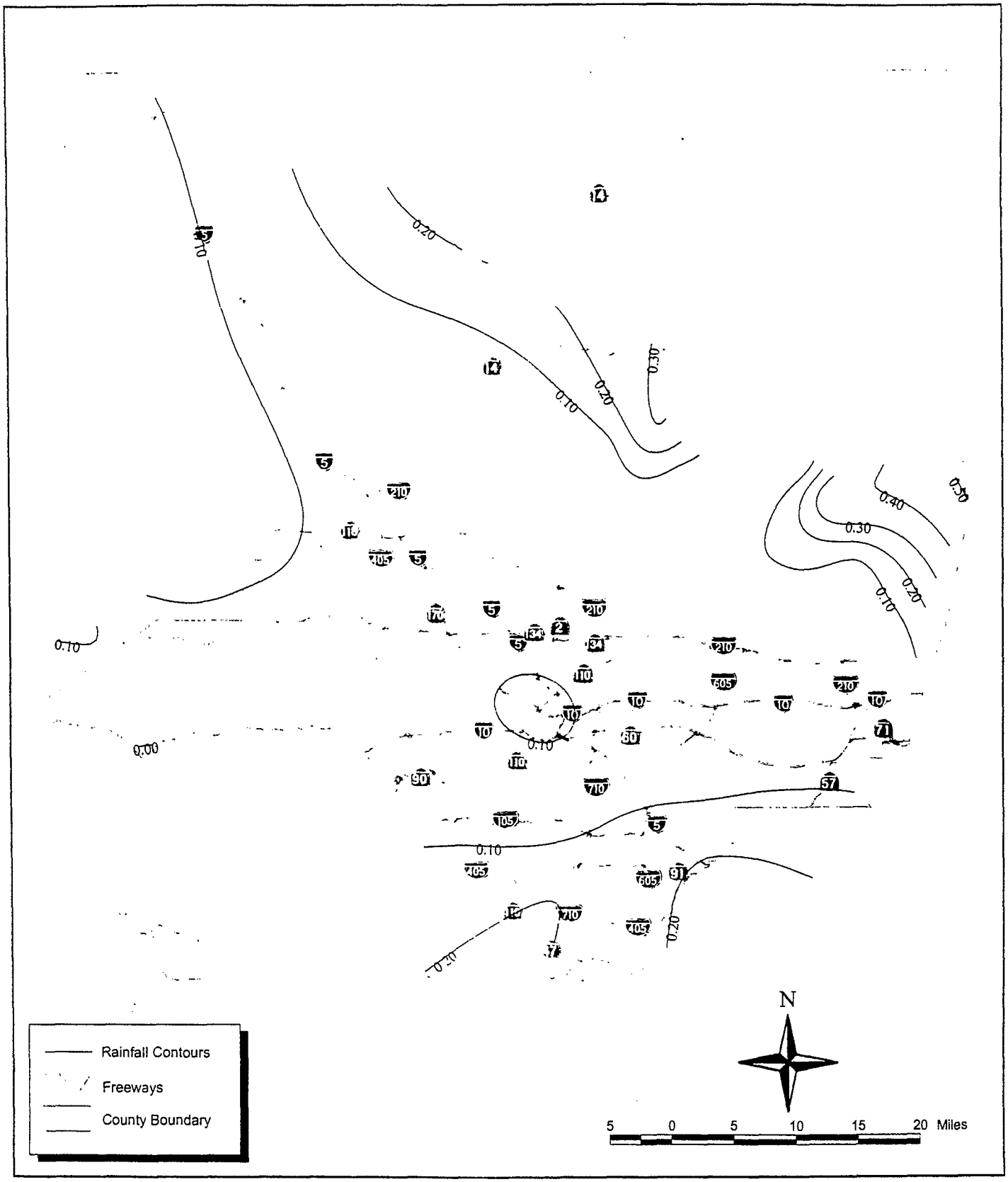
RAINFALL CONTOURS
2000 - 2001 STORM SEASON



STORM EVENT DATE: 2001 Storm Season RUN DATE: 06/12/2001

R0012653

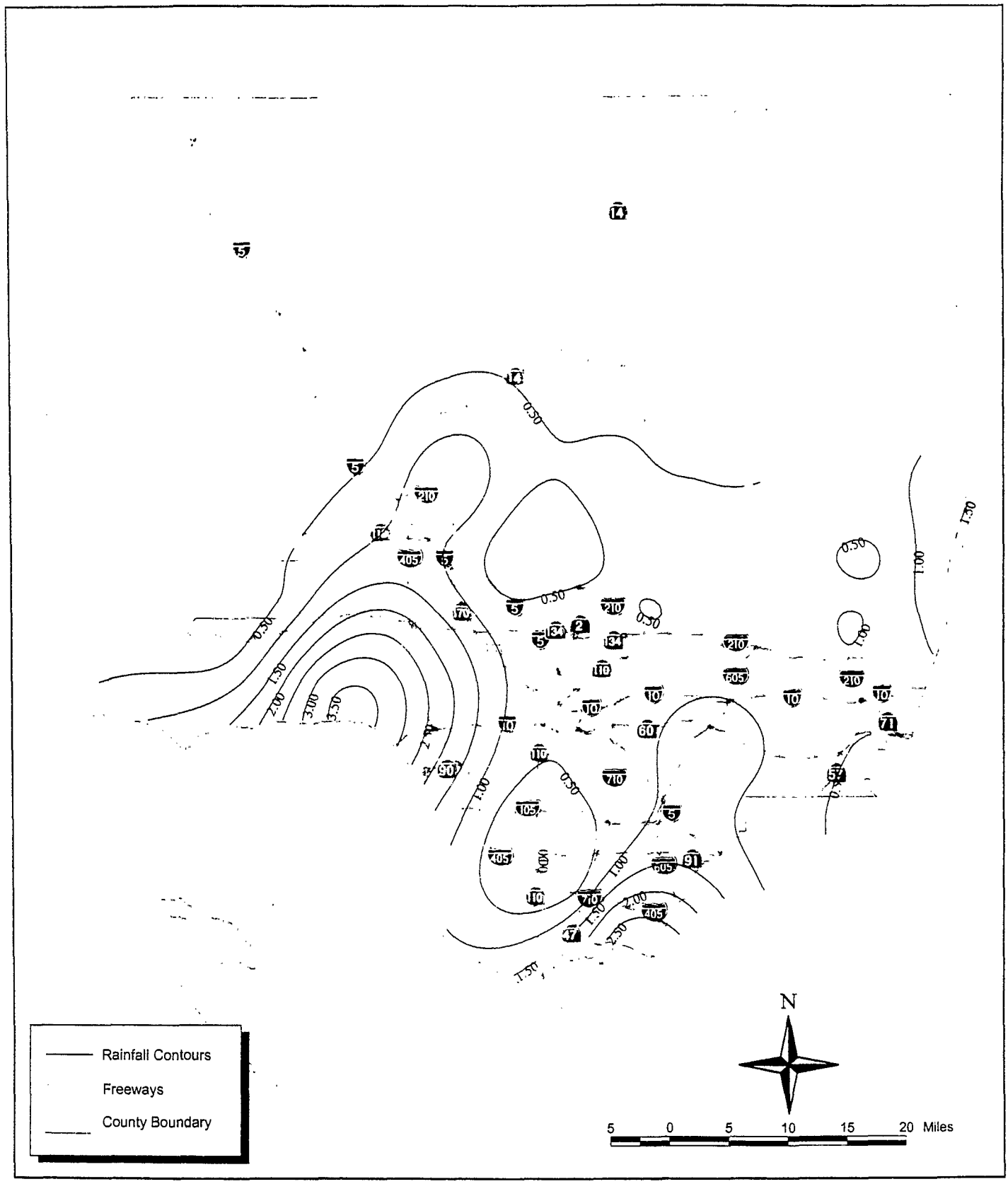
RAINFALL CONTOURS
STORM EVENT DATE 10/12/2000



STORM EVENT DATE: 10/12/2000 RUN DATE: 06/11/2001

R0012654

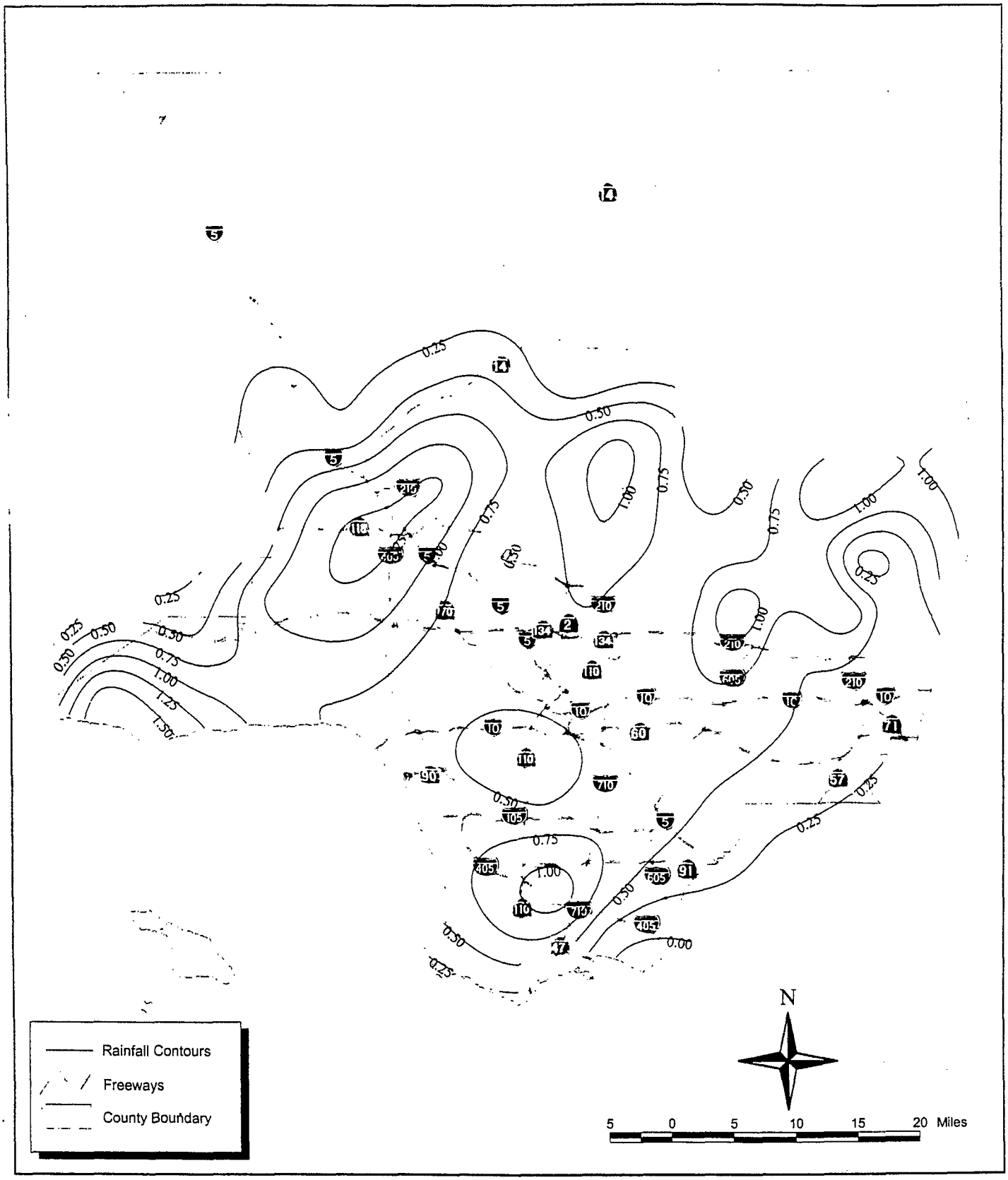
RAINFALL CONTOURS
STORM EVENT DATE 10/26/2000



STORM EVENT DATE: 10/26/2000 RUN DATE: 06/11/2001

R0012655

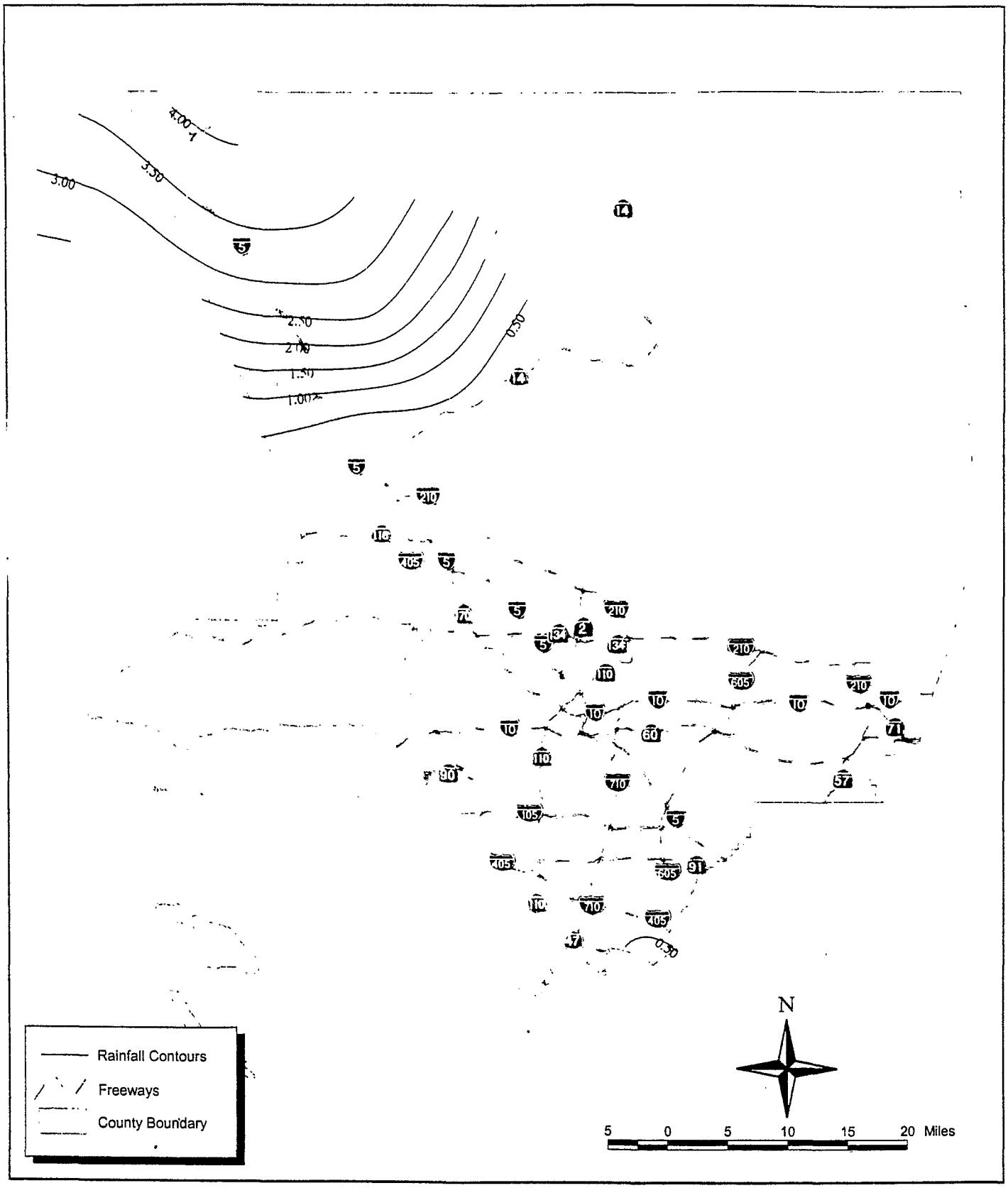
RAINFALL CONTOURS
STORM EVENT DATE: 10/29/2000



STORM EVENT DATE: 10/29/2000 RUN DATE: 06/11/2001

R0012656

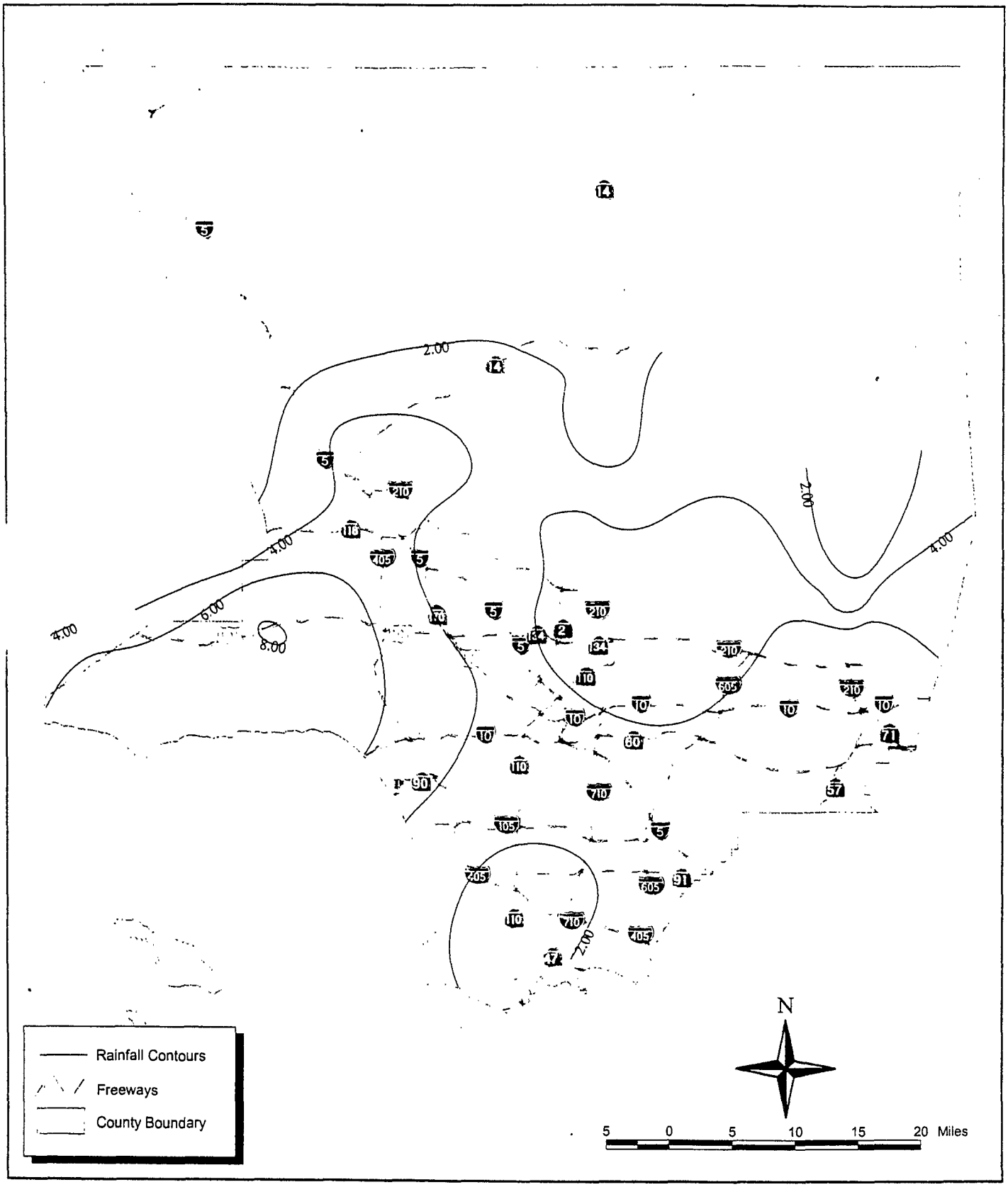
RAINFALL CONTOURS
STORM EVENT DATE: 01/08/2001



STORM EVENT DATE: 01/08/2001 RUN DATE: 06/11/2001

R0012657

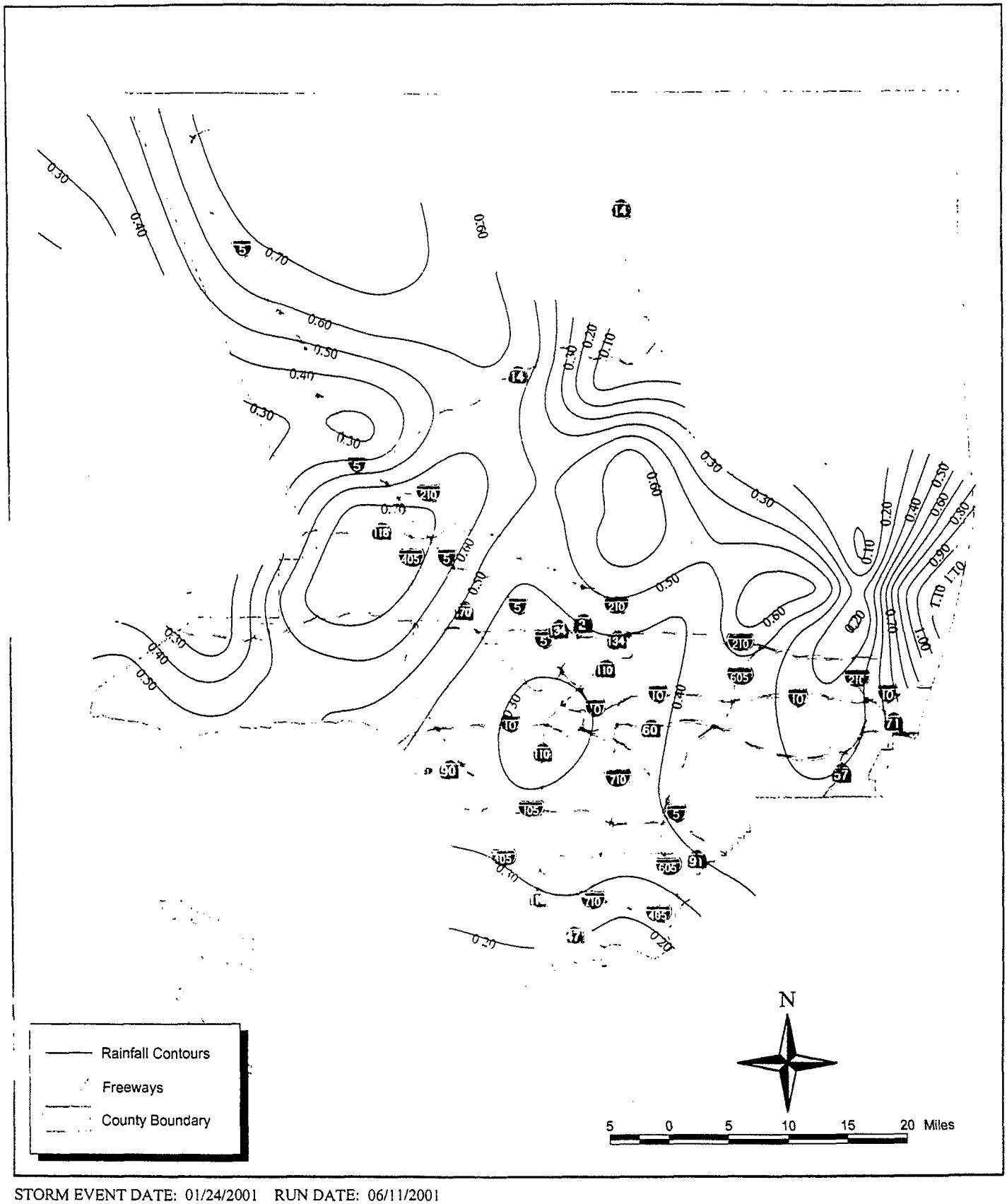
RAINFALL CONTOURS
STORM EVENT: 01/10/2001



STORM EVENT DATE: 01/10/2001 RUN DATE: 06/11/2001

R0012658

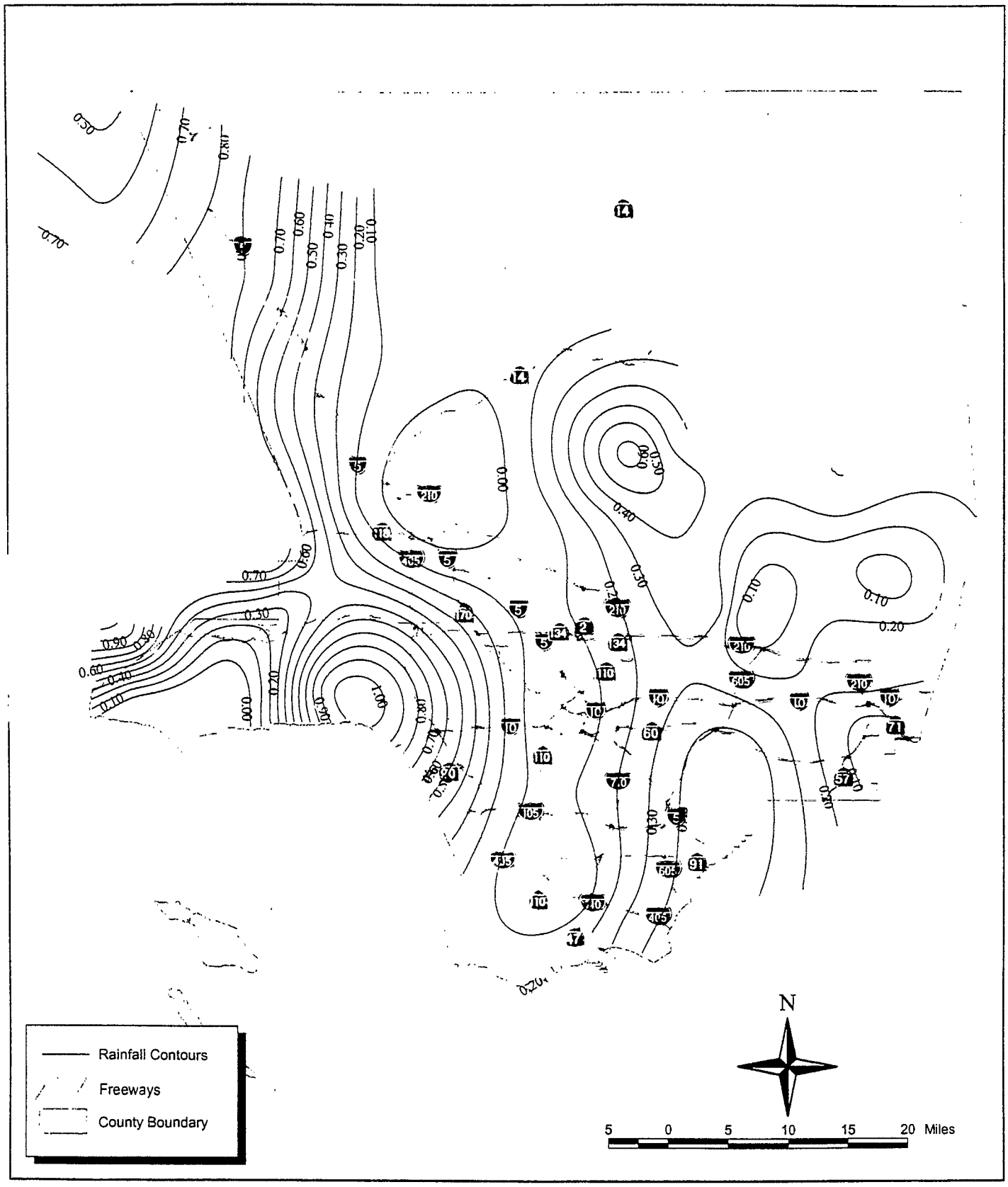
RAINFALL CONTOURS
STORM EVENT DATE: 01/24/2001



STORM EVENT DATE: 01/24/2001 RUN DATE: 06/11/2001

R0012659

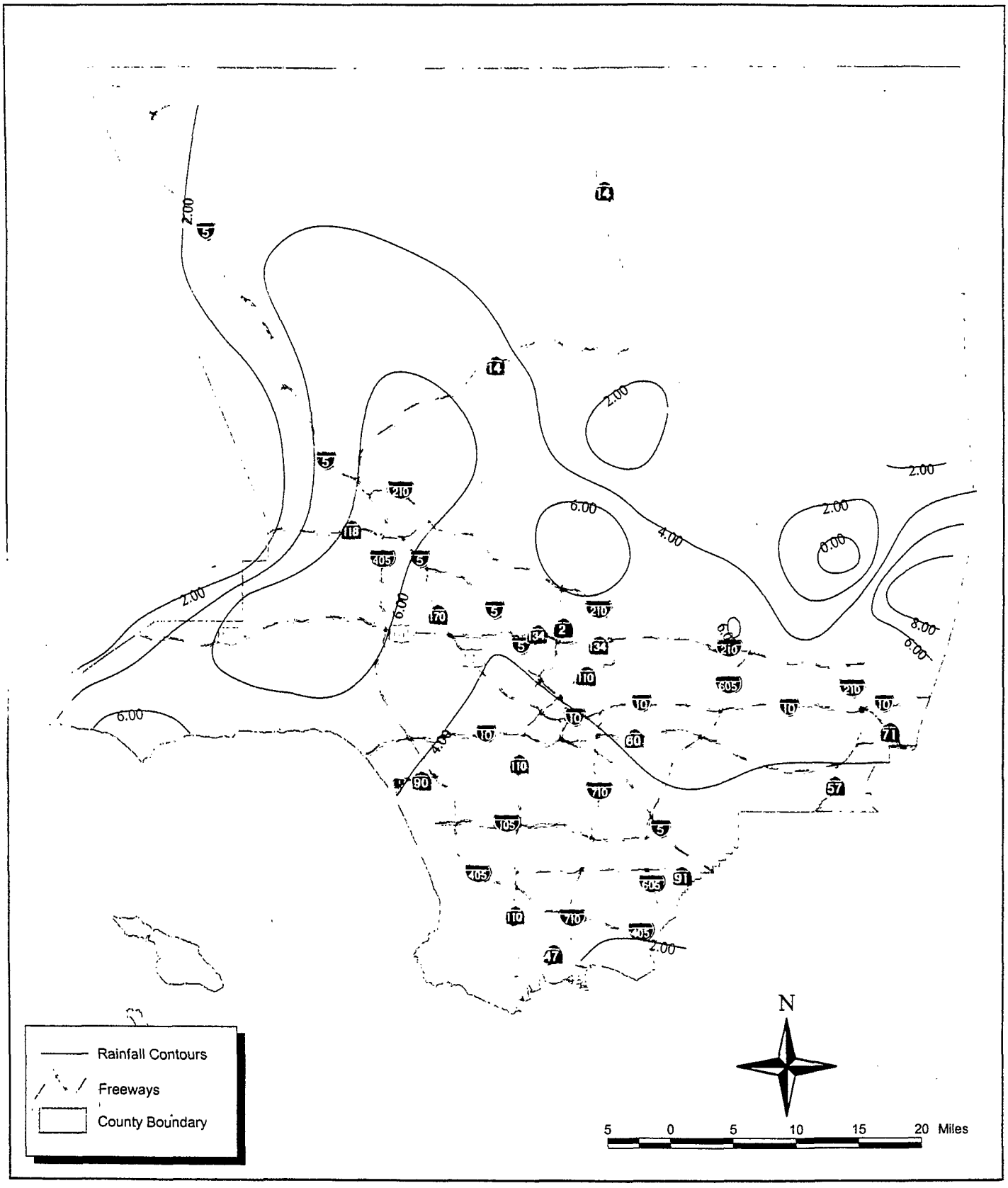
RAINFALL CONTOURS
STORM EVENT DATE: 01/26/2001



STORM EVENT DATE: 01/26/2001 RUN DATE: 06/11/2001

R0012660

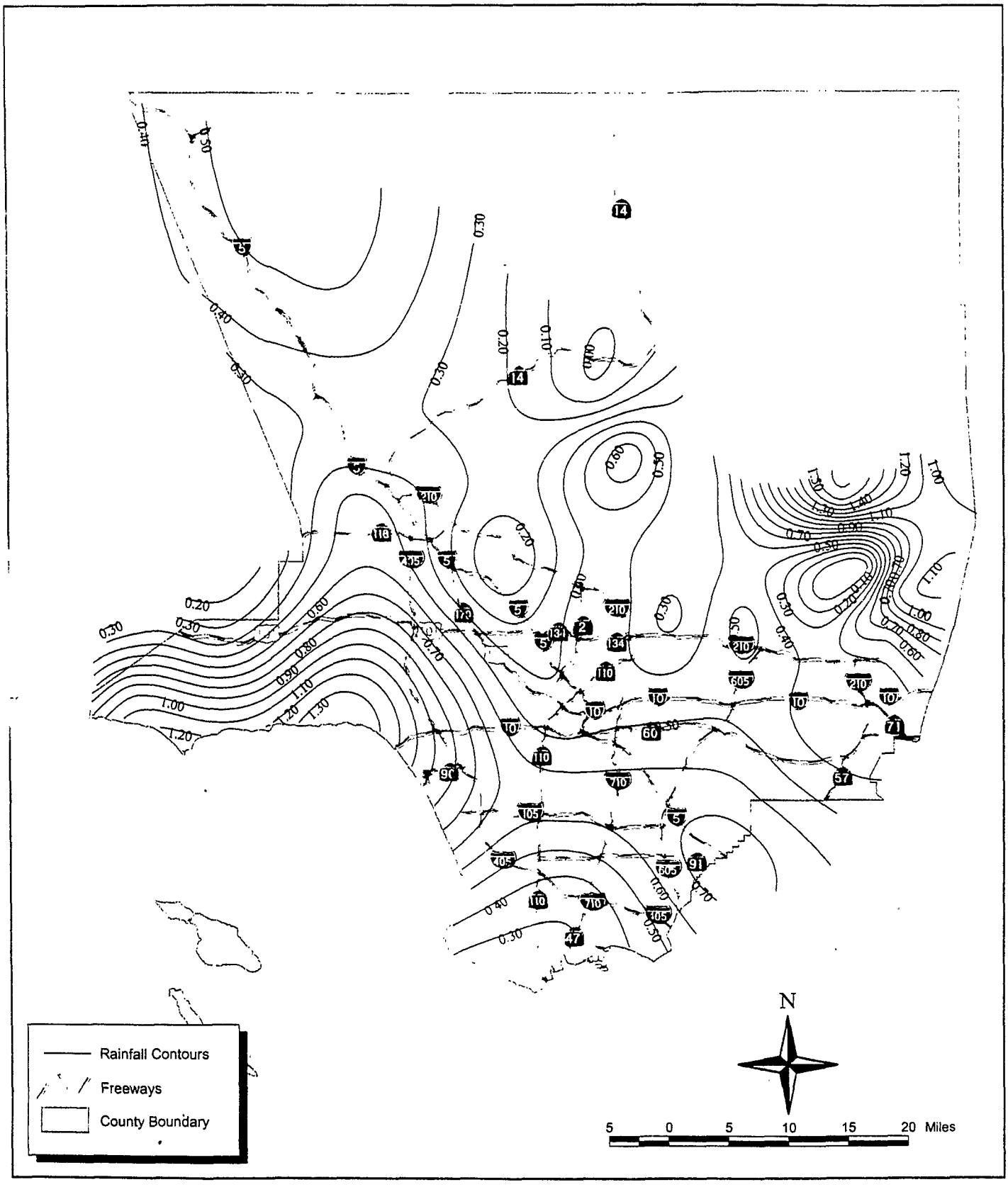
RAINFALL CONTOURS
STORM EVENT DATE: 02/10/2001



STORM EVENT DATE: 02/10/2001 RUN DATE: 06/11/2001

R0012661

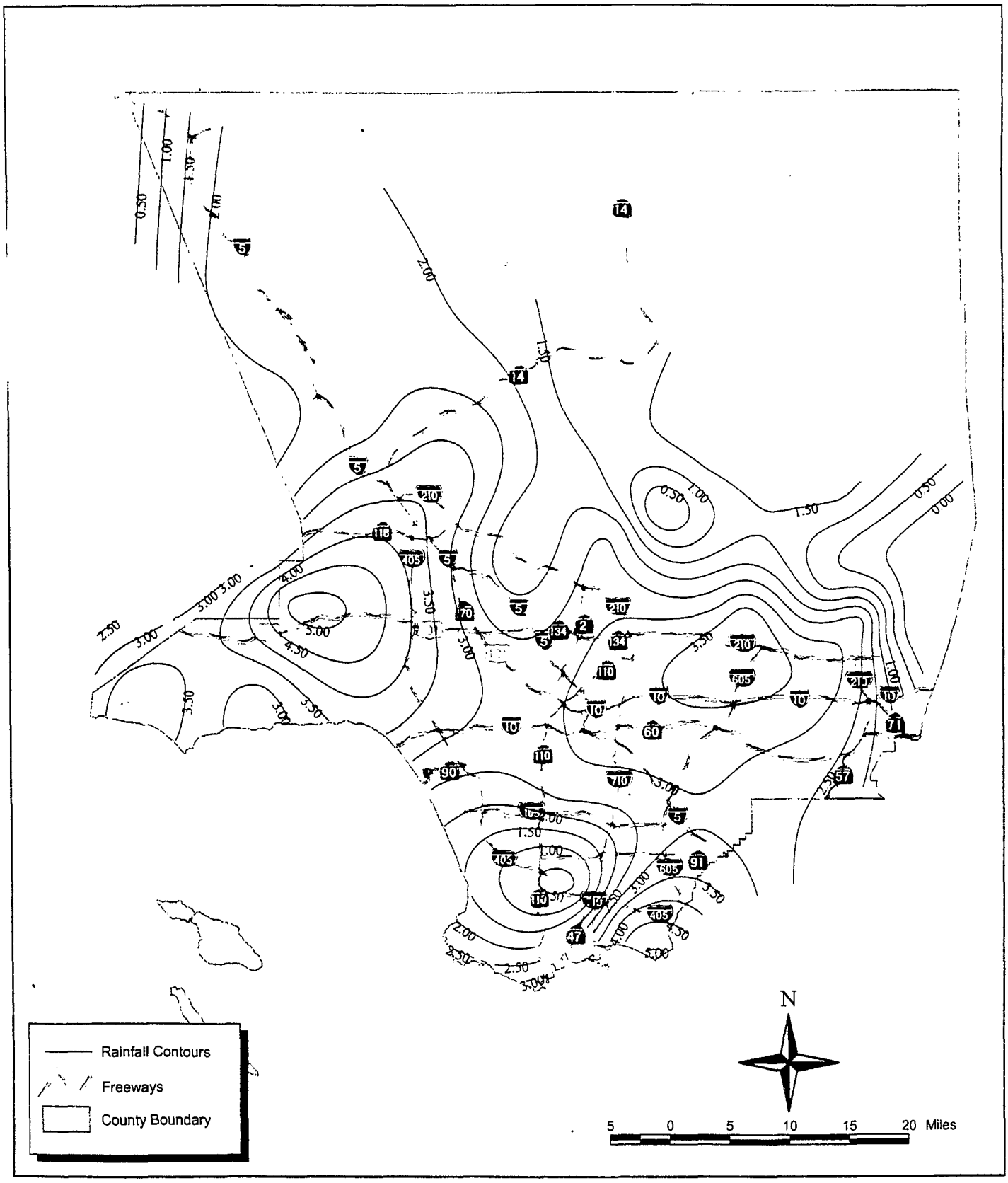
RAINFALL CONTOURS
STORM EVENT DATE: 02/19/2001



STORM EVENT DATE: 02/19/2001 RUN DATE: 06/11/2001

R0012662

RAINFALL CONTOURS
STORM EVENT DATE: 02/24/2001



STORM EVENT DATE: 02/24/2001 RUN DATE: 06/11/2001

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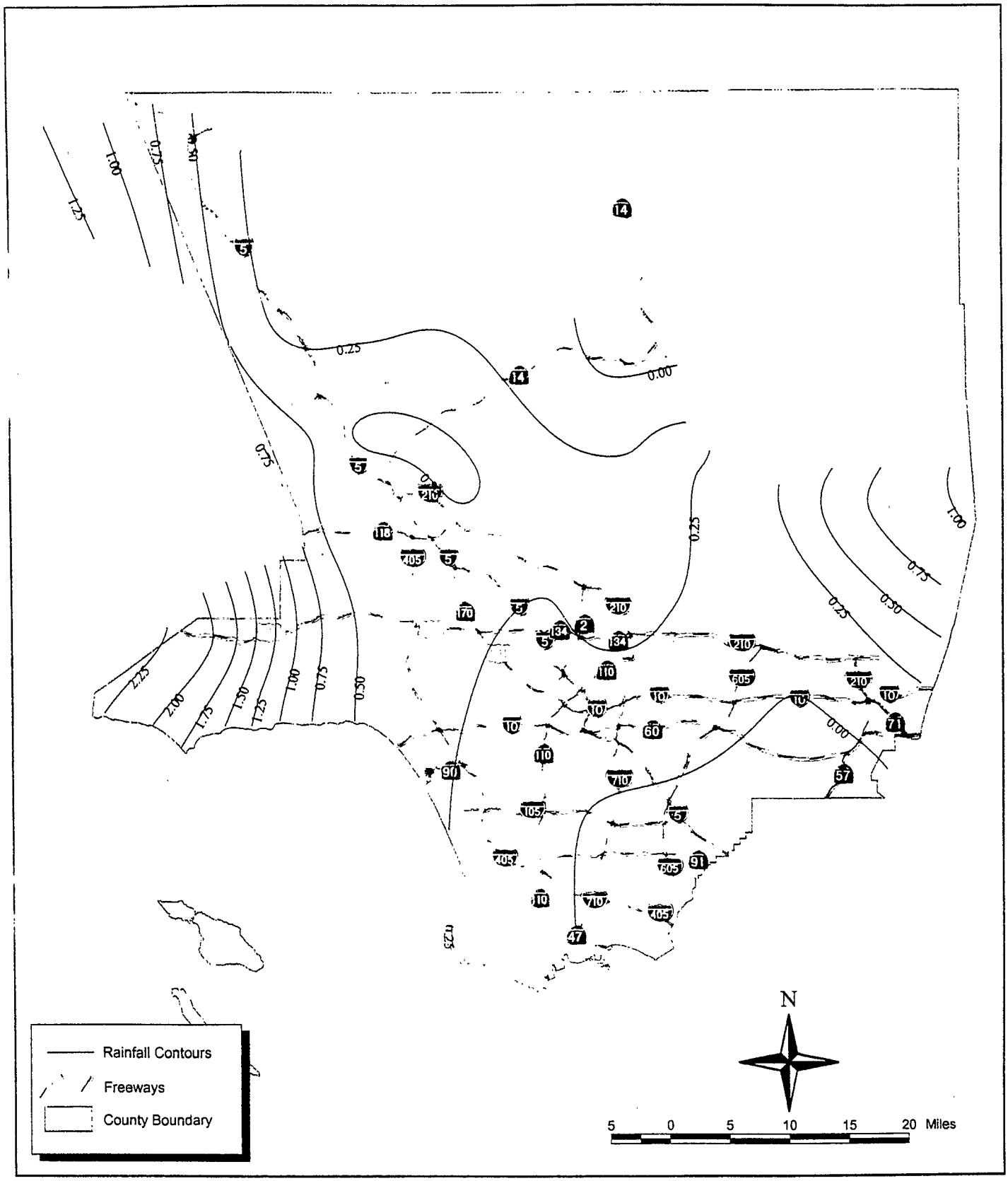

STORM EVENT DATE: 03/04/2001 RUN DATE: 06/12/2001

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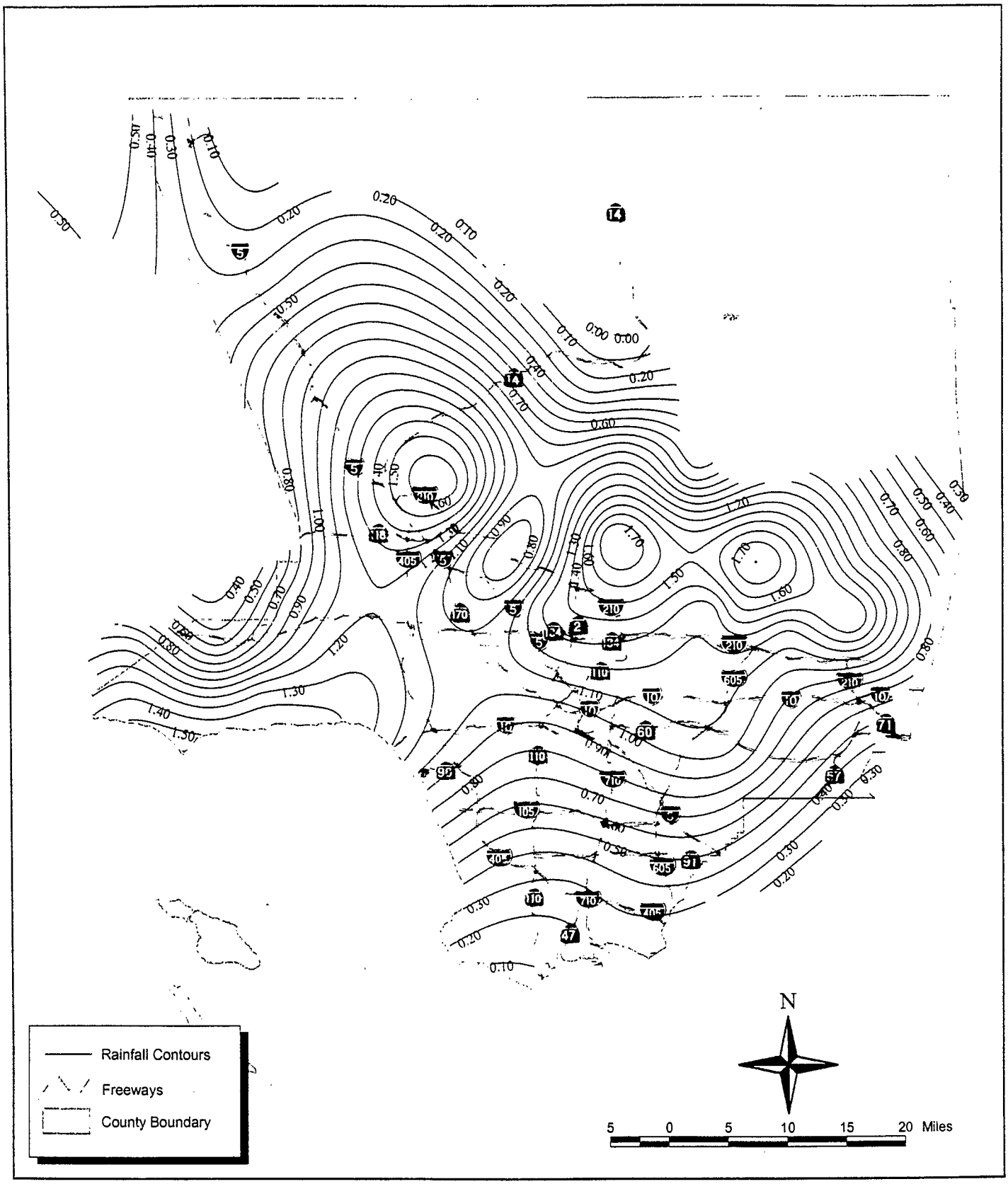
RAINFALL CONTOURS
STORM EVENT DATE: 04/07/2001



STORM EVENT DATE: 04/07/2001 RUN DATE: 06/12/2001

R0012665

Appendix B

Stormwater Quality Data For The 2000-2001 Storm Season

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Abbreviations

BMP	best management practices
CSO	combined sewer overflow
DOT	Department of Transportation
DPW	Department of Public Works
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
MCTT	Multi-Chambered Treatment Tank
MDE	Maryland Department of Environment
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
TEA-21	Transportation Equity Act for the 21st Century
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System

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GAO
Accountability • Integrity • Reliability

United States General Accounting Office
Washington, D.C. 20548

June 29, 2001

The Honorable Olympia Snowe
United States Senate

The Honorable Sherrod Brown
The Honorable Martin Meehan
The Honorable James Oberstar
The Honorable Jack Quinn
House of Representatives

Nonpoint source pollution—that is, pollution from contaminants picked up and carried into surface water by water running over land—is known to be one of the leading causes of water quality problems in the United States. Water that runs over developed areas, including paved surfaces such as roads and parking lots, before reaching a water body is known as urban runoff and is an increasingly important category of water pollution. As urban areas have expanded over the past several decades, the amount of urban runoff has also increased. Although the overall quality of the nation's waters has improved since the passage of the Clean Water Act in 1972, a significant number of water bodies still suffer from poor water quality. Because the act brought discharges from "point sources," such as industrial plants and municipal treatment plants, under control, the continuing pollution of these waters suggests that other sources, including urban runoff, are contributing to water quality problems. As a result, the Environmental Protection Agency (EPA) now classifies urban runoff as a significant cause of impairment to water quality. The Water Quality Act of 1987, which amended the Clean Water Act, required EPA, among other things, to regulate as a point source urban runoff that reaches municipal sewer systems. EPA's National Pollutant Discharge Elimination System Program for storm water requires that certain local governments take measures to control storm water runoff.

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Concerned about the degradation of water quality in urban areas, you asked us to report on (1) the amount of runoff from urban areas, particularly from roads, highways, and other impervious surfaces,[1] and its effects on water quality and (2) the programs that federal regulations require local governments to develop to address urban runoff, and the costs and effectiveness of those programs. To address these issues, we reviewed federal and other studies and interviewed experts on the relationship between the amount of paved and other impervious surfaces and the amount of runoff, and on the types of materials typically contained in urban runoff. We also reviewed studies and interviewed experts on the sources of these materials and any actual or potential effects on water quality from urban runoff. We visited five urban areas and organizations that are affiliated with their watersheds[2] to obtain site-specific information about urban runoff problems, programs these areas have implemented in response to federal requirements, and the costs and effectiveness of these programs. Finally, we reviewed studies and estimates of the costs and investment requirements associated with implementing storm water management programs. Because this report focuses on local governments' actions, we did not review the portions of the National Pollutant Discharge Elimination System Storm Water Program that address industrial facilities and construction sites.

We performed our review from August 2000 through May 2001 in accordance with generally accepted government auditing standards.

Results in Brief

The volume of urban storm water runoff increased throughout the United States in the last half of the 20th century because of the growth in impervious surfaces that resulted from the development of urban and suburban areas. According to the U.S. Department of Agriculture, between 1945 and 1997, land devoted to urban areas in the United States has increased by about 327 percent; according to EPA, paved road mileage has increased by 278 percent. Because paved surfaces are almost impervious, they allow little storm water to infiltrate the ground; therefore, the storm water runs off into creeks, rivers, and lakes. As storm water runs across these impervious surfaces and land, it picks up pollutants from these surfaces and carries them to receiving bodies of water—either directly or

[1]An impervious surface keeps water from soaking into soils.

[2]A watershed is an area of land in which all surface water drains to a common point.

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through conveyances such as gutters, storm sewers, and culverts. EPA's 1998 *National Water Quality Inventory Report to Congress* showed that certain rivers, streams, lakes, and estuaries are impaired in terms of their ability to support such uses as aquatic life, swimming, and fish consumption, and concluded that urban runoff was a major source of this impairment. Studies have shown that urban runoff and the pollutants it carries can cause increases in sedimentation, water temperature, and pathogen levels and decreases in dissolved oxygen levels in bodies of water. These changes can lead to the degradation of habitat in these water bodies and a decline in diversity of aquatic life and can endanger public health. For example, metals, a pollutant typically found in urban runoff, can be toxic to aquatic organisms. Pathogens, such as bacteria from animal waste, another pollutant commonly found in urban runoff, can pose public health problems when present in waters used for recreational purposes. The magnitude and nature of these effects vary by region, depending on the type and concentration of pollutants in storm water, rainfall characteristics, land use, and other factors.

Local governments are required to address urban runoff through EPA's National Pollutant Discharge Elimination System Storm Water Program. Under permits that EPA and states issue through this program, over 1,000 local governments must meet EPA's requirements to implement storm water management programs to reduce contaminants in storm water to the "maximum extent practicable." EPA recommends that these cities use "best management practices" to reduce contaminants in storm water runoff. The most typical practices included controlling runoff through a combination of structural means, such as detention ponds, and nonstructural means, such as increasing the frequency of street sweeping and educating the public about how to prevent pollutants from reaching storm sewers. Cities also used specialized practices to address specific local runoff problems. For example, Baltimore, Maryland, has focused on reducing the level of nutrients, such as fertilizers, in its runoff because of its proximity to the Chesapeake Bay, which suffers from high nutrient levels.

Neither the overall costs of implementing the storm water program nor the program's effectiveness has been determined. EPA estimated in a 1996 report to congress that the potential need for spending on storm water runoff and overflows of sewage resulting from runoff was over $50 billion over 20 years, but the agency also believes this estimate will increase when it issues its next report in 2002. EPA's regulations require that permitted cities annually report the costs of implementing their storm water

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programs, along with the results of their monitoring of storm water runoff and water quality. However, in part because EPA has not established guidelines for reporting costs, these data have not been calculated or reported consistently and, therefore, are not currently useful in characterizing the program's overall cost. EPA, state, and city officials generally believe that managing storm water runoff will reduce the volume of runoff and concentrations of pollutants in the runoff, as well as improve water quality, but no systematic effort to evaluate the program's results has been started. EPA and the states have generally been unsuccessful in developing measurable program goals and in demonstrating program effectiveness through the review of water quality data reported by local governments.

We believe it is time for EPA to begin evaluating this program, which is directed at one of the nation's most significant water quality problems. Therefore, this report includes a recommendation to EPA to work with states to develop program goals, establish standards for reporting on program costs and effectiveness, and review reported water quality data to determine whether the current storm water management programs are having the intended effect of improving the quality of the nation's waters and how much the programs cost. We provided a draft of this report to EPA and the Department of Transportation (DOT). EPA generally agreed with the report and plans to take action to implement several parts of the recommendation; the agency did not comment on the other parts of the recommendation. DOT generally agreed with the report. (See the Agency Comments and Our Evaluation section of this report.)

Background

Nonpoint source pollution can result when water, such as precipitation, runs over land surfaces and into bodies of water. Significant nonpoint sources of pollution can include paved urban areas, agricultural practices, forestry, and mining. However, in urban and suburban areas, this runoff generally enters a sewer system that can be regulated as a point source of water pollution. For example, precipitation from rain or snowmelt may run into a municipal separate storm sewer system (MS4 or storm sewer) that eventually discharges into a body of water. The precipitation may also run into a combined sewer system, which carries a combination of storm water runoff, industrial waste, and raw sewage in a single pipe to a sewage treatment facility for discharge after treatment. Lastly, the precipitation may run off of land or paved surfaces directly into nearby receiving waters.

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EPA's Office of Wastewater Management, which is within the Office of Water, implements the National Pollutant Discharge Elimination System (NPDES) Program. The program was created in 1972 with the passage of the Clean Water Act. Created to control water pollution from point sources—those sources, such as a factory or wastewater treatment plant, that contribute pollutants directly into a body of water from a pipe or other conveyance—the NPDES Program did not specifically address storm water discharges. In 1987, the Congress amended the Clean Water Act with the Water Quality Act, which directed EPA to also control storm water discharges that enter MS4s—essentially requiring EPA to treat such storm water as a point source.[3] MS4s are defined as those sewers that collect and convey storm water; are owned or operated by the federal, state, or local government; and are not part of a publicly owned treatment (sewage) facility.

To regulate urban storm water runoff, EPA published regulations in 1990 that established the NPDES Storm Water Program and described permit application requirements. According to EPA, the program's objective, in part, is to preserve, protect, and improve water quality by, among other things, controlling the volume of runoff from paved surfaces and by reducing the level of runoff pollutants to the maximum extent practicable using best management practices (BMP).[4] The 1987 act also authorized EPA to implement a program that provides federal funds and technical assistance to states to develop their own nonpoint source pollution management programs. States can use the federal funds they receive for nonpoint source programs to address nonpoint sources of pollution as well as urban runoff.

Currently, EPA manages NPDES Storm Water programs in six states (Alaska, Arizona, Idaho, Massachusetts, New Hampshire, and New Mexico) and has delegated authority to the remaining 44 states to manage these programs. The storm water program is being implemented in two phases. Local governments meeting the following criteria must comply with EPA's storm water program regulations. First, Phase I of the program requires that municipalities with a population of 100,000 or more obtain a permit for their MS4 system; second, the program requires that entities obtain a

[3]Section 402(p) of the Clean Water Act.

[4]According to EPA, a best management practice is a device, practice, or method for removing, reducing, retarding, or preventing targeted storm water runoff constituents, pollutants, and contaminants from reaching receiving waters.

R0012673

permit if they discharge storm water from sites with industrial activities, including construction activities that disturb 5 acres or more of land. In addition, NPDES permitting authorities may also bring other municipalities and industrial entities into the program if they deem it necessary. Municipalities that meet these conditions must submit a permit application to EPA or the governing regulatory state agency. In 1990, the regulations specifically identified 220 municipalities throughout the United States that were required to apply for a Phase I permit. According to EPA, as of April 2001, about 256 Phase 1 MS4 permits had been issued and about 17 more still needed to be issued. Because some permits cover more than one municipality, these permits cover about 1,000 medium and large municipalities nationwide.

The final rule for Phase II of the program was issued in December 1999. Phase II extends Phase I efforts by requiring that a storm water discharge permit be obtained by (1) operators of all MS4s not already covered by Phase I of the program in urbanized areas[5] and (2) construction sites that disturb areas equal to or greater than 1 acre and less than 5 acres of land. As with Phase I of the program, permitting authorities may require additional small MS4s and construction sites to obtain a permit if they are a significant contributor of pollutants. Currently, EPA anticipates that about 5,000 municipalities may be subject to permitting requirements under Phase II of the storm water program. These municipalities are required to obtain permits no later than March 10, 2003.

[5]The Bureau of the Census generally defines an urbanized area as a land area comprising one or more places—central place(s)—and the adjacent densely settled surrounding area—urban fringe—that together have a residential population of at least 50,000 and an overall population density of at least 1,000 per square mile.

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EPA also regulates combined sewer overflows (CSO) that can be caused by urban storm water runoff. Combined sewer systems, in which storm water enters pipes already carrying sewage, may overflow when rain or snowmelt entering the system exceeds the system's flow capacity. In the CSO that results, the mixture of untreated sewage and runoff bypasses the water treatment facility and is diverted directly into receiving waters. (See fig. 1 for an illustration of combined and separate sewer systems.) These combined systems generally serve the older parts of approximately 900 cities in the United States. Pipes carrying sewage and storm water separately generally serve newer parts of cities. EPA's 1994 CSO policy requires communities with combined sewer systems to take immediate and long-term actions to address CSO problems. The policy contains provisions for developing appropriate, site-specific NPDES permit requirements for all combined sewer systems that overflow because of wet-weather events. The Wet Weather Water Quality Act of 2000 requires that any permit, order, or decree issued for a CSO conform to the 1994 policy. Under this act, EPA is also required to submit a report to the Congress by September 2001 on the status of the program.[6]

[6]Sanitary sewer overflows, which are illegal under the Clean Water Act, can also result from rainfall. A sanitary sewer overflow may occur when rainwater or snowmelt leaks into sanitary sewage pipes, thereby exceeding the pipes' capacity and causing them to overflow. This discharge of raw sewage from municipal sanitary sewer systems can release untreated sewage into places such as streams, basements, and streets. EPA proposed regulations to require municipalities to reduce the number of overflows. However, these regulations have been withdrawn for further review.

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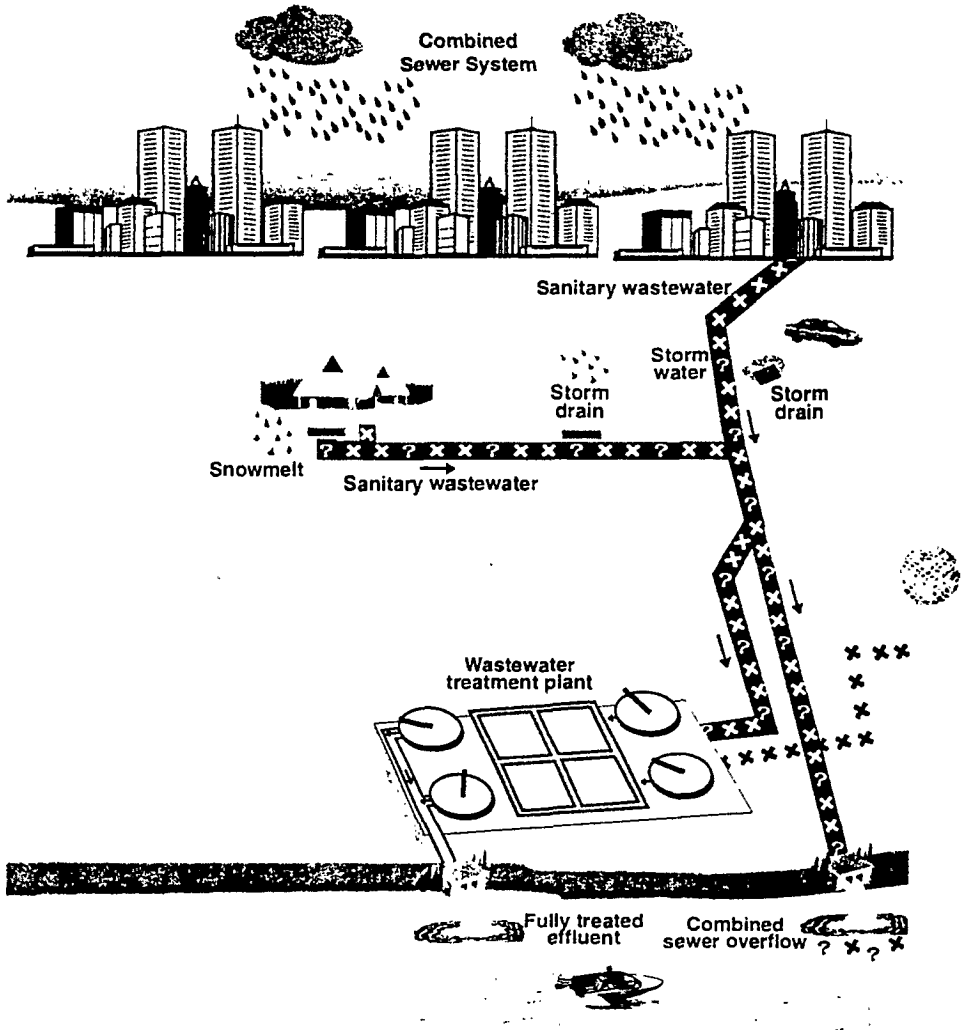
Figure 1: Urban Runoff Flows in Different Types of Sewer Systems



✖ Sanitary sewage/wastewater
? Storm water runoff with potential contaminants

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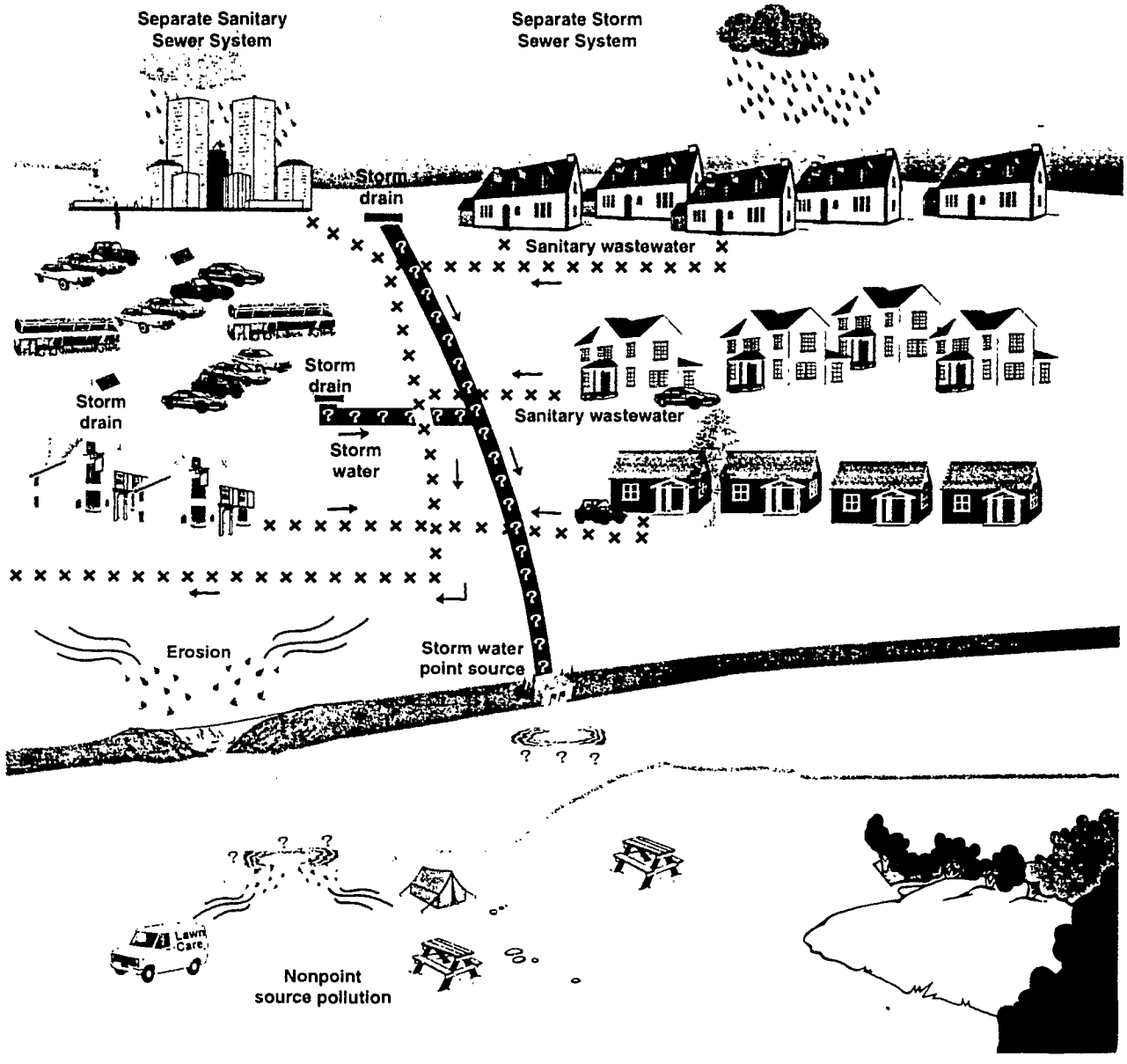

Source: GAO illustration based on EPA data.

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The Total Maximum Daily Load (TMDL) Program, established under the Clean Water Act, is intended to address water bodies that do not meet water quality standards because of pollutant loadings from point and nonpoint sources. Currently, it is unclear how and when this program will affect EPA's and states' issuance of storm water permits. A TMDL is a calculation of the maximum amount of a pollutant that a body of water can receive and still meet the water quality standard set by the state. Under EPA's regulations, the state is to allocate this "pollutant load" among the point and nonpoint pollutant sources that flow into the water body and then take steps to ensure that no source exceeds its assigned load. In 1996, EPA issued a policy that outlined an interim approach to including water quality standards in storm water permits. The policy promoted the use of BMPs in the first 5-year term permits, followed by a tailoring of BMPs in the second round of permits as necessary to comply with water quality standards. Until recently, few TMDLs had been established, and citizen organizations sued EPA for its lack of action. EPA issued a new set of regulations for the TMDL Program in 2000, but the Congress prevented EPA from spending money to implement the rule in 2000 and 2001. It is possible that establishing a TMDL for a body of water could result in the application of a numeric effluent limit to outfalls[7] that release storm water into that body of water. Some city officials we spoke with generally felt that numeric effluent limits would significantly increase the cost of managing storm water.

Volume of Urban Runoff Increases With the Expansion of Urban Development and Can Affect Water Quality

Since World War II, urban runoff has increased throughout the United States. This increase is directly related to growth in the amount of impervious surfaces due to urban and suburban development and the construction of roads, highways, and other impervious surfaces. Coinciding with this growth in impervious surfaces has been a reduction in wetlands and in the amount of storm water that infiltrates the ground to recharge aquifers. Moreover, the loss of vegetation due to development and related runoff can cause major erosion. Ultimately, much of this runoff is channeled into gutters, storm drains, and paved channels, and vegetation and sediment removed with the runoff may end up in receiving waters. EPA has identified urban storm water runoff as one of the leading sources of pollution to the nation's rivers, streams, lakes, and estuaries. Runoff from impervious surfaces picks up potentially harmful pollutants and

[7]An outfall is an outlet, such as a pipe, that allows storm water to flow into a river, lake, or other body of water.

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carries them into receiving waters. Studies have shown that urban runoff and the pollutants it carries can negatively affect water quality, aquatic life, and public health.

Paved Surfaces Have Increased With Urban and Suburban Expansion and Growth in Automobile Use

According to the U.S. Department of Agriculture, between 1945 and 1997, urban land area increased by almost 327 percent, from 15 million acres to about 64 million acres in the contiguous 48 states. From 1992 through 1997, the annual rate of development averaged about 1 million acres per year. The land developed between 1945 and 1997 came primarily from forestland and pasture and range.[8] For example, according to the Bureau of the Census, between 1960 and 1990, the amount of land used for urban purposes in Baltimore, Maryland, and Washington, D.C., grew by about 170 percent and 177 percent, respectively. As a result, urbanization, with its accompanying expansion of impervious surfaces like sidewalks, roofs, parking lots, and roads, has significantly increased the nation's total developed land and paved surface area.[9] Figure 2 demonstrates the growth in the urbanized areas of Baltimore and Washington, D.C., over the last half of the 20th century.

[8] *Agricultural Resources and Environmental Indicators, 2000,* U.S. Department of Agriculture, Economic Research Service, Resource Economics Division.

[9] *Our Built and Natural Environments, A Technical Review of the Interaction Between Land Use, Transportation and Environmental Quality,* U.S. Environmental Protection Agency (EPA 231-R-00-005, Nov. 2000).

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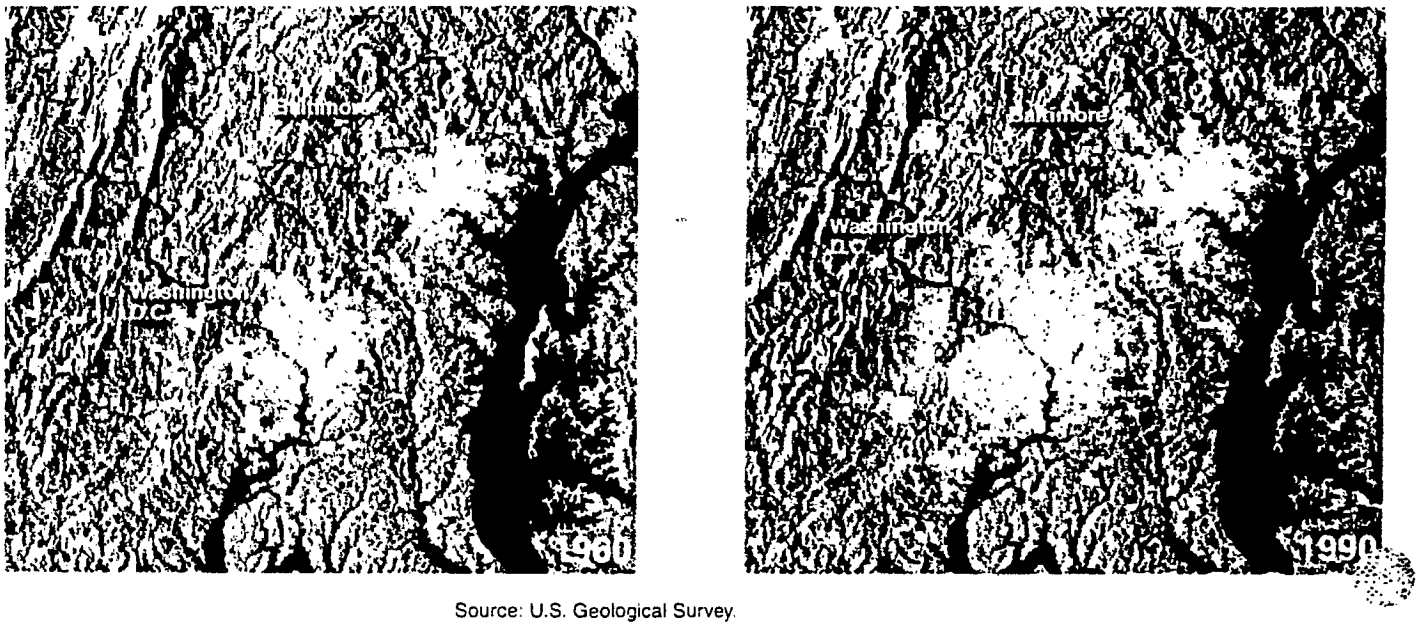
Figure 2: Increase in Urbanized Land in Selected Cities, 1960-90



Source: U.S. Geological Survey.

The increase in paved surfaces has been spurred not only by urban and suburban development, but also by a steady increase in the use of automobiles, the primary mode of daily transportation for most Americans. Roads also play an important role in the economy of the United States, since trucks carry about 75 percent of the value of all goods shipped. According to EPA, paved road mileage in the United States increased by 278 percent from 1945 to 1997. In 1945, 19 percent of the public roads in the country were paved; by 1997, that percentage had increased to 61. (See fig. 3.) According to a 1999 study, motor-vehicle infrastructure, such as roads and parking lots, accounts for close to half of the land area in U.S. urban cities.[10]

[10] *Stormwater Strategies, Community Responses to Runoff Pollution,* Natural Resources Defense Council (May 1999).

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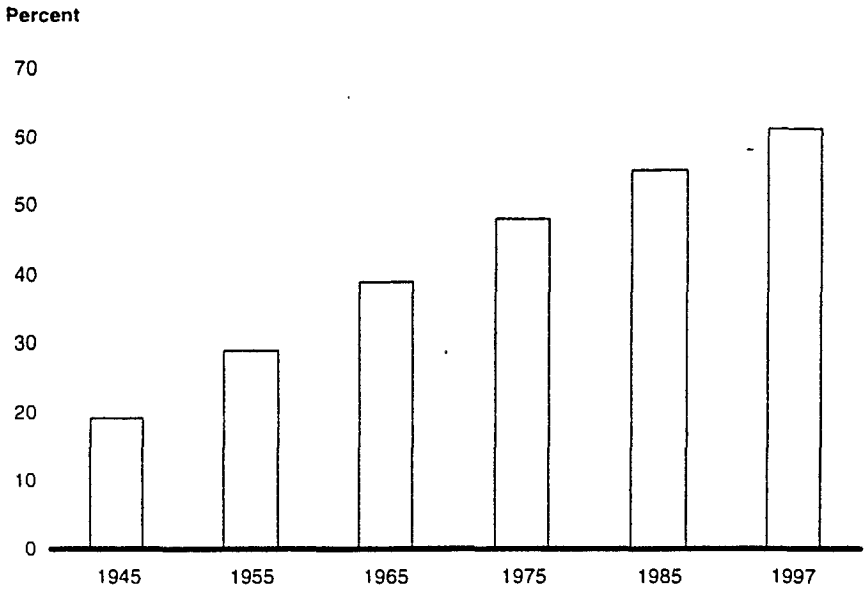
Figure 3: Percentage of Paved Public Road Miles, 1945-97



Source: EPA.

Increase in Impervious Surfaces Leads to Increased Runoff

The increase in impervious surfaces over the past several decades has led to an increase in storm water runoff. In part, this has occurred because highways and other developments have reduced the amount of wetlands and other undeveloped land. Wetlands mitigate the effects of storm water runoff by acting as a natural form of flood control, facilitating sediment replenishment, and improving water quality by removing excess nutrients and other chemical contaminants before the contaminants can affect receiving waters. According to a 2000 EPA report,[11] of the 12 states that listed wetland losses, six reported that they had significant losses due to highway construction, and 10 reported that they had significant losses due to residential growth and development. However, the effect of road building on wetland loss has been reduced in recent years. According to a Federal Highway Administration (FHWA) official, since 1996, wetlands have been replaced and restored under the Federal-Aid Highway Program

[11]See footnote 9.

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at an average rate of 2.7 acres for every acre lost to highway building. Other undeveloped land with vegetation also performs some of the roles that wetlands play in managing runoff, although to a lesser extent.

Furthermore, as impervious surfaces increase, less storm water is able to infiltrate through the soil to groundwater. Impervious areas allow only a very small amount of initial infiltration compared with unpaved areas whose infiltration capacity varies, depending on the soil type. Figure 4 demonstrates EPA's estimates of the impact of impervious surfaces on the percentages of storm water that runs off, infiltrates the ground, and is lost through evapotranspiration.[12] When natural ground cover is present over an entire site, normally 10 percent of precipitation runs off the land into nearby creeks, rivers, and lakes. In contrast, when a site is 75- to 100-percent impervious, 55 percent of the precipitation runs off into these receiving waters. However, according to an FHWA official, the runoff rates can be reduced if developers take mitigating actions to develop and implement BMPs to control flooding or runoff.

[12]Evapotranspiration represents water loss from evaporation and the absorption and eventual release into the atmosphere of water that plants and trees have collected. The extent to which evapotranspiration occurs is dependent primarily on the solar energy available to vaporize the water. As a result, the effect of evapotranspiration varies greatly across the country.

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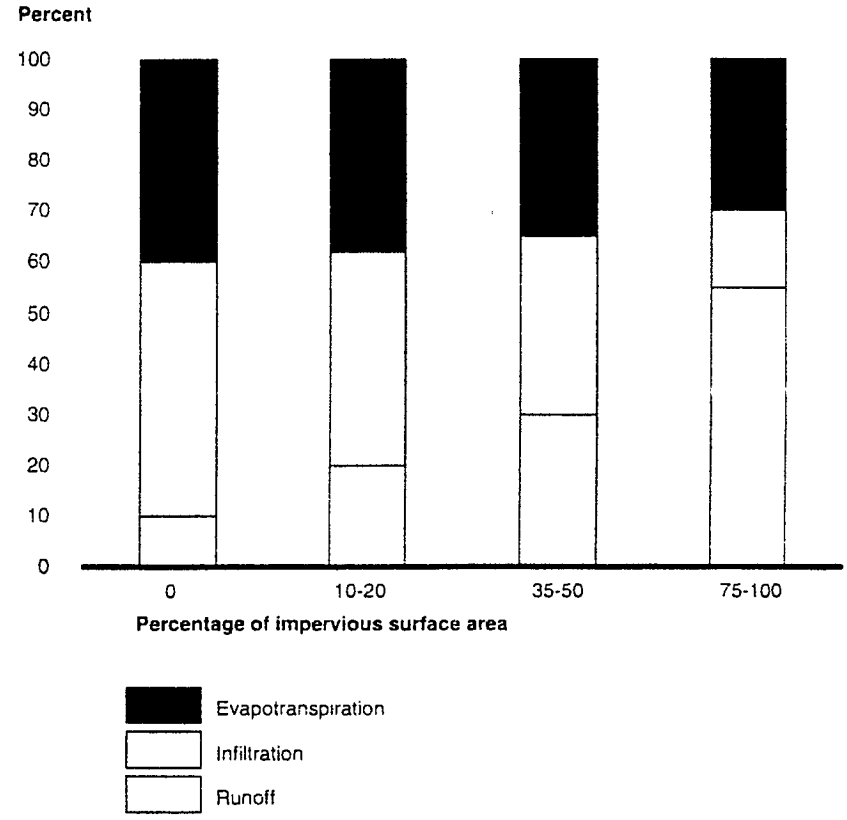
Figure 4: Impact of Impervious Surfaces on the Amount of Storm Water That Runs Off, Infiltrates, and Evapotranspires



Source: EPA.

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The decrease in storm water infiltration that accompanies urbanization also reduces the amount of water that is available to recharge groundwater supplies. For this reason, reduced infiltration may lead to problems with the water table in certain urban areas. For example, a Massachusetts Department of Environmental Protection official noted that a low recharge rate affects water quality because it can result in a loss of wetlands and adversely affect aquatic habitat as water-table levels fall during dry weather.[13] In addition, officials from the Charles River Watershed Association in Massachusetts are concerned that the lack of infiltration might cause some communities to run short of drinking water in the next 20 years.

Urban Runoff Has the Potential to Impair Water Quality and Disrupt Biological Integrity

Urban runoff can adversely affect the quality of the nation's waters, and urban storm water runoff has been identified as one of the leading sources of pollution to rivers, streams, lakes, and estuaries.[14] Section 305(b) of the Clean Water Act requires states and other jurisdictions to report on the quality of their waters to EPA every 2 years. The 1998 *National Water Quality Inventory Report to Congress* showed that 35 percent of assessed river and stream miles, 45 percent of assessed lake acres, and 44 percent of assessed estuarine square miles were impaired in terms of their ability to support uses such as aquatic life, swimming, and fish consumption.[15] The report identified urban storm water runoff as one of the leading sources of impairment to the assessed waters.

[13]Dry weather is defined as a period when rainfall measuring at least 0.10 of an inch has not occurred for 72 hours.

[14]Other leading sources of pollution include agricultural runoff, municipal point sources, hydrologic modifications, and atmospheric deposition.

[15]Information contained in the 1998 report reflects only those waters assessed by states and other jurisdictions and cannot be used to characterize nationwide water quality. Furthermore, water quality standards among states are not identical, and the monitoring design used to collect data differed among states.

R0012684

Studies have shown that as the percentage of impervious cover increases within a watershed, biodiversity also declines. Research conducted by the Center for Watershed Protection found that, generally speaking, when a watershed has 10 percent or less impervious cover, the associated stream can be categorized as sensitive.[16] Sensitive streams are characterized as having high fish diversity and good water quality. Once the percentage of impervious cover exceeds 25 to 30 percent of the watershed, however, streams tend to become nonsupporting. Nonsupporting streams are highly unstable, have poor diversity of fish and aquatic life, and have poor water quality. For example, one study evaluated the relationship between the extent of impervious cover in watersheds to the number and diversity of fish populations in 47 small streams in southeastern Wisconsin between the 1970s and 1990s.[17] The results revealed that the number of fish species per site was highly variable for drainage areas that had less than 10-percent imperviousness. In contrast, sites that had greater than 10-percent imperviousness had consistently low numbers of fish species.

Other studies have associated urban runoff with basic changes in the receiving body of water. Runoff can carry sediment into surface water, and this sediment can carry contaminants, harm aquatic plants, and smother organisms. Runoff can also be warmed by the impervious surfaces it flows across. When sufficient amounts of warmed runoff enter a water body, the water temperature can rise. Less oxygen is then available for aquatic organisms because water holds less oxygen as it becomes warmer. These combined factors lead to the degradation of aquatic habitat. According to EPA, the common effects of these types of pollution on aquatic life include a decline in biodiversity and an increase in invasive species.

An increase in the volume of storm water runoff also increases the likelihood of erosion, which allows for transport of eroded sediment downstream into receiving waters. For example, during a site visit, we observed extensive erosion along the Gingerville Creek Subbasin in Anne Arundel County, Maryland, that was caused by urban runoff channeled into the creek. Figure 5 depicts the eroded banks and channel of this creek.

[16]"The Importance of Imperviousness," *Watershed Protection Techniques*, v.1:3, Fall, 1994. The article reviews 18 studies on the relationship between urbanization and stream quality.

[17]L. Wang and others, "Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams," *Journal of the American Water Resources Association*, Oct. 2000, Vol. 36, No. 5.

R0012685

Figure 5: Damage Caused by Storm Water Runoff From Urbanized Areas in the Gingerville Creek Subbasin



Source: Anne Arundel County, Maryland, Department of Public Works.

Contaminants in Urban Runoff Can Affect Aquatic Life and Human Health

There have been several efforts to characterize the chemicals and other constituents in urban runoff. The Nationwide Urban Runoff Program, conducted by EPA between 1978 and 1983, examined the characteristics of urban runoff. Another federal effort to characterize urban runoff is an ongoing joint project of the U.S. Geological Survey (USGS) and the FHWA to evaluate guidelines for highway runoff. As table 1 indicates, these studies and others have shown that the principal contaminants found in

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urban runoff include nutrients, solids, pathogens, metals, hydrocarbons, organics, salt, and trash. Water flowing over various surfaces, such as streets, parking lots, construction sites, industrial facilities, rooftops, and lawns, carries these pollutants to receiving waters. The contaminants have the potential to impair water quality, degrade aquatic ecosystems, and pose health risks to swimmers.

Table 1: Storm Water Pollutants in Urban Runoff, Including Sources and Potential Impacts

Contaminant	Source	Potential impact
Nutrients		
Nitrogen, phosphorous	Animal waste, fertilizers, failing septic systems, atmospheric deposition,[a] CSOs	Nutrient enrichment can cause an excessive growth of algae. Nuisance levels of algae are associated with dissolved oxygen deficiencies leading to fish kills, loss of submerged aquatic vegetation that serves as a habitat for aquatic organisms, and loss of natural biodiversity.
Solids		
Sediment	Construction sites, other disturbed and/or nonvegetated lands, eroding banks, road sanding	Sediment can cause infection and disease among fish, scour submerged aquatic vegetation, prevent sunlight from reaching aquatic plants, and bury bottom-dwelling aquatic organisms.
Pathogens		
Bacteria, viruses	Animal waste, failing septic systems, illicit connections and discharges to storm sewer system, CSOs	Pathogens entering waters used for recreational purposes can pose human health risks.
Metals		
Lead, cadmium, copper, zinc, mercury, chromium, aluminum, and others	Industrial processes, normal wear of automobile brake linings and tires, automobile emissions, automobile fluid leaks, metal roofs	Metals can cause acute or chronic toxicity for aquatic organisms.
Hydrocarbons		
Oil and grease, polycyclic aromatic hydrocarbons	Industrial processes, automobile wear, automobile emissions, automobile fluid leaks, waste oil	Hydrocarbons have the potential to be acutely toxic for aquatic organisms and several are suspected carcinogens.
Organics		
Pesticides, polychlorinated biphenyls (PCB), synthetic chemicals	Pesticides (herbicides, insecticides, fungicides, rodenticides, etc.), industrial processes	Low concentrations of some organics have the potential to bioaccumulate in the food chain.

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Contaminant	Source	Potential impact
Salt		
Sodium Chlorides	Road salting and uncovered salt storage	Salt can damage roadside vegetation, transport high levels of chlorides to receiving waters, and degrade aquatic ecosystems. Chloride can be harmful to some species of fish.
Trash		
	Street refuse and improperly discarded waste material	Trash impairs water quality by inhibiting the growth of aquatic vegetation and conveys nutrients, toxic substances, and other pollutants to aquatic ecosystems.

[a]Atmospheric deposition occurs when pollutants in the air fall on land or water.

Sources: Massachusetts Department of Environmental Protection Stormwater Policy; EPA reports and guidance, including *Preliminary Data Summary of Urban Storm Water Best Management Practices, Combined Sewer Overflow Control Policy, Innovative Urban Wet-Weather Flow Management Systems*, and the 1998 *National Water Quality Inventory Report to Congress*; the California Regional Water Quality Control Board; the Natural Resources Defense Council's *Stormwater Strategies: Community Responses to Runoff Pollution*; "Accretion of Pollutants in Roadway Snow Exposed to Urban Traffic and Winter Storm Maintenance Activities - Part I," Draft,[18] and USGS' National Water Quality Assessment Program.

[18]J.J. Sansalone and D.W. Glenn, "Accretion of Pollutants in Roadway Snow Exposed to Urban Traffic and Winter Storm Maintenance Activities –Part I," DRAFT.

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In our visits to cities with Phase I permits and their watersheds, we identified specific instances in which these contaminants had affected water quality. The Chesapeake Bay, for example, has been polluted with the nutrients nitrogen and phosphorus and with excess sediment caused, in part, by urban runoff. The excess nutrients cause algae blooms that block sunlight from reaching bay grasses—which are a source of food, shelter, and nursery grounds for many aquatic species. In an effort to control nutrient pollution in the Chesapeake Bay, the Executive Council of the Chesapeake Bay Program[19] established a goal to reduce the nitrogen and phosphorus entering the Chesapeake Bay by 40 percent, including through control of runoff from urban areas. In addition, an assessment of the status of chemical contaminant effects on living resources in the bay's tidal rivers found "hot spots" of contaminated sediment. As a result, the Baltimore Harbor and the Patapsco River in Maryland; the Anacostia River in Washington, D.C.; and the Elizabeth River in Virginia were designated as "regions of concern." Urban storm water runoff is a significant source of contaminants in the three regions. The Chesapeake Executive Council has committed to reduce by 30 percent the chemicals of concern in the regions of concern by 2010 through pollution prevention measures and other voluntary means.[20]

Pathogens such as bacteria and viruses, which are often present in urban runoff, can pose public health problems. For example, the Santa Monica Bay Restoration Project conducted a study to identify adverse health effects of untreated urban runoff by surveying over 13,000 swimmers at three bay beaches.[21] The study established a positive association between an increased risk of illness and swimming near flowing storm-drain outlets. Table 2 explains health outcome measures at various distances from storm drains. For example, the study found a 1-in-14 chance of fever for swimmers in front of the drain versus a 1-in-22 chance at 400 or more yards away.

[19]The Chesapeake Executive Council includes the governors of Maryland, Pennsylvania, and Virginia; the Administrator of the U.S. Environmental Protection Agency; the mayor of the District of Columbia, and the chair of the Chesapeake Bay Commission.

[20]Chesapeake Bay Program Office, *Toxics 2000 Strategy: A Chesapeake Bay Watershed Strategy for Chemical Contaminant Reduction, Prevention, and Assessment,* Dec. 2000.

[21]R.W. Haile and others, "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology,* July 1999, Vol. 10, No. 4.

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Table 2: Comparative Health Outcomes for Swimming in Front of Drains Versus 400 or More Yards Away

Health outcomes	0 yards	400 or more yards
Fever	1:14	1:22
Chills	1:26	1:42
Ear discharge	1:68	1:143
Coughing with phlegm	1:20	1:33
Significant respiratory disease (fever and nasal congestion, fever and sore throat, and cough with phlegm)	1:12	1:22

Note: This table includes the statistically significant health outcomes.

Source: GAO analysis of data from "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology*, July 1999, Vol. 10, No. 4.

Metals and polycyclic aromatic hydrocarbons (PAH) in urban runoff can present a threat to aquatic life. Studies have found the following:

- Storm water runoff from an urban area proved to be toxic to sea urchin fertilization in the Santa Monica Bay, and dissolved zinc and copper were determined to be contributors to this toxicity. [22]
- Brown bullheads (a bottom-dwelling catfish) in the Anacostia River developed tumors that were believed to be caused by PAHs associated in part with urban runoff.[23]
- High PAH and heavy metal concentrations were found in crayfish tissue samples from several urban streams in Milwaukee. The study associated these contaminants with storm water runoff.[24]

[22]Southern California Coastal Water Research Project, *Study of the Impact of Stormwater Discharge on Santa Monica Bay-Executive Summary*, Nov. 1, 1999.

[23]Chesapeake Bay Program Office.

[24]J.P. Masterson and R.T. Bannerman, "Impacts of Stormwater Runoff on Urban Streams in Milwaukee County, Wisconsin," *National Symposium on Water Quality, American Water Resources Association*, Nov. 1994.

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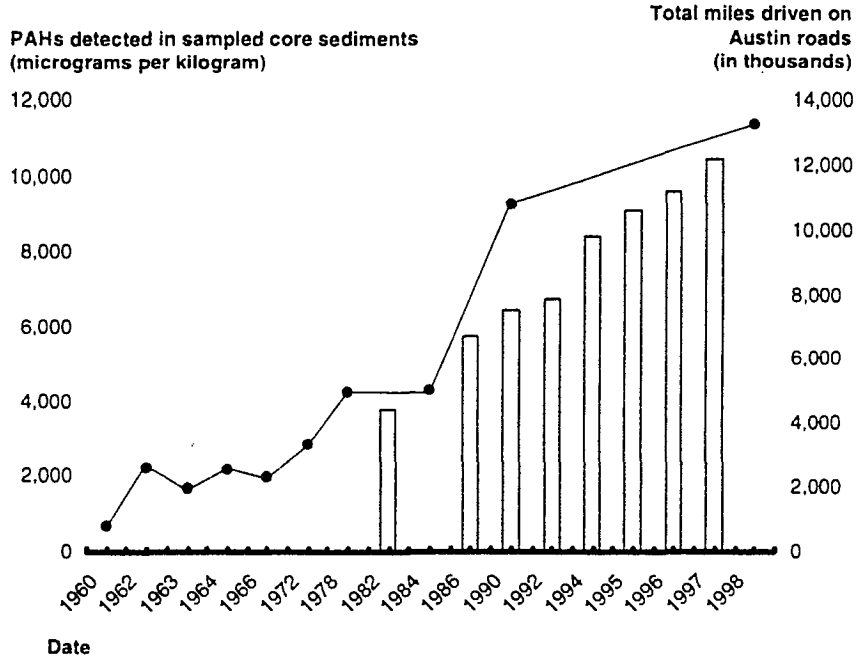
In addition, USGS tracked trends in the concentrations of PAHs found in sediment in 10 lakes and reservoirs in six metropolitan areas over the last several decades. This study found that PAH concentrations in developed watersheds are increasing and that these increases may be linked to the amount of urban development and vehicle traffic in urban and suburban areas.[25] For example, from 1982 to 1996, PAH concentrations in the sediment core in Town Lake (Austin, Texas) and total miles driven in greater Austin both increased by about 2.5 times. Figure 6 illustrates this correlation.

Figure 6: Comparison of Town Lake PAHs and Traffic Trends



Note: According to USGS, irregularities in the date pattern are due to intervals at which sediment samples were collected.

Source: USGS National Water Quality Assessment Reconstructed Trends Program

[25]P. Van Metre, B. Mahler, and E. Furlong, "Urban Sprawl Leaves Its PAH Signature," *Environmental Science and Technology*, Vol. 34, No. 19, 2000.

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Although the studies we reviewed show that certain contaminants are likely to be present in urban runoff, factors such as land development practices, climate conditions, atmospheric deposition, and traffic characteristics all can affect the characteristics of runoff from a particular area. Therefore, given the diffuse nature of many storm water discharges and the variability of other contributing factors, characterizing the concentrations of pollutants contained in storm water runoff has been challenging. Recent USGS reports also suggest that improvements are needed in the methods used to analyze sediment and metals in runoff.[26]

Local Governments Take Actions to Manage Urban Storm Water Runoff, but Information Is Limited on the Cost and Effectiveness of These Actions

To comply with federal and state storm water management for Phase I permitting requirements, permitted municipalities must create and implement storm water management programs. The three primary activities used in these programs include efforts to characterize storm water runoff; BMPs aimed at reducing pollutants in storm water runoff to the maximum extent practicable; and reporting program activities, monitoring results, and costs of implementing the program. Some BMPs are structural—meaning that they are designed to trap and detain runoff until constituents settle or are filtered out. Other BMPs are nonstructural—meaning that they are designed to prevent contaminants from entering storm water through actions like street sweeping and inspections. Many permitted municipalities use specialized BMPs tailored to address particular runoff problems in their locations. Over 1,000 cities are undertaking these efforts under the NPDES Storm Water Program, but information on the overall costs of managing urban runoff and the effectiveness of the actions taken is limited. EPA's attempts to forecast costs have not encompassed the entire program or are out of date. In addition, the permitted municipal agencies we visited estimated their annual storm water management costs and reported them to state agencies or EPA, but the approaches they used to calculate these estimates varied considerably, making it difficult to draw any conclusions. Although EPA and state agencies believe that the program will be effective in improving water quality, EPA has not made a systematic effort to evaluate the program. Without such an effort, EPA cannot tell what effect the program is having on water quality nationally.

[26]The USGS reports indicate that certain methods used to analyze sediment and metals samples can be unreliable. For example, sample collection and processing methods can have an effect on measured concentrations of metals.

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Municipalities Comply With Federal and State Requirements Through Monitoring, Best Management Practices, and Reporting

The NPDES Storm Water Program requires municipalities operating under a Phase I MS4 permit to characterize and monitor storm water runoff, implement BMPs to reduce pollutants to the maximum extent practicable, and report costs and monitoring results to the permitting authorities. Because of these requirements, local governments have generally shifted the focus of their storm water management from water quantity control or flood management to water quality concerns.

Besides following the basic federal requirements, municipalities must follow any additional regulations developed by states that have been delegated the authority to manage the NPDES Storm Water Program. For example, Wisconsin's Department of Natural Resources broadened the requirements for determining which municipalities must get permits. The state requires local governments with storm sewer systems in priority watersheds (based on the significance of storm water runoff as a pollutant source) that serve a populace of 50,000 or more[27] to obtain a permit with requirements similar to those for a Phase I permit. Wisconsin's Department of Natural Resources also requires municipalities that are located in one of the state's five Great Lakes Areas of Concern[28] to obtain a state permit. Furthermore, in line with specific criteria in Wisconsin's Administrative Code, the state requires other municipalities to obtain a permit if the municipality is found to significantly contribute storm water pollutants to waters of the state. These various requirements increased the number of municipalities that must get permits from the two under federal requirements to over 70 under the states' requirements.

The local governments we reviewed were undertaking three primary activities when applying for permits and implementing their storm water management programs. Specifically, these activities were (1) characterizing storm water runoff; (2) developing BMPs to reduce discharges of pollutants to the maximum extent practicable; and (3) reporting program activities, monitoring results, and reporting program costs.

First, to characterize runoff, applicants are to provide quantitative data that describe the volume and quality of discharges from municipal storm

[27]For example, we visited West Allis, Wisconsin, which has a permit even though its population is under 100,000.

[28]Areas of concern have persistent water quality problems, which impair beneficial uses.

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sewers. For example, cities must map all storm sewer outfalls—an undertaking that one group representing cities described as significant. After the permit application is approved, additional monitoring is required throughout the life of the permit to facilitate the design of effective storm water management programs and to document the nature of the storm water. The local governments we visited were all monitoring for a variety of purposes, including characterizing runoff from different types of land use in order to target their BMPs, testing the effectiveness of a particular BMP, or establishing a baseline for their storm water quality evaluations.

Second, the storm water management programs that local governments develop focus on implementing BMPs. While active treatment, such as sending storm water through a treatment facility, is a possible BMP, the cities we visited were generally not using active treatment. EPA's February 2000 report[29] on the Phase I program described the program as based on the "use of low-cost, common-sense solutions." The five cities we visited were generally using similar types of structural and nonstructural BMPs, as follows:

- Structural BMPs are designed to separate contaminants from storm water. For example, detention ponds temporarily hold storm water runoff to allow solids and other constituents in the runoff to settle before the water is released at a predetermined rate into receiving waters. In addition, catch-basin inserts, placed in a storm drain, catch trash and other debris, and particle separators, placed beneath the surface of an impervious area such as a parking lot, separate oils from runoff and allow sediment and debris to settle. Structural devices such as these require regular maintenance to function properly and remain effective.
- Nonstructural BMPs are primarily designed to minimize the contaminants that enter storm water. These nonstructural BMPs include
  - "good housekeeping" practices by the local government, such as oil collection and recycling, spill response, household and hazardous waste collection, pesticide controls, flood control management, and street sweeping;

[29] *Report to Congress on the Phase I Storm Water Regulations*, U.S. Environmental Protection Agency, February 2000. This report includes information on the program for local governments, industries, and construction sites.

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- public education programs, such as storm-drain stenciling, to remind the public that trash, motor oil, and other pollutants thrown into storm drains end up in nearby receiving waters;[30]
- new ordinances to control pollution sources, such as prohibiting the disposal of lawn clippings in storm drains and requiring pet owners to clean up after their pets;[31]
- requirements that developers comply with storm water regulations and incorporate erosion and sediment controls at all new development sites;
- requirements that runoff from properties owned or activities sponsored by the municipality be properly controlled; and
- efforts to identify and eliminate illicit connections and illegal discharges to the storm sewer systems, such as those from pipes carrying sewage.

We found that the NPDES Program's requirements allowed local governments to tailor their storm water management efforts to prioritize local concerns, such as a particular type of contaminant, a particular climatic condition, or a particular body of water. Some cities also developed specialized BMPs to address these concerns. The following information highlights specific storm water-related concerns in the five cities we visited and the specialized BMPs these municipalities have developed to address these particular concerns. (See apps. I to V for additional information on these cities' storm water management programs.)

[30]Other public education programs we observed included in-school education programs, partnerships with grassroots organizations concerned with water quality issues, and the identification of commercial businesses and industries to educate owners on methods to control storm water runoff.

[31]According to Worcester, Massachusetts' April 2000 *City of Worcester DPW Stormwater Management Program Annual Report*, the city has proposed ordinances that prohibit the disposal of lawn clippings and other yard waste in catch basins and that require pet owners to clean up after their pets. As of April 2001, neither ordinance had been implemented.

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- In **Baltimore, Maryland**, excessive levels of nutrients, particularly phosphorus and nitrogen, are among the city's major water quality concerns because of the city's participation in the Chesapeake Bay Program. Baltimore City agreed to assist the state in reaching the Chesapeake Bay Program's goal to reduce nutrients discharged to the bay by 40 percent by the year 2000. According to a Chesapeake Bay Program Office representative,[32] as of March 2001, the program has not met this goal but expects to reach it within the next several years.
- In **Boston, Massachusetts**, the Boston Water and Sewer Commission, which holds the permit for Boston's storm sewer system, is concerned about runoff from roadways, especially runoff containing salt and sand used in the winter months and dissolved metals (copper and zinc) from automobiles. In September 2000, the commission began a 3-year program to develop and implement a citywide catch-basin inspection, cleaning, and preventive maintenance program. The program will also include the development of a database and map that can be linked to the commission's Geographic Information System.
- **Los Angeles County, California**, is responding to a TMDL for trash in the Los Angeles River Watershed that will require the county, over a 10-year period, to eliminate trash in runoff. The county is testing a variety of devices that remove trash from runoff and specialized catch-basin devices that are designed to prevent trash from ever reaching the storm sewers.
- **Milwaukee, Wisconsin**, changed its monitoring and public education activities in its recent permit to test the effectiveness of a BMP targeting public education efforts to a specific community. The new permit also requires a monitoring program aimed at the community, its associated watershed, and city employees who work in the area.
- **Worcester, Massachusetts**, had a significant problem with illicit connections to its storm sewers and with flow in these sewers during dry weather. Worcester's Department of Public Works (DPW) screened 71 of its storm water outfalls and determined that 32 of them had drainage areas that carried both sanitary sewage and storm drainage in separate conduits through common manholes. DPW has retrofitted over 65 percent of the manholes to prevent sewage from mixing with storm water.

[32]The Chesapeake Bay Program Office, U.S. EPA Region III, was founded in 1983 with the formation of the Chesapeake Bay Program. The program is a voluntary regional partnership that leads and directs restoration of the Chesapeake Bay. Members of the Chesapeake Bay Program include Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission (a tristate legislative body), EPA, and participating citizen advisory groups.

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Third, local governments participating in the Phase I program are required to report annually to EPA or the state regulatory agency on their storm water programs. These reports are to include a status report on the program; a summary of data, including monitoring results collected during the reporting year; information on annual expenditures on the program and a budget for the coming year; and a description of any water quality improvements or degradation.

Information on the Costs of Addressing Storm Water Runoff Is Limited

Good information about the cost of implementing federal storm water requirements is limited. EPA conducted a survey to estimate the nation's future water infrastructure needs over a 20-year period—from 1996 to 2016. In its 1996 report,[33] EPA estimated that states would require over $50 billion to meet their current (as of 1996) water infrastructure needs. The estimate consists of storm water management needs (at $7.4 billion) and CSO needs (at $44.7 billion).[34] EPA noted, however, that estimated storm water management needs are likely too low and could increase following an analysis of data collected to prepare the agency's 2000 clean water needs survey—to be released in 2002. According to EPA, many cities have implemented the Phase I program since EPA reported to the Congress in 1996, and municipalities should now be better able to provide documented cost data. As a result, EPA will need to rely less on modeled storm water needs than it did in the 1996 needs survey. EPA did not project the costs and benefits of the program when it was initiated; therefore, no initial cost estimates are available. When EPA promulgated the Phase I program regulations in 1990, the agency decided that the storm water program did not meet the requirements for preparing a benefit/cost analysis.

[33] *1996 Clean Water Needs Survey Report to Congress*, U.S. Environmental Protection Agency (Sept. 1997). EPA's estimate represents the estimated capital costs for water quality projects eligible for state revolving fund support.

[34] EPA also estimates that $81.9 billion of its 20-year water infrastructure needs cost can be attributed to sanitary sewer overflows. These overflows may occur when rainwater or snowmelt leaks into sanitary sewage pipes, exceeding the pipes' capacity and causing them to overflow. This overflow can release untreated sewage from municipal sanitary sewer systems into streams, basements, and streets.

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The costs to local governments of complying with the Phase I program have generally been portrayed as high. However, because of inconsistencies in cost accounting and reporting practices, we could not determine the cost of the program to several of the cities we visited. Although municipalities are required to provide information on the expenditures that they anticipate will be needed to implement their storm water management programs for each fiscal year covered by the permit, EPA has not issued any cost reporting guidelines. Consequently, while the reported fiscal year 1999 total cost to manage and treat storm water runoff across the five municipalities in our review ranged from less than $1 million (Milwaukee) to $135 million (Los Angeles County),[35] these numbers are not comparable because the municipalities did not have consistent cost accounting and reporting practices and did not fully express storm water management costs.[36] For example, some cities reported only the costs of activities that were funded by the city department that held the permit. Significant activities funded by other city departments were not reported, even if they were important components of the storm water program. Officials in the Milwaukee Department of Infrastructure Services and the Boston Water and Sewer Commission told us that other city departments perform and fund activities such as street sweeping and flood control. The costs of these activities are not reported as storm water program costs because the activities serve other purposes besides preventing storm water pollution.

In addition, according to some city officials, these activities were in place before the permit was issued and, therefore, cannot be characterized solely as storm water costs. The cost of street sweeping can be significant—for fiscal year 1999, Baltimore City and Worcester, which did include street-sweeping costs in their storm water program's cost estimate, stated that their street-sweeping expenses totaled about $9.5 million and $1.2 million, respectively. Similarly, Milwaukee did not report the cost of a significant project related to storm water runoff because it was mostly funded by the state of Wisconsin.

[35]Los Angeles County's cost was projected by the municipal permit holder and represents the cost of the 85 cities covered by the permit.

[36]We were unable to obtain comprehensive information on the total cost to the Boston Water and Sewer Commission of managing storm water, so their fiscal year 1999 costs could not be included in this range.

R0012698

An EPA official told us that the agency had not yet made a national effort to analyze the information that Phase I permittees submitted on the costs of their storm water programs. This official cited the inconsistent formats of the annual reports as a reason that the information was not readily available at the national level and also indicated that adequate staff are not available to analyze the data. In addition, other EPA officials informed us that the Office of Wastewater Management must divide its resources among a number of issues that will challenge the agency's water program over the next decade.

Several officials in the cities we visited said that their annual costs are likely to increase. A number of factors could affect the costs. For example, a Baltimore City official explained that the anticipated, future program costs depend on several factors, including (1) requirements in watershed-management plans currently being developed, (2) pollution-reduction goals the city will be required to achieve, (3) requirements of the state regulatory agency in future permits, and (4) requirements the city may have to meet if TMDLs or numeric effluent limits are incorporated into NPDES storm water permits. Other city officials also expressed concern about the extent to which TMDLs could affect their future costs. These city officials are concerned that when and if TMDLs are established, their future storm water permits may require that storm water runoff meet specific water quality standards. For example, Los Angeles County's trash TMDL could potentially drive the county's storm water management costs upward, and the county expects additional TMDLs to be imposed. On the other hand, Worcester officials estimated that their future storm water costs would be about the same as they were at the time of our review—about $4.5 million per year.

In a separate analysis, EPA estimated in 1999 that it will cost Phase II municipalities about $848 million to $981 million per year (in 1998 dollars) to manage storm water runoff. Because Phase II permits have not been issued as of May 2001, we did not gather any cost information on them from these cities.

Funding for Managing Storm Water Runoff Is Available From Local and Federal Sources

The five cities we visited had not generally obtained federal funds for their storm water management efforts. They used local sources, including general revenues, bonds, revenue from specifically created storm water utilities, state grants, and inspection and permit fees.

R0012699

While several sections of the Clean Water Act provide funding that can be used for municipal storm water control, relatively few federal funds have been directed to these types of projects. The most significant source of funds is the state revolving loan funds administered by states.[37] These revolving loan funds provide loans for eligible storm water control projects. In some cases, nonpoint source projects may also qualify for funding when storm water permits are not required or issued. However, municipal storm water management is generally a low priority in these programs. Specifically, in the year 2000, revolving fund loans were made in the "storm sewers" category in the amount of $38.76 million for 44 different projects. These funds represented less than 1 percent of the amounts loaned from these revolving funds that year. Activities eligible for revolving fund loans include constructing BMPs to control runoff, but support for ongoing operations and maintenance is not eligible. Revolving fund loans can also be used for eligible CSO control projects. In 2000, Clean Water State Revolving Fund Program loans were made in the "CSO Correction" category of a national EPA database in the amount of $411.3 million for 69 different projects and could have been used for CSO or sanitary sewer overflow projects. This amount represented about 9 percent of the funds loaned in 2000.

According to EPA, the agency also issues grants to universities and other research institutions to help implement the storm water program. Some of these grants provide training and guidance to Phase I permittees on watershed protection and the proper selection of BMPs.

Other sources of funding may be available to local governments beginning in 2002. In December 2000, the Congress authorized programs for fiscal years 2002 through 2004 to provide grants to local governments for (1) pilot projects for managing municipal CSOs, sanitary sewer overflows, and storm water discharges on a watershed basis and for testing BMPs and (2) controlling pollutants from MS4s to demonstrate and determine cost-effective, innovative technologies for reducing pollutants from storm water discharge. EPA's proposed budget does not request funds for these programs. In addition, the Congress authorized programs for fiscal years 2002 and 2003 to provide grants to local governments for planning, designing, and constructing treatment works to intercept, transport,

[37]Under the Clean Water State Revolving Fund Program, the federal government provides grants to capitalize states' funds. States provide loans to local governments for wastewater projects.

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control, or treat municipal CSOs and sanitary sewer overflows. EPA's proposed budget requested $450 million for this program.

EPA, States, and Local Governments Believe the NPDES Storm Water Program Is Effective, but It Has Not Been Evaluated

EPA, state, and municipal officials generally believe that the NPDES Storm Water Program will improve water quality. These officials believe that the program will result in more bodies of water that meet water quality standards, improved aesthetic conditions, reduced risk from bacterial contamination, and improvements attributable to the discovery and management of pollutants in storm water that otherwise would have gone unnoticed. EPA attempted to put a dollar value on these benefits in its benefit/cost analysis prepared for the Phase II storm water regulations, estimating that such benefits could range from $672 million to $1.1 billion per year (in 1998 dollars).[38]

However, little information is currently available on the benefits of the storm water program or its general effectiveness. There is no doubt that it will take time for the results of the Phase I program to be demonstrated. As EPA notes in its February 2000 report to the Congress, pollution control efforts under water quality management programs produce long-term changes, and the agency expects water quality improvements attributable to the Phase I program to become evident in the future, as the program matures. In this report, EPA concluded that the program has improved storm water management at the local level, improved water quality, and decreased pollutant loads in storm water. However, EPA relied on a survey of only nine Phase I cities in making these conclusions and, therefore, also reported that the agency could not provide national estimates on water quality protection and improvements generated by Phase I of the program. To evaluate the entire program, EPA would have to establish goals for the program that are based on its mission; obtain information about the program's results; compare the results with the goals; and make changes to the program, if warranted, to get closer to achieving the agency's goals.

EPA and the states also have not taken advantage of information that is available to evaluate the program. Each city we visited was regularly monitoring its storm water to establish baseline information on pollutant levels and was reporting this information to EPA or the regulatory state agency each year. Although cities with Phase I permits are required to report on their storm water monitoring results and changes in water

[38]Using another method, EPA estimated the benefits at $1.6 billion per year.

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quality, overall, EPA and the states have not successfully developed measurable goals for the program or demonstrated its effectiveness through the review of municipal reports. An EPA official said that some states had requested funding to analyze program data because they did not have the resources to do so, and that EPA had provided the funding in a few cases. EPA also has not established any guidelines for how these data should be reported. Therefore, the reports may be as variable as the cost information we obtained in our five site visits.

EPA has not yet taken any of these data-analysis steps because, according to EPA officials, other program challenges within the Office of Wastewater Management compete with storm water management efforts for priority. For example, EPA officials stressed that available resources within the office must address other significant wet-weather pollution problems, such as CSOs and sanitary sewer overflows, and nonpoint source pollution problems, such as agricultural practices, forestry, and mining. One agency official noted that the highest priority is addressing needs that the agency and local governments have identified for improving wastewater infrastructure, such as sewage treatment facilities. The program also has relatively few staff assigned—about five in the headquarters office and about 10 in the regional offices—for the municipal, industrial, and construction portions of the program. In a program plan recently prepared for the storm water program, EPA estimated that nine to 10 staff would be needed in EPA headquarters to evaluate the program and implement other program requirements.

EPA officials described two efforts that may be the first steps in developing better information about the program. First, EPA intends to issue a grant to the University of Alabama in June 2001 to evaluate monitoring data submitted by a sample of municipalities with Phase I permits. This effort will (1) determine the different types of monitoring being conducted by Phase I municipalities, (2) assess water quality in and around permitted municipalities and determine any correlation between program implementation and impacts on water quality, and (3) recommend approaches for improving the effectiveness of municipal storm water monitoring programs. EPA expects the results of this study in 2003. Second, an EPA official stated that the agency would like to establish a system for analyzing program findings, incorporating necessary changes that are based on these findings, and evaluating the program's effectiveness. The agency plans to implement a pilot project in 2001 in the agency's Atlanta Region IV office for analyzing data reported in annual

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reports and developing key indicators for the program. If this project is successful and resources are available, the project could be expanded.

Conclusions

EPA regards urban runoff as a significant threat to water quality across the nation and considers it to be one of the most significant reasons that water quality standards are not being met nationwide. Prompted by the Congress, EPA has responded with a variety of programs, including the NPDES Storm Water Program, which requires more than 1,000 local governments to implement storm water management programs. Those municipalities that are currently involved in Phase I of the program have been attempting to reduce pollutants in storm water runoff for several years. It is time to begin evaluating these efforts. However, EPA has not established measurable goals for this program. In addition, the agency has not attempted to evaluate the effectiveness of this program in reducing storm water pollution or to determine its cost. The agency attributes this problem to inconsistent data reporting from permitted municipalities, insufficient staff resources, and other competing priorities within the Office of Wastewater Management. Although Phase I municipalities report monitoring and cost data to EPA or state regulatory agencies annually, these agencies have not reviewed this information to determine whether it can be of use in determining the program's overall effectiveness or cost. Our analysis shows that the reported cost information will be difficult to analyze unless EPA and its state partners set guidelines designed to elicit more standardized reporting. Better data on costs and program effectiveness are needed—especially in light of the Phase II program that will involve thousands more municipalities in 2003. EPA's planned research grant to the University of Alabama and its pilot project in the agency's Region IV to analyze data from annual reports and develop baseline indicators is a step in the right direction and could point the way for a more comprehensive approach.

Recommendation

To determine the extent to which activities undertaken through the NPDES Storm Water Program are reducing pollutants in urban runoff and improving water quality, and the costs of this program to local governments, we recommend that the Administrator, EPA, direct the Assistant Administrator for the Office of Water to

- establish measurable goals for the program;

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- establish guidelines for obtaining consistent and reliable data from local governments with Phase I permits, including data on the effects of the program and the costs to these governments;
- review the data submitted by these permittees to determine whether program goals are being met and to identify the costs of the program; and
- assess whether the agency has allocated sufficient resources to oversee and monitor the program.

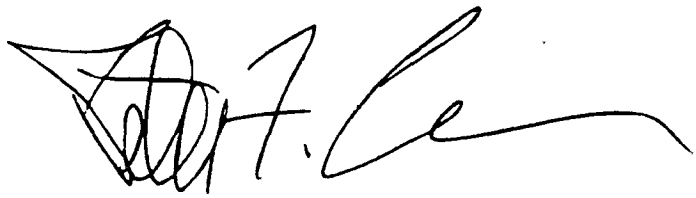
Agency Comments and Our Evaluation

We provided a draft of this report to EPA and DOT for their review and comment. EPA generally agreed with the report and with the recommendation, although it did not explicitly comment on all parts of it. (EPA's comments appear in app. VI.) In response to our recommendation that EPA set measurable goals for the storm water program, EPA stated that under the second phase of the program, local governments will establish their own goals. Although this is an important activity, EPA will have difficulty evaluating the program's effectiveness at a national level without setting goals that reflect the program's mission of improving water quality. The agency (1) agreed that it should establish guidelines for obtaining consistent and reliable data from local governments about their programs and (2) plans to award grants to two universities for reviews of monitoring data reported by local governments. EPA did not comment on whether local governments should report on the costs of their programs. EPA also agreed that it and its state partners should review data reported by local governments to determine whether the program's goals are being met. In April 2001, EPA officials told us that the agency planned to undertake a project in the Region IV (Atlanta) office to evaluate the methods local governments are using to control storm water. EPA's letter indicates that the agency now plans to implement this project in three regional offices and 10 states. EPA did not comment on the part of our recommendation that the agency review the level of resources devoted to overseeing and monitoring the program. EPA also provided technical comments that we incorporated where appropriate.

DOT generally agreed with the draft report and provided technical comments that we incorporated where appropriate. In particular, DOT suggested that we revise several references in the draft report to paved surface area and its relationship to increases in urban runoff, to emphasize that impervious surfaces, of which paved surfaces are a significant subset, cause increases in runoff. We revised the language in these places.

R0012704

As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after the date of this report. At that time, we will send copies of this report to the Administrator, Environmental Protection Agency, and the Secretary of Transportation. We will make copies available to others on request. If you or your staff have any questions about this report, please call me at (202) 512-2834. Key contributors to this report are listed in appendix VII.



Peter F. Guerrero
Director, Physical Infrastructure Issues

R0012705

The Storm Water Program in Baltimore City, Maryland

Baltimore City's municipal separate storm sewer system (MS4) is regulated by the Maryland Department of Environment (MDE) and, according to a city official, services the entire city. The city is currently implementing its second, 5-year National Pollutant Discharge Elimination System (NPDES) permit, issued on February 8, 1999. Before obtaining the first NPDES storm water permit in 1993, Baltimore City addressed the adverse affects of storm water runoff by implementing Maryland's Storm Water Management Program and Erosion and Sediment Control Program. According to the 2000 census, Baltimore City's population is about 651,000.

Urban Runoff Problems in Baltimore City

Baltimore City's urban runoff discharges to four major areas—Gwynns Falls, Jones Falls, Herring Run, and the Patapsco River—and then ultimately to the Chesapeake Bay. In 1990, the Environmental Protection Agency's (EPA) 319(a) report[1] implicated urban runoff as the main source of pollution in these waters. Moreover, Baltimore City was one of the areas studied in EPA's Nationwide Urban Runoff Program in the 1980s. This study reported that urban runoff contributed over 60 percent of the total nitrogen, phosphorus, and organic carbon; over 70 percent of the chemical oxygen demand; and over 80 percent of the total suspended solids, lead, and zinc in local water bodies.

An MDE official told us that nutrients, zinc, and suspended solids are among the constituents most commonly found in urban runoff, but the quantitative contribution to water quality impairment in the state's waters was not known. Also, in 1996, the Chesapeake Executive Council designated the Baltimore Harbor as one of three toxic regions of concern in the Chesapeake Bay. The harbor suffers from sediment contaminated by banned substances (such as the termiticide chlordane) and contaminants currently being released (such as metals and organics). Furthermore, according to the Chesapeake Bay Program Office, data collected from Phase I permittees indicate that storm water runoff can be a significant source of metals and organics in the harbor.

A Baltimore City official told us that some portions of Maryland's waters are impaired because of unacceptable levels of nutrients, metals,

[1]Section 319(a) of the Clean Water Act requires, among other things, that states identify and report to EPA the navigable waters that cannot reasonably be expected to maintain water quality standards (e.g., established water body uses) without additional action to control nonpoint source pollution.

R0012706

suspended sediments, and chlordane. Moreover, this official noted that the state does not consider data that municipalities collect under their NPDES storm water permits during the 303(d) listing process. Therefore, he believes that streams in Maryland are much more impaired than indicated by the listing process.

Baltimore City's Use of Best Management Practices

Like other NPDES storm water permit holders, Baltimore City uses a variety of best management practices (BMP) to reduce the amount of pollutants in runoff to the maximum extent practicable. These BMPs include detention ponds, shallow marshes (which use the biological and naturally occurring chemical processes in water and plants to remove pollutants), sand filter devices, public education programs, and the identification of illicit discharges to the MS4 system. Furthermore, Baltimore City participates in Maryland's effort to reduce nutrient levels in the Chesapeake Bay. Refer to the section of this report describing local government efforts to manage storm water for details concerning this nutrient-reduction goal. One other BMP includes the following:

- Baltimore City has incorporated the *2000 Maryland Storm Water Design Manual's* management policies, principles, methods, and practices into its current NPDES storm water discharge permit. The purpose of the design manual is to (1) protect the waters of the state from the adverse effects of urban storm water runoff; (2) provide design guidance on the most effective structural and nonstructural BMPs for development sites; and (3) improve the quality of BMPs that are constructed in the state, with particular attention to their performance, longevity, safety, ease of maintenance, community acceptance, and environmental benefit.

Costs Associated With Managing Storm Water

We were not able to obtain comprehensive information on the total cost to Baltimore City of managing storm water. Therefore, we do not present that information here.

Funding Sources

Baltimore City funds its storm water management control efforts with city water and sewer user fees and with state funds.

R0012707

The Storm Water Program in Boston, Massachusetts

The Boston Water and Sewer Commission received a NPDES storm water permit in October 1999. The commission is a separate entity from the city of Boston and, therefore, does not manage some storm water controls that are common in Phase I permits, such as street sweeping, winter deicing, and many of the urban runoff controls required for new developments. Boston has combined sewer systems as well as separate sanitary sewers and storm drains. The commission maintains 206 storm water outfalls and serves approximately 33 percent of the city through its separate MS4 system. In addition to the resident population of about 589,000, this system also almost daily serves 340,000 commuting workers; 70,000 shoppers, tourists, and business people; and 75,000 commuting students. The commission's sanitary and combined flows are transported to the Massachusetts Water Resources Authority at Deer Island. The commission is also the permittee for EPA's Combined Sewer Overflow Program.

Urban Runoff Problems in Boston

The commission considers the identification and elimination of illegal sanitary sewer connections as the most effective means of improving water quality and protecting public health. It is also concerned with the washoff of animal wastes from residential and open land, which is another major contributor to the impairment of water quality because it can cause an increase in coliform levels in the storm water discharges to the receiving waters.

The commission has contracted for various studies to determine the impact of storm water runoff. The following two studies identified sources of bacterial contamination and characterized the quality of storm water discharged from different types of land uses. The studies included metering storm water flows, collecting and analyzing the storm water and receiving water quality samples, and identifying and remediating illegal sewer connections. Observations from the studies include the following:

- A 1996 study determined that pet waste, rather than sanitary sewage, was a key contributor of bacteria to the storm drain system that had possibly led to beach closings in the area.
- A 1998 study identified several illegal connections to the storm drain system. Furthermore, the study showed that deicing and sanding efforts resulted in levels of sodium, chloride, total dissolved solids, and cyanide that exceeded EPA's acute (high dose) toxicity levels.

R0012708

Boston's Use of Best Management Practices

To meet the NPDES permit's requirements, the commission, like other permittees, continued BMPs, such as identifying illegal connections, and implemented new BMPs aimed at preventing the discharge of pollutants to storm drains and receiving waters. Refer to the section of this report describing local government efforts to manage storm water for details describing the commission's citywide catch-basin inspection cleaning and preventative maintenance program. Other efforts include the following:

- The commission has placed particle separators, which remove oil, grease, and sediments from storm water flows, throughout the city. The commission requires particle separators to be installed by developers on all newly constructed storm drains that serve outdoor parking areas. Fuel-dispensing areas not covered by a canopy or other type of roof enclosure must also have a particle separator.
- The commission requires developers to consider on-site retention of storm water for all new projects, wherever feasible. On-site retention aids in controlling the rate, volume, and quality of storm water discharged to the commission's storm drainage system.

Costs Associated With Managing Storm Water

We were not able to obtain comprehensive information on the total cost to the commission of managing storm water because the commission does not separate the cost of its storm water program from the cost of its sewer operations. Therefore, we do not present that information here.

Funding Sources

The commission funds its storm water management control efforts primarily with city water and sewer user fees and bond proceeds.

R0012709

The Storm Water Program in Los Angeles County, California

Under the NPDES Storm Water Program, the Los Angeles Regional Water Quality Control Board issues 5-year permits to Los Angeles County for its municipal storm water program. The Los Angeles County permit, issued in July 1996, is the county's second storm water permit. This permit includes Los Angeles County as the principal permittee and 85 cities as permittees. According to the 2000 census, Los Angeles County's population is about 9.5 million.

Urban Runoff Problems in Los Angeles County

The effects of urban runoff on the ocean are of particular concern in southern California. Contaminated sediments, impaired natural resources, and potential human illness could threaten the county's tourism economy, estimated to be about $2 billion a year.

The following three studies have shown that urban runoff can pose health risks to swimmers near storm drains and contribute toxic metals to receiving water sediments:

- The Santa Monica Bay Restoration Project conducted a study to assess the possible adverse health effects of swimming in waters contaminated by urban runoff.[1] This study revealed that there is an increased risk of illness associated with swimming near flowing storm drain outlets and an increased risk of illness associated with swimming in areas with high concentrations of bacteria indicators. Furthermore, illnesses were reported more frequently on days when the samples were positive for enteric viruses. Refer to the section of this report describing the effects of runoff on aquatic life and human health for more details.
- The Southern California Coastal Water Research Project coordinated a study that assessed microbiological water quality and found that the majority of shoreline waters exceeded water quality standards during wet-weather conditions. Furthermore, the ocean waters near storm water outlets demonstrated the worst water quality regardless of the weather.[2]
- The Southern California Coastal Water Research Project also compared the runoff from an urban area and a nonurban area in the Santa Monica

[1]R.W. Haile and others, "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology*, July 1999, Vol. 10, No. 4.

[2]Southern California Coastal Water Research Project, *Southern California Bight 1998 Regional Monitoring Program, Volume 3: Storm Event Shoreline Microbiology*, 2000.

R0012710

Bay Watershed.[3] The results of the study indicated that storm water plumes extended up to several miles offshore and persisted for a few days. Furthermore, the runoff from the urban area proved to be toxic to sea urchin fertilization, and dissolved zinc and copper were determined to be contributors to the toxicity. The study also found that in urban areas, sediments offshore generally had higher concentrations of contaminants such as lead and zinc.

Los Angeles County's Use of Best Management Practices

As in the other sites we visited, the county is managing its runoff through the use of conventional BMPs. These BMPs include the elimination of illicit connections and discharges to the storm sewer system, construction control measures, routine inspections, staff training, pollution prevention plans for public vehicle maintenance and material storage facilities, sweeping and cleaning public parking facilities, street sweeping, catch-basin cleaning, and public education.

The Los Angeles Regional Water Quality Control Board recently adopted a Total Maximum Daily Load (TMDL) Program to reduce trash loads to the Los Angeles River. As a result, the county is exploring a number of trash reduction BMPs, which are discussed in the section of this report describing local government efforts to manage storm water.

Costs Associated With Managing Storm Water

Table 3 indicates that the county and the other permittees have allocated significant funding for storm water management activities over the years. For example, for fiscal year 1999,[4] projected funding for storm water management activities for the county and the other permittees amounted to over $134 million.[5] The largest projections for both went toward public agency activities. For example, during fiscal year 1999, the principal permittee and the permittees together projected almost 67 percent of storm water management funds to public agency activities. The activities in this

[3]Southern California Coastal Water Research Project, *Study of the Impact of Stormwater Discharge on Santa Monica Bay–Executive Summary,* Nov. 1, 1999.

[4]The county's fiscal year begins July 1 and ends June 30.

[5]According to an official with the Los Angeles Regional Water Quality Control Board, this figure may also include activities that are outside the scope of the permit.

R0012711

program include staff training, inspections of construction projects, street sweeping, and catch-basin cleaning.

Table 3: Summary of Fiscal Resources Projected for Los Angeles County and Its Co-permittees, Fiscal Years 1997-99

(Dollars in thousands)[a]

	Fiscal year 1997		Fiscal year 1998		Fiscal year 1999	
Activity	County	Others[b]	County	Others[b]	County	Others
Program Management	$2,225	$6,195	$1,856	$4,874	$1,466	$6,187
Illicit Connection, Illicit Discharge Program	1,620	3,515	1,017	3,075	764	2,901
Development planning and construction	784	6,208	1,300	3,769	1,452	5,743
Public agency activities	38,544	40,915	40,256	31,992	43,316	46,657
Public information and participation	2,840	5,538	4,360	3,856	4,629	6,177
Monitoring	2,018	619	1,768	729	1,598	737
Other	187	13,991	490	8,656	1,318	11,834
Total	**$48,218**	**$76,981**	**$51,048**	**$56,950**	**$54,543**	**$80,237**

[a]Totals may not add up because of rounding.

[b]Does not include 17 permittees for fiscal year 1998 and 13 permittees for fiscal year 1997 for the following reasons: The permittee operated on a different budget cycle, the final document was not available at the time of the annual report, or the information submitted by the permittee was not complete.

Source: GAO's analysis of cost data provided by the Los Angeles County Department of Public Works.

As shown in table 3, the county maintains primary responsibility for monitoring activities, having projected over $2 million for storm water monitoring activities in fiscal year 1997, almost $2 million in fiscal year 1998, and over $1.5 million in fiscal year 1999. Conversely, the permittees' projected funding levels for monitoring activities amounted to only $619,000 in fiscal year 1997, $729,000 in fiscal year 1998, and $737,000 in fiscal year 1999. According to an official with the Los Angeles Regional Water Quality Control Board, the County has consistently maintained primary responsibility for monitoring activities required under the permit.

R0012712

Funding Sources

The primary source of funds for the county's storm water program is flood control assessments collected throughout the district. Although the county has not applied for any state revolving funds, it has applied for and received approval for federal funds through the Transportation Equity Act for the 21st Century (TEA-21) for a pilot study of an engineering device that would remove trash from storm water. Additionally, the county has received partial funding through Proposition A of the Safe Neighborhood Parks of 1992 and 1996[6] for two Vortex Separation Systems—a Continuous Deflective Separation unit and a Stormceptor unit. Additionally, the county received grant money from the Metropolitan Transit Authority, which partially funded catch-basin screens, a Continuous Deflective Separation unit, and 120 catch-basin inserts.[7]

[6]The Los Angeles County Regional Park and Open Spaces District (a district within the Parks Department) received this funding from Proposition A and, in turn, made grants to the Los Angeles County Department of Public Works for the BMP devices.

[7]The Metropolitan Transit Authority receives TEA-21 funds from the California Department of Transportation.

R0012713

The Storm Water Program in Milwaukee, Wisconsin

The Wisconsin Department of Natural Resources (WDNR) has the authority to regulate the discharge of storm water from municipalities, construction sites, and industries under Natural Resources Code 216. This rule identifies Wisconsin municipalities that are required to obtain a storm water discharge permit under the Wisconsin Pollutant Discharge Elimination System (WPDES). Milwaukee completed its application process in 1994, and WDNR issued a WPDES permit to the city in October 1994. This was the first municipal storm water permit issued to a municipality in EPA's Region 5 covering the midwest. In July 2000, WDNR reissued Milwaukee's storm water permit. According to the 2000 census, Milwaukee's population is about 597,000.

Urban Runoff Problems in Milwaukee

Milwaukee has a combined sewer system as well as a separate sanitary sewer system. The Milwaukee Metropolitan Sewerage District implemented a rehabilitation program that cost over $2 billion to reduce the number of combined sewer overflow (CSO) events each year. The rehabilitation program involved the construction of deep tunnels to store untreated wastewater and rainwater for later treatment at a wastewater treatment plant. Since 1996, the deep tunnels have significantly reduced the number of overflow events from an average of 50 to 60 per year before the construction to an average of two per year afterwards.

Urban runoff has been identified as a leading source of pollution to the Milwaukee River basin's streams, lakes, and wetlands and the Milwaukee River estuary. To address pollution from urban runoff, WDNR issues storm water permits to municipalities with MS4s serving areas with populations of 100,000 or more, municipalities in Great Lakes "areas of concern" where water quality has been identified as a serious problem, municipalities with populations of 50,000 or more that are located in priority watershed planning areas, and designated municipalities that contribute to the violation of a water-quality standard or are significant contributors of pollutants to state waters.

Milwaukee's Use of Best Management Practices

In addition to BMPs such as the elimination of illicit connections and discharges to the storm sewer system, the reduction of pollutants in storm water runoff from construction sites, public education, catch-basin cleaning, street sweeping, and the use of detention basins, Milwaukee has explored the use of innovative BMPs. Refer to the section of this report describing local government efforts to manage storm water for more

R0012714

details about an educational campaign directed at a specific watershed. Additional BMPs include the following:

- An innovative storm water control device was installed in a parking lot at a heavily used municipal public works yard that was found to discharge significant amounts of storm water pollutants. Termed the Multi-Chambered Treatment Tank (MCTT), this device is suitable for areas with limited space, cleans up polluted runoff close to its source, removes pollutants that are not susceptible to other treatment methods, and is hidden from view. The MCTT consists of a catch basin, a settling chamber, and a filter. Although the results of the monitoring studies have revealed that the device has a positive effect on water quality, officials with the Department of Public Works explained that it is cost-prohibitive and suitable only for sites with limited space.
- The permittee has also been working with WDNR, the Department of Transportation, the U.S. Geological Survey, and a neighborhood association in a joint effort to develop a storm water monitoring assessment program consisting of two innovative storm water treatment devices. One device removes grit, contaminated sediments, heavy metals, and oily floating pollutants from surface runoff. The other device removes a broad range of pollutants from runoff, such as bacteria, heavy metals, nutrients, petroleum hydrocarbons, and suspended solids. The devices are to be installed along a new reach of the Milwaukee Riverwalk through the third ward of Milwaukee.

Costs Associated With Managing Storm Water

Reliable data on the total cost to manage storm water in Milwaukee were not available and cannot be presented here because certain activities are not reported as program costs in the city's annual report. These activities include street sweeping; leaf collection; catch-basin and inlet cleaning; maintenance of public boulevards, parks, and public green spaces; and the recycling of waste oil and antifreeze. Therefore, the program costs reflected in the annual report do not take into account many of the nonstructural BMPs employed by the city nor do the totals include activities funded through grants. The storm water management activities that were included in the city's 2000 budget request were estimated to cost $460,000.

Funding Sources

Milwaukee's storm water program is primarily funded through the city's sewer maintenance fund. Unlike the general revenue account, which is

R0012715

based on property taxes, the sewer maintenance fund is based on water consumption. The city has also received supplemental funding from the Wisconsin Nonpoint Source Water Pollution Abatement Program in the form of WDNR grants. The city has received over $1 million since 1991 for a wide variety of storm water management activities.

R0012716

The Storm Water Program in Worcester, Massachusetts

Worcester's Department of Public Works (DPW) received a NPDES permit on November 1, 1998. The Sewer Operations Division, within the DPW, is directly responsible for operating and maintaining the city's separate storm sewer system, along with the sanitary and combined sewer system. Since 1993, the Sewer Operations Division has had a full-time storm water coordinator, reflecting Worcester's increased emphasis on meeting NPDES program requirements. Worcester has a population of about 173,000. Its water system covers an extensive area, including 371 miles of sanitary sewers, 340 miles of storm sewers, 56 miles of combined sewers, 27,000 manholes, over 14,000 catch basins, and 263 outfalls. Worcester's separate storm drain systems consist of 93 main drainage areas covering approximately 6,680 acres.

Urban Runoff Problems in Worcester

The constituents that are typically found in urban runoff in Worcester are the same as those normally found in urban runoff in older cities. Because virtually all of the paved surfaces in the Worcester area are devoted to the city's transportation infrastructure, the constituents generated include automobile-related petroleum products, such as total petroleum hydrocarbons, oil and grease, along with total suspended solids. Also, coliform, silt, and sediment have been identified in the city's runoff.

Worcester's Use of Best Management Practices

Like other permittees, the DPW has implemented BMPs under the major areas of education outreach, pollution prevention and source controls, storm-drainage system maintenance, regulatory efforts, and storm-drainage system infrastructure. Additionally, to reduce storm water pollution, the DPW has retrofitted a number of twin manholes in the city as discussed below. BMPs that are specific to Worcester include the following:

- The DPW implemented a demonstration project to determine the effectiveness of an oil and grit separator installed on a street drain. The drain is a major surface sewer main that services approximately 226 acres of heavily urbanized area with a typical mix of residential, commercial, and industrial use. The drain discharges into Lake Quinsigamond, which is a large lake used for recreational purposes such as swimming and boating. In its April 2000 annual plan submitted to EPA, the DPW noted that because of drought conditions, it currently did not have sufficient sampling data to determine the effectiveness of the project.

R0012717

- The DPW has embarked on a comprehensive program to minimize the possibility that sewage and storm water will be mixed in its twin invert manholes. Since the program began, the DPW has installed hold-down devices on over 1,680 of the approximately 2,580 twin invert manholes in the city. The DPW expects to continue the program until all of the manholes have been retrofitted.
- The DPW is also working closely with the Massachusetts Department of Environmental Protection in its ongoing tracking efforts to ensure that industries in Worcester are doing their part to reduce storm water pollution.
- To improve its storm-drainage infrastructure, the city has established a voluntary plan to reduce the number of unpaved private roads. The dirt from these roads, especially after rain storms, causes sediment to build up in the drainage system. The DPW has developed a plan to pave the streets at a lower grade than would be necessary to meet the legal requirements for a public street. Under this plan, residents would not have to pay the additional betterment taxes that are now required to cover the costs of sediment removal and less sediment would be transported in runoff.

Costs Associated With Managing Storm Water

Since 1993, the DPW has allocated significant funding from the water and sewer utility fees it collects for controlling the effects of runoff, especially through catch-basin cleaning, street sweeping, and correcting illegal connections. For example, its fiscal year 1993 budget for storm water programs included about $1.6 million for specific programs and another $1 million for capital improvement programs, such as inflow/infiltration and flood control. The DPW also spent $500,000 to develop and submit its permit application. Furthermore, as shown in table 4, Worcester made extensive capital expenditures during fiscal years 1994 through 1999 on pertinent storm water projects to improve the quality of storm water runoff emanating from the city's storm water sewer system.

R0012718

Table 4: City of Worcester's Capital Expenditures for Storm Water Management

(Dollars in thousands)

	Fiscal year					
Activity	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Sewer construction	$0	$500	$500	$300	$300	$300
Infiltration control	0	400	400	100	100	100
Pump station rehabilitation	200	200	200	200	200	200
Sewer rehabilitation	300	750	300	750	750	1,500
Landfill closeout	150	1,200	200	500	0	0
Belmont Drainage project	0	100	600	100	0	0
Beaver Brook Culvert project	0	500	100	100	300	100
Surface drain control	40	150	200	200	200	200
Geographic Information System	0	0	0	125	125	125
Other	0	70	10	0	0	0
Total	**$690**	**$3,870**	**$2,510**	**$2,375**	**$1,975**	**$2,525**

Note: The Belmont Drainage project involved enlarging the drain to eliminate surcharging and siltation and moving the outfall to eliminate stagnation. The Beaver Brook Culvert project involved repairing the culvert and conducting a study that included a detailed hydraulic analysis of the drainage basin.

Source: Worcester Department of Public Works.

Furthermore, during fiscal year 1999, the DPW spent approximately another $2.1 million to operate and maintain storm water activities. Key expenditures included about $1.2 million for street sweeping, about $617,000 for catch-basin maintenance, $52,000 for root control, and another $48,000 for street paving. Also included was $40,000 per year for sampling five outfalls around the city three times per year as required by the permit. According to a DPW official, in previous fiscal years, the DPW funded the same or similar operation and maintenance activities to help control storm water runoff. As a result, the costs since 1994 were similar to those for 1999, except for annual adjustments for inflation. Therefore, the annual operation and maintenance expenditures ranged from about $1.7 million for 1994 to about $2.1 million for 1999.

According to a DPW official, the department expects to spend from $3 million to $4.5 million annually over the next several years on storm water-

R0012719

related activities. The amount of the cost increase will depend on whether EPA asks the city to increase its spending.

Funding Sources

The DPW funds its storm water management controls effort from the water and sewer user fees it assesses to homes and businesses.

R0012720

Comments From the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C 20460

JUN 14 2001

OFFICE OF WATER

Mr. Peter F. Guerrero
Director, Physical Infrastructure Issues
United States General Accounting Office
Washington, DC 20548

Dear Mr. Guerrero:

Thank you for the opportunity to review your draft report entitled "Better Data and Evaluation of Urban Runoff Needed to Assess Effectiveness." We appreciate the difficulty that assimilating and interpreting such information on an extremely complex subject must have presented. Your report provides a fair and balanced depiction of the Agency's efforts, with the assistance of our State and local partners, to implement a national urban storm water runoff control program.

As the report correctly acknowledges, the Environmental Protection Agency (EPA) believes that urban runoff is a significant threat to water quality and is actively working to control the discharge of pollutants in storm water runoff. EPA's urban storm water control program has been a very successful undertaking to date and we are taking steps to address several of the recommendations identified in the report.

One of the challenges of controlling urban storm water runoff is to be able to address a wide array of complex environmental issues, even within the boundaries of one municipality. EPA's urban storm water program is developed with the understanding that a "one size fits all" approach will not work. For example, existing municipal separate storm sewer system (MS4) permits are tailored to suit the needs of each individual municipality. In fact, the municipalities select the majority of the measures that will be implemented to control storm water runoff. Similarly, EPA's Phase II regulatory framework for small MS4s requires the municipality to identify appropriate BMPs to control runoff and establish measurable goals against which program effectiveness will be measured. These BMPs and measurable goals then become the enforceable permit conditions for that municipality. EPA expects that approximately 5,000 small MS4s will each have a unique set of measurable goals that will define expectations of a successful storm water control program.

While EPA has developed a sound regulatory basis for urban storm water control, competing initiatives have limited our ability to invest sufficient resources to fully evaluate the effectiveness of the program and the associated implementation costs. We believe that the flexibility afforded MS4 permittees provides some assurance that permit requirements do not become onerous or unjustified. Additionally, with the MS4 permits reissued every five years,

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EPA expects that dialogue between MS4s and permitting authorities will better focus on those activities found to be most beneficial.

Over the next year, we will address challenges relating to evaluating the effectiveness of municipal storm water programs. Consistent with the first recommendation, EPA will evaluate storm water monitoring data that has been collected since program inception. Two grantees (UCLA and the University of Alabama) will review monitoring data that has been submitted as part of routine discharge monitoring reports and annual reports. EPA expects these efforts will evaluate the correlation between storm water discharges and trends in water quality impairment. Another anticipated finding from these grants is a compilation of the range of monitoring activities required of municipalities in storm water permits and the identification of the monitoring that appears to be most effective in demonstrating program results.

To meet another challenge, we are evaluating MS4 permit requirements and annual reports to identify the types of storm water control activities in place and the environmental and programmatic results of these activities. Initially, this effort will evaluate MS4s in at least three EPA Regions and 10 states to gather information on the range of methods employed by permitted MS4s to control storm water discharges. Through this effort, EPA expects to determine whether program goals are being met and establish meaningful indicators of program performance. Should this effort prove useful, EPA will expand the evaluation to a national effort that will evaluate MS4 permits and annual reports in all affected EPA Regions and states. In either case, results of this effort will be disseminated nationally to ensure that findings are incorporated into other MS4 programs, as appropriate.

Enclosed are additional comments on terminology and regulatory citations provided in the report. Again, we appreciate the opportunity to review and comment on the draft report. If you have any questions about these comments or would like to discuss urban storm water runoff issues, please contact me or call Jeff Lape, Acting Director of the Water Permits Division, at (202) 564-9545.

Sincerely,

Michael B. Cook
Director
Office of Wastewater Management

Enclosure

R0012722

Enclosure

Below are several additional comments for your consideration that address terminology and regulatory citations provided in the report:

- The term "nonpoint source" throughout the report, when referring to storm water runoff, is somewhat misleading in that the federal definition of "point source" includes many of the types of storm water discharges discussed in the draft report as "nonpoint source pollution." We recommend clarifying that EPA's NPDES storm water permits regulate point source discharges that includes storm water runoff from small, medium, and large municipal separate storm sewer systems. In fact, to avoid confusion between point sources and nonpoint sources in an NPDES context, we recommend that you consider using the term "wet weather discharges" when referring to storm water runoff.

- The third sentence in the first full paragraph on page 3 states that "EPA requires cities to use 'best management practices' to reduce contamination in storm water runoff." We recommend that you change the word "requires" to "recommends." While best management practices are common for reducing storm water contamination, EPA regulations allow MS4s to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, and system, design, and engineering methods, and such other provisions which are appropriate.

- The last sentence in the second full paragraph on page 3 states that "managing storm water runoff will reduce runoff and improve water quality." We recommend changing this sentence to indicate that "managing storm water runoff will reduce the volume and concentration of pollutants in runoff and improve water quality.

- The last sentence of the same paragraph indicates that "Neither EPA nor states have developed measurable program goals or reviewed municipal reports on the results of storm water programs to determined whether the reports provide information that could demonstrate the program's effectiveness." A similar statement is made in the first full paragraph on page 31. We recommend that these two sentences be revised to indicate that "EPA and states have generally been unsuccessful in developing measurable program goals and in demonstrating program effectiveness through the review of municipal reports." EPA and some states have attempted to determine program effectiveness through the review of municipal reports but, to date, these efforts have been unsuccessful in making this determination.

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GAO Contacts and Staff Acknowledgments

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Staff Acknowledgments

In addition to those named above, Jennifer Clayborne, Richard LaMore, Sally Coburn, Elizabeth McNally, Charles Bausell, and Timothy Guinane made key contributions to this report.

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Comparison of NPDES Program Findings for Selected Cities in the United States

The U.S. Environmental Protection Agency, under section 402(p) of the Water Quality Act of 1987, has required municipalities with populations of more than 100,000 to obtain National Pollutant Discharge Elimination System (NPDES) permits for urban stormwater discharge. This regulation is intended to minimize pollutant loadings from urbanized areas and preserve the quality of streams that receive stormwater. To apply for a NPDES permit, a municipality must monitor the chemistry of stormwater from basins having residential, commercial, and industrial land uses, and estimate storm- and annual-pollutant loads and event-mean concentrations of 12 selected properties and constituents. The properties and constituents include biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, total recoverable cadmium, total recoverable copper, total recoverable lead, and total recoverable zinc. These estimates will be used by the municipalities to evaluate the magnitude of pollutant loadings and the efficiency of management strategies that are intended to reduce pollutant loads.

As part of a national synthesis of the study units in the U.S. Geological Survey (USGS) NPDES program, data were compiled on concentrations of the 12 properties and constituents required for load calculations. This report presents a comparison of these data.

Data Collection

The USGS, in cooperation with local agencies, sampled stormwater from 1991 through 1996 in 13 cities and metropolitan areas that are required to obtain NPDES permits (fig. 1). For this comparison, Birmingham and Montgomery, Alabama, were considered one study unit and designated as Birmingham/Montgomery, Alabama. Samples were collected from various conveyances, such as culverts, concrete pipes, lined ditches, and unlined channels. The drainage area of sampling sites typically was small and ranged from 4.0 to 2,564 acres. Each site had a predominant land use—residential, commercial, or industrial (fig. 2). Flow and rainfall data either were collected on site or were estimated from nearby gages. Flow data are used to calculate loads from the concentration data. Samples were collected either by manually collecting discrete samples at timed intervals and flow-weighting volumes of these discrete samples or by collecting flow-weighted composite samples using an automatic sampler. Flow-weighted samples were collected during the first 3 hours of the storm or until the stream returned to pre-storm levels. Samples were collected at a particular site about 30 or more days apart and after approximately 72 hours of less than 0.1 inch of rain.

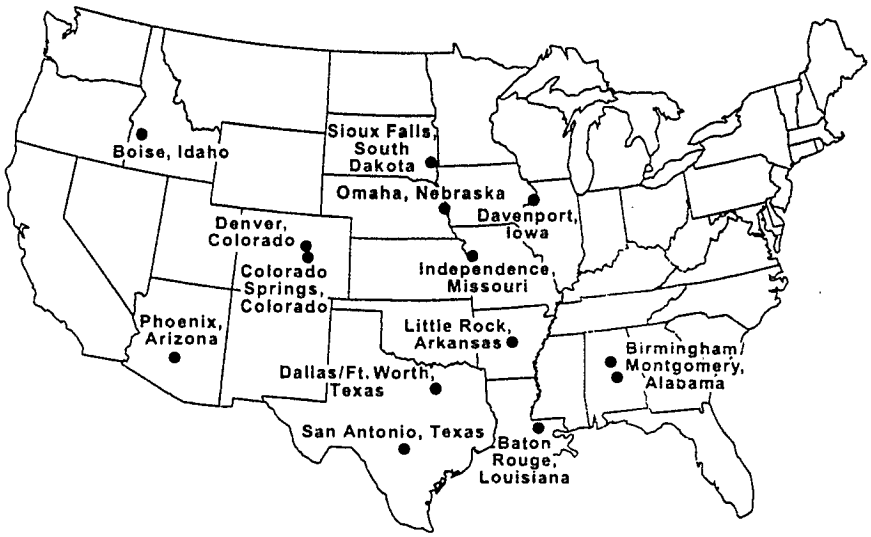

Figure 1. Cities and metropolitan areas where NPDES constituents were sampled in urban stormwater, 1991–96.

Data Analysis

Analyses of the flow-weighted composite samples were done at the USGS National Water-Quality Laboratory with the exception of the Sioux Falls, South Dakota, and BOD analyses. These analyses were done at the individual USGS offices or at contract laboratories.

Nationwide Data Comparison

In an effort to compare storm loads for different land uses, concentration and flow data were compiled from study units in the USGS NPDES data bases. Concentration data and flow volumes were combined along with a unit-conversion factor to obtain storm loads in pounds for each storm. The storm loads then were divided by the area of the individual basins to obtain storm load per unit area, in pounds per acre. Mean storm loads for all constituents then were calculated for the three land uses in each city or metropolitan area (table 1). This manipulation allows direct comparison of the storm loads for each land use.

R0012726

Table 1. Mean storm loads in pounds per acre for 11 NPDES properties and constituents in the United States, 1991–96
[— not analyzed for; ND, 50 percent or more of values below detection limit]

Study unit	Biochemical oxygen demand	Chemical oxygen demand	Suspended solids	Dissolved solids	Total nitrogen	Total ammonia plus organic nitrogen	Total phosphorus	Dissolved phosphorus	Total recoverable copper	Total recoverable lead	Total recoverable zinc
Residential land use											
Birmingham / Montgomery, Alabama	—	7.3	1.1	1.2	0.034	0.025	0.022	0.022	5.1×10^{-2}	1.3×10^{-4}	9.6×10^{-4}
Phoenix, Arizona	0.30	1.6	4.1	1.2	.061	.050	.0067	.0030	2.7×10^{-4}	6.0×10^{-4}	3.0×10^{-3}
Little Rock, Arkansas	.41	2.6	11	1.2	.091	.060	.017	.011	1.9×10^{-4}	4.2×10^{-4}	1.5×10^{-3}
Colorado Springs, Colorado	.75	2.0	3.1	.86	.025	.022	.0048	.0018	8.3×10^{-5}	5.6×10^{-4}	1.3×10^{-3}
Denver, Colorado	.60	2.4	5.9	1.6	.068	.052	.013	.0035	6.0×10^{-4}	6.6×10^{-5}	2.9×10^{-3}
Boise, Idaho	.08	.36	.28	.17	.0013	.0064	.0009	.0006	3.1×10^{-5}	8.3×10^{-5}	4.4×10^{-4}
Davenport, Iowa	—	—	—	—	.013	.0085	.0027	.0028	—	—	—
Baton Rouge, Louisiana	.57	5.5	63	4.3	.36	.34	.059	.021	2.8×10^{-3}	1.1×10^{-2}	2.6×10^{-2}
Independence, Missouri	.49	3.0	6.3	2.4	.032	.020	.0074	.0024	9.4×10^{-4}	1.2×10^{-3}	4.8×10^{-3}
Omaha, Nebraska	.23	1.1	2.6	1.1	.042	.028	.0083	.0035	1.5×10^{-4}	3.5×10^{-4}	1.4×10^{-3}
Sioux Falls, South Dakota	.09	.35	1.5	1.3	.030	.025	.0030	.0010	ND	ND	6.2×10^{-4}
Dallas/Fort Worth, Texas	.22	2.9	3.3	2.8	.068	.047	.013	.0089	2.7×10^{-4}	5.8×10^{-4}	2.3×10^{-3}
San Antonio, Texas	.46	6.8	12	3.8	.11	.092	.022	.012	7.6×10^{-4}	2.6×10^{-3}	8.9×10^{-3}
Commercial land use											
Birmingham / Montgomery, Alabama	—	4.9	.45	.74	.019	.014	.0031	.0020	1.4×10^{-4}	2.0×10^{-4}	2.0×10^{-3}
Phoenix, Arizona	2.2	14	6.7	7.2	33	.26	.034	.027	1.1×10^{-3}	6.8×10^{-4}	1.3×10^{-2}
Little Rock, Arkansas	.81	4.4	5.1	1.8	.076	.049	.0097	.0072	6.8×10^{-4}	1.5×10^{-3}	7.6×10^{-3}
Colorado Springs, Colorado	.89	6.3	8.8	2.8	.075	.050	.0081	.0036	3.6×10^{-4}	3.1×10^{-3}	6.1×10^{-3}
Denver, Colorado	10	15	4.5	3.2	.099	.065	.0082	.0037	2.7×10^{-3}	1.5×10^{-3}	7.7×10^{-3}
Boise, Idaho	1.4	3.6	2.2	.68	.21	.21	.0079	.0043	6.3×10^{-4}	9.0×10^{-4}	4.6×10^{-3}
Davenport, Iowa	—	—	—	—	.030	.020	.0033	.0041	—	—	—
Baton Rouge, Louisiana	1.8	14	33	12	.32	.25	.034	.017	2.4×10^{-3}	9.1×10^{-3}	4.2×10^{-2}
Independence, Missouri	1.8	14	11	3.1	.13	.094	.018	.0059	1.1×10^{-3}	4.6×10^{-3}	1.4×10^{-2}
Omaha, Nebraska	.43	1.6	4.5	1.8	.046	.028	.0061	.0037	2.1×10^{-4}	5.1×10^{-4}	2.3×10^{-3}
Sioux Falls, South Dakota	.23	.49	1.3	1.6	.024	.019	.0022	.0012	ND	ND	1.1×10^{-3}
Dallas/Fort Worth, Texas	.49	4.7	4.0	4.8	.11	.068	.012	.0058	8.9×10^{-4}	2.4×10^{-3}	7.2×10^{-3}
San Antonio, Texas	.73	8.9	15	5.5	.15	.12	.028	.012	1.2×10^{-3}	4.9×10^{-3}	1.8×10^{-2}
Industrial land use											
Birmingham / Montgomery, Alabama	—	3.4	2.2	1.5	.024	.017	.0067	.0045	9.9×10^{-4}	1.7×10^{-3}	7.2×10^{-3}
Phoenix, Arizona	5.9	5.8	7.7	2.2	.099	.062	.014	.0050	1.4×10^{-3}	1.6×10^{-3}	7.2×10^{-3}
Little Rock, Arkansas	.88	4.6	3.0	2.3	.22	.19	.047	.016	5.3×10^{-4}	1.1×10^{-3}	9.4×10^{-3}
Colorado Springs, Colorado	.25	1.4	3.1	.52	.016	.011	.0017	.0010	2.0×10^{-4}	1.0×10^{-3}	3.7×10^{-3}
Denver, Colorado	5.4	9.2	22	2.4	.13	.092	.021	.0084	5.9×10^{-3}	1.2×10^{-2}	4.0×10^{-2}
Boise, Idaho	—	—	—	—	—	—	—	—	—	—	—
Davenport, Iowa	—	—	—	—	.036	.034	.0009	.0001	—	—	—
Baton Rouge, Louisiana	2.9	37	41	33	.54	.43	.074	.044	6.3×10^{-3}	3.9×10^{-2}	8.3×10^{-2}
Independence, Missouri	3.1	5.5	20	250	.033	.019	.014	.0024	8.8×10^{-4}	1.5×10^{-2}	1.1×10^{-1}
Omaha, Nebraska	1.7	6.7	66	6.5	.16	.11	.025	.012	2.2×10^{-3}	5.3×10^{-3}	2.2×10^{-2}
Sioux Falls, South Dakota	.05	.17	.62	.52	.017	.013	.0027	.0010	ND	ND	4.9×10^{-4}
Dallas/Fort Worth, Texas	.53	5.6	19	5.4	.11	.064	.020	.010	7.5×10^{-3}	4.8×10^{-3}	1.5×10^{-2}
San Antonio, Texas	.50	6.3	10	6.0	.10	.061	.025	.018	7.4×10^{-4}	1.1×10^{-3}	1.5×10^{-2}

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Physical Properties

BOD, COD, suspended solids, and dissolved solids were compared for all the cities with the exception of Davenport, Iowa; Boise, Idaho; and Birmingham/Montgomery, Alabama. Samples from Davenport, Iowa, were not analyzed for these properties and constituents. An industrial land-use basin was not sampled in Boise, Idaho. Samples from Birmingham/Montgomery, Alabama, were not analyzed for BOD.

BOD and COD are determined by measurement of the quantity of oxygen utilized by organic matter and chemicals in stormwater samples and are used to indicate pollution (Hem, 1992). Mean storm loads of BOD varied by two orders of magnitude, from 0.05 to 10 pounds per acre. The largest mean storm loads of BOD were associated with industrial land-use basins, except for the maximum that occurred in commercial land-use basins in Denver, Colorado. Mean storm loads of COD varied by two orders of magnitude, from 0.17 to 37 pounds per acre. The largest mean storm loads of COD were associated with commercial land-use sites, except for the maximum that occurred in industrial land-use basins in Baton Rouge, Louisiana.

Concentrations of suspended solids and dissolved solids are measures of solids loads in stormwater and also may be used as indicators of pollution. Mean storm loads of suspended solids varied by more than two orders of magnitude, from 0.28 to 66 pounds per acre. The largest mean storm loads of suspended solids were associated with the industrial land-use basins; the maximum occurred in Omaha, Nebraska. Mean storm loads of dissolved solids varied by more than three orders of magnitude, from 0.17 to 250 pounds per acre. The largest mean storm loads of dissolved solids were associated with industrial land-use basins; the maximum occurred in Independence, Missouri.

Nutrients

Four nutrient constituents—total nitrogen, total ammonia plus organic nitrogen, total phosphorus, and dissolved phosphorus—are being analyzed by the USGS NPDES program. These constituents were compared for all land uses in selected cities, with the exception of industrial land-use basins in Boise, Idaho. An industrial land-use basin was not part of the sampling program in Boise.

Nutrients are essential components in plant growth; however, an overabundance of these constituents will cause undesirable algal blooms in bodies of water that are used for urban drinking-water supplies (Hem, 1992). These algal blooms cause adverse effects on the taste and odor of drinking water and have the potential to cause more serious health problems.

Mean storm loads of total nitrogen varied by more than two orders of magnitude, from 0.0013 to 0.54 pounds per acre. The largest mean storm loads of total nitrogen are associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

Mean storm loads of total ammonia plus organic nitrogen varied by almost two orders of magnitude, from 0.0064 to 0.43 pounds per acre. The largest mean storm loads of total ammonia plus organic nitrogen were associated with industrial and commercial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

Mean storm loads of total phosphorus varied by almost two orders of magnitude, from 0.0009 to 0.074 pounds per acre. The largest mean storm loads of total phosphorus were associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

Mean storm loads of dissolved phosphorus varied by more than three orders of magnitude, from 0.0001 to 0.044 pounds per acre. The largest mean storm loads of dissolved phosphorus were associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.



Figure 2. National Pollutant Discharge Elimination System (NPDES) residential land-use site at Glendale, Arizona.

R0012728

Trace Metals

Concentrations of four trace-metal constituents—total recoverable copper, total recoverable zinc, total recoverable cadmium, and total recoverable lead are being analyzed by the USGS NPDES program. These constituents were compared for all land uses in the selected cities with the exception of Davenport, Iowa, and Boise, Idaho. Concentrations of these constituents were not determined in Davenport, Iowa, and an industrial land-use basin was not sampled in Boise, Idaho.

Copper and zinc are essential to plant and animal metabolism and are needed in small amounts by all plants and animals. Large amounts of these metals in drinking water, however, can cause adverse effects on the taste and odor of drinking water.

Mean storm loads of total recoverable copper varied by more than three orders of magnitude, from 3.1×10^{-5} to 5.1×10^{2} pounds per acre. The largest mean storm loads of total recoverable copper were associated with commercial and industrial land-use basins. The exception was the maximum that occurred in a residential land-use basin in Birmingham/Montgomery, Alabama.

Mean storm loads of total recoverable zinc varied by almost three orders of magnitude, from 4.4×10^{-4} to 1.1×10^{-1} pounds per acre (fig. 3). The largest mean storm loads of total recoverable zinc were associated with industrial land-use basins, the maximum occurred in Independence, Missouri.

Cadmium and lead tend to bioaccumulate in plants and animals. Large concentrations of these metals lead to toxicity and health problems in plants and humans (Hem, 1992).

Concentrations of total recoverable cadmium were considered in this analysis of data, but more than 70 percent of the analyses were below detection limits. No mean storm loads of cadmium were included in the data tables.

Mean storm loads of total recoverable lead varied by almost three orders of magnitude, from 8.3×10^{-5} to 3.9×10^{-2} pounds per acre. The largest mean storm loads of total recoverable lead were associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

The majority of minimum mean storm loads occurred in residential land-use basins and the majority of maximum mean storm loads occurred in industrial land-use basins. The information contained in this fact sheet is part of ongoing studies and may be updated upon completion of the NPDES program.

—Kenneth D. Fossum and Dawn S. McDoniel

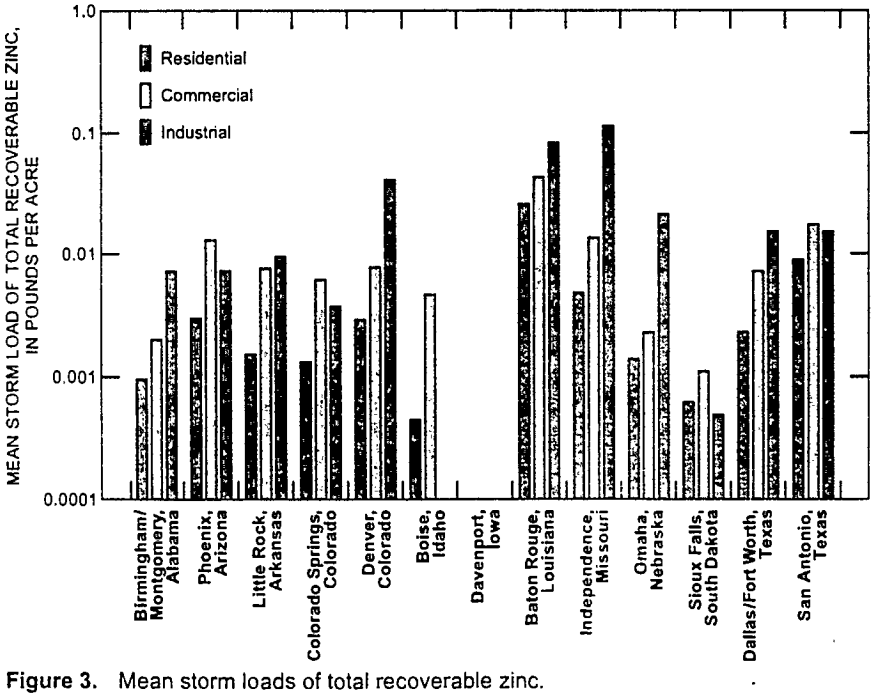

Figure 3. Mean storm loads of total recoverable zinc.

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January 1998

USGS Fact Sheet
FS-192-97

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Appendix D
Costs

LACDPW WATER QUALITY MONITORING COSTS 2000-2001 Storm Season Totals as of: 06/13/2000								
Element	No. of Sites	No. of Events*	Capital (not including 1990 permit costs)	Sampling Labor	Materials	Station Maintenance	Laboratory	TOTAL
Receiving Waters	0	0	$0	$0	$0	$0	$0	$0
Mass Emissions	5	12	$0	$23,316	$0	$0	$9,366	$32,682
Land Use	7	13	$0	$10,470	$0	$0	$141,031	$151,500
Critical Source	30	9	$33,293	$76,322	$0	$0	$113,953	$223,568
River Toxicity	0	0	$0	$0	$0	$0	$0	$0
El Niño Study	0	0	$0	$0	$0	$0	$0	$0
Aerial Deposition	1	14	$75,000	N/A	N/A	N/A	N/A	$75,000
TOTAL 2000-2001	43	48	$108,293	$110,108	$0	$0	$264,350	$482,751

N/A = Not Applicable
* Not every station collected every storm.

Appendix E
Contacts

TOPIC	CONTACT	TELEPHONE	E-MAIL
Rainfall Data	Belinda Kwan, LACDPW	(626) 458-6135	bkwan@dpw.co.la.ca.us
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GIS data, Hydrographs, and Pollutant Loading	Eduardo Escobar, LACDPW	(626) 458-3582	eescobar@dpw.co.la.ca.us
Critical Source Monitoring Program	Mert Ramos, LACDPW	(626) 458-3528	mramos@dpw.co.la.ca.us
Land Use Monitoring Program	Bill DePoto, LACDPW	(626) 458-3537	bdepoto@dpw.co.la.ca.us
Mass Emission Monitoring Program	Bill DePoto, LACDPW	(626) 458-3537	bdepoto@dpw.co.la.ca.us
Automated Sampling Equipment	Mert Ramos, LACDPW	(626) 458-3528	mramos@dpw.co.la.ca.us
Industrial Stormwater Permits	Robert Tom, LARWQCB	(213) 576-6789	rtom@rb4.swrcb.ca.gov

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United States General Accounting Office

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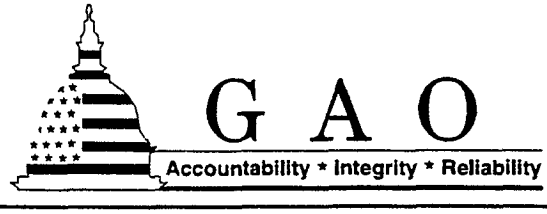
Report to Congressional Requesters

June 2001

WATER QUALITY

Better Data and Evaluation of Urban Runoff Programs Needed to Assess Effectiveness





GAO-01-679

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Abbreviations

BMP	best management practices
CSO	combined sewer overflow
DOT	Department of Transportation
DPW	Department of Public Works
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
MCTT	Multi-Chambered Treatment Tank
MDE	Maryland Department of Environment
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
PAH	polycyclic aromatic hydrocarbons
PCB	polychlorinated biphenyls
TEA-21	Transportation Equity Act for the 21st Century
TMDL	total maximum daily load
USGS	U.S. Geological Survey
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System

R0012736

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United States General Accounting Office
Washington, D.C. 20548

June 29, 2001

The Honorable Olympia Snowe
United States Senate

The Honorable Sherrod Brown
The Honorable Martin Meehan
The Honorable James Oberstar
The Honorable Jack Quinn
House of Representatives

Nonpoint source pollution—that is, pollution from contaminants picked up and carried into surface water by water running over land—is known to be one of the leading causes of water quality problems in the United States. Water that runs over developed areas, including paved surfaces such as roads and parking lots, before reaching a water body is known as urban runoff and is an increasingly important category of water pollution. As urban areas have expanded over the past several decades, the amount of urban runoff has also increased. Although the overall quality of the nation's waters has improved since the passage of the Clean Water Act in 1972, a significant number of water bodies still suffer from poor water quality. Because the act brought discharges from "point sources," such as industrial plants and municipal treatment plants, under control, the continuing pollution of these waters suggests that other sources, including urban runoff, are contributing to water quality problems. As a result, the Environmental Protection Agency (EPA) now classifies urban runoff as a significant cause of impairment to water quality. The Water Quality Act of 1987, which amended the Clean Water Act, required EPA, among other things, to regulate as a point source urban runoff that reaches municipal sewer systems. EPA's National Pollutant Discharge Elimination System Program for storm water requires that certain local governments take measures to control storm water runoff.

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Concerned about the degradation of water quality in urban areas, you asked us to report on (1) the amount of runoff from urban areas, particularly from roads, highways, and other impervious surfaces,[1] and its effects on water quality and (2) the programs that federal regulations require local governments to develop to address urban runoff, and the costs and effectiveness of those programs. To address these issues, we reviewed federal and other studies and interviewed experts on the relationship between the amount of paved and other impervious surfaces and the amount of runoff, and on the types of materials typically contained in urban runoff. We also reviewed studies and interviewed experts on the sources of these materials and any actual or potential effects on water quality from urban runoff. We visited five urban areas and organizations that are affiliated with their watersheds[2] to obtain site-specific information about urban runoff problems, programs these areas have implemented in response to federal requirements, and the costs and effectiveness of these programs. Finally, we reviewed studies and estimates of the costs and investment requirements associated with implementing storm water management programs. Because this report focuses on local governments' actions, we did not review the portions of the National Pollutant Discharge Elimination System Storm Water Program that address industrial facilities and construction sites.

We performed our review from August 2000 through May 2001 in accordance with generally accepted government auditing standards.

Results in Brief

The volume of urban storm water runoff increased throughout the United States in the last half of the 20th century because of the growth in impervious surfaces that resulted from the development of urban and suburban areas. According to the U.S. Department of Agriculture, between 1945 and 1997, land devoted to urban areas in the United States has increased by about 327 percent; according to EPA, paved road mileage has increased by 278 percent. Because paved surfaces are almost impervious, they allow little storm water to infiltrate the ground; therefore, the storm water runs off into creeks, rivers, and lakes. As storm water runs across these impervious surfaces and land, it picks up pollutants from these surfaces and carries them to receiving bodies of water—either directly or

[1]An impervious surface keeps water from soaking into soils.

[2]A watershed is an area of land in which all surface water drains to a common point.

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through conveyances such as gutters, storm sewers, and culverts. EPA's 1998 *National Water Quality Inventory Report to Congress* showed that certain rivers, streams, lakes, and estuaries are impaired in terms of their ability to support such uses as aquatic life, swimming, and fish consumption, and concluded that urban runoff was a major source of this impairment. Studies have shown that urban runoff and the pollutants it carries can cause increases in sedimentation, water temperature, and pathogen levels and decreases in dissolved oxygen levels in bodies of water. These changes can lead to the degradation of habitat in these water bodies and a decline in diversity of aquatic life and can endanger public health. For example, metals, a pollutant typically found in urban runoff, can be toxic to aquatic organisms. Pathogens, such as bacteria from animal waste, another pollutant commonly found in urban runoff, can pose public health problems when present in waters used for recreational purposes. The magnitude and nature of these effects vary by region, depending on the type and concentration of pollutants in storm water, rainfall characteristics, land use, and other factors.

Local governments are required to address urban runoff through EPA's National Pollutant Discharge Elimination System Storm Water Program. Under permits that EPA and states issue through this program, over 1,000 local governments must meet EPA's requirements to implement storm water management programs to reduce contaminants in storm water to the "maximum extent practicable." EPA recommends that these cities use "best management practices" to reduce contaminants in storm water runoff. The most typical practices included controlling runoff through a combination of structural means, such as detention ponds, and nonstructural means, such as increasing the frequency of street sweeping and educating the public about how to prevent pollutants from reaching storm sewers. Cities also used specialized practices to address specific local runoff problems. For example, Baltimore, Maryland, has focused on reducing the level of nutrients, such as fertilizers, in its runoff because of its proximity to the Chesapeake Bay, which suffers from high nutrient levels.

Neither the overall costs of implementing the storm water program nor the program's effectiveness has been determined. EPA estimated in a 1996 report to congress that the potential need for spending on storm water runoff and overflows of sewage resulting from runoff was over $50 billion over 20 years, but the agency also believes this estimate will increase when it issues its next report in 2002. EPA's regulations require that permitted cities annually report the costs of implementing their storm water

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programs, along with the results of their monitoring of storm water runoff and water quality. However, in part because EPA has not established guidelines for reporting costs, these data have not been calculated or reported consistently and, therefore, are not currently useful in characterizing the program's overall cost. EPA, state, and city officials generally believe that managing storm water runoff will reduce the volume of runoff and concentrations of pollutants in the runoff, as well as improve water quality, but no systematic effort to evaluate the program's results has been started. EPA and the states have generally been unsuccessful in developing measurable program goals and in demonstrating program effectiveness through the review of water quality data reported by local governments.

We believe it is time for EPA to begin evaluating this program, which is directed at one of the nation's most significant water quality problems. Therefore, this report includes a recommendation to EPA to work with states to develop program goals, establish standards for reporting on program costs and effectiveness, and review reported water quality data to determine whether the current storm water management programs are having the intended effect of improving the quality of the nation's waters and how much the programs cost. We provided a draft of this report to EPA and the Department of Transportation (DOT). EPA generally agreed with the report and plans to take action to implement several parts of the recommendation; the agency did not comment on the other parts of the recommendation. DOT generally agreed with the report. (See the Agency Comments and Our Evaluation section of this report.)

Background

Nonpoint source pollution can result when water, such as precipitation, runs over land surfaces and into bodies of water. Significant nonpoint sources of pollution can include paved urban areas, agricultural practices, forestry, and mining. However, in urban and suburban areas, this runoff generally enters a sewer system that can be regulated as a point source of water pollution. For example, precipitation from rain or snowmelt may run into a municipal separate storm sewer system (MS4 or storm sewer) that eventually discharges into a body of water. The precipitation may also run into a combined sewer system, which carries a combination of storm water runoff, industrial waste, and raw sewage in a single pipe to a sewage treatment facility for discharge after treatment. Lastly, the precipitation may run off of land or paved surfaces directly into nearby receiving waters.

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EPA's Office of Wastewater Management, which is within the Office of Water, implements the National Pollutant Discharge Elimination System (NPDES) Program. The program was created in 1972 with the passage of the Clean Water Act. Created to control water pollution from point sources—those sources, such as a factory or wastewater treatment plant, that contribute pollutants directly into a body of water from a pipe or other conveyance—the NPDES Program did not specifically address storm water discharges. In 1987, the Congress amended the Clean Water Act with the Water Quality Act, which directed EPA to also control storm water discharges that enter MS4s—essentially requiring EPA to treat such storm water as a point source.[3] MS4s are defined as those sewers that collect and convey storm water; are owned or operated by the federal, state, or local government; and are not part of a publicly owned treatment (sewage) facility.

To regulate urban storm water runoff, EPA published regulations in 1990 that established the NPDES Storm Water Program and described permit application requirements. According to EPA, the program's objective, in part, is to preserve, protect, and improve water quality by, among other things, controlling the volume of runoff from paved surfaces and by reducing the level of runoff pollutants to the maximum extent practicable using best management practices (BMP).[4] The 1987 act also authorized EPA to implement a program that provides federal funds and technical assistance to states to develop their own nonpoint source pollution management programs. States can use the federal funds they receive for nonpoint source programs to address nonpoint sources of pollution as well as urban runoff.

Currently, EPA manages NPDES Storm Water programs in six states (Alaska, Arizona, Idaho, Massachusetts, New Hampshire, and New Mexico) and has delegated authority to the remaining 44 states to manage these programs. The storm water program is being implemented in two phases. Local governments meeting the following criteria must comply with EPA's storm water program regulations. First, Phase I of the program requires that municipalities with a population of 100,000 or more obtain a permit for their MS4 system; second, the program requires that entities obtain a

[3]Section 402(p) of the Clean Water Act.

[4]According to EPA, a best management practice is a device, practice, or method for removing, reducing, retarding, or preventing targeted storm water runoff constituents, pollutants, and contaminants from reaching receiving waters.

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permit if they discharge storm water from sites with industrial activities, including construction activities that disturb 5 acres or more of land. In addition, NPDES permitting authorities may also bring other municipalities and industrial entities into the program if they deem it necessary. Municipalities that meet these conditions must submit a permit application to EPA or the governing regulatory state agency. In 1990, the regulations specifically identified 220 municipalities throughout the United States that were required to apply for a Phase I permit. According to EPA, as of April 2001, about 256 Phase 1 MS4 permits had been issued and about 17 more still needed to be issued. Because some permits cover more than one municipality, these permits cover about 1,000 medium and large municipalities nationwide.

The final rule for Phase II of the program was issued in December 1999. Phase II extends Phase I efforts by requiring that a storm water discharge permit be obtained by (1) operators of all MS4s not already covered by Phase I of the program in urbanized areas[5] and (2) construction sites that disturb areas equal to or greater than 1 acre and less than 5 acres of land. As with Phase I of the program, permitting authorities may require additional small MS4s and construction sites to obtain a permit if they are a significant contributor of pollutants. Currently, EPA anticipates that about 5,000 municipalities may be subject to permitting requirements under Phase II of the storm water program. These municipalities are required to obtain permits no later than March 10, 2003.

[5]The Bureau of the Census generally defines an urbanized area as a land area comprising one or more places—central place(s)—and the adjacent densely settled surrounding area—urban fringe—that together have a residential population of at least 50,000 and an overall population density of at least 1,000 per square mile.

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EPA also regulates combined sewer overflows (CSO) that can be caused by urban storm water runoff. Combined sewer systems, in which storm water enters pipes already carrying sewage, may overflow when rain or snowmelt entering the system exceeds the system's flow capacity. In the CSO that results, the mixture of untreated sewage and runoff bypasses the water treatment facility and is diverted directly into receiving waters. (See fig. 1 for an illustration of combined and separate sewer systems.) These combined systems generally serve the older parts of approximately 900 cities in the United States. Pipes carrying sewage and storm water separately generally serve newer parts of cities. EPA's 1994 CSO policy requires communities with combined sewer systems to take immediate and long-term actions to address CSO problems. The policy contains provisions for developing appropriate, site-specific NPDES permit requirements for all combined sewer systems that overflow because of wet-weather events. The Wet Weather Water Quality Act of 2000 requires that any permit, order, or decree issued for a CSO conform to the 1994 policy. Under this act, EPA is also required to submit a report to the Congress by September 2001 on the status of the program.[6]

[6]Sanitary sewer overflows, which are illegal under the Clean Water Act, can also result from rainfall. A sanitary sewer overflow may occur when rainwater or snowmelt leaks into sanitary sewage pipes, thereby exceeding the pipes' capacity and causing them to overflow. This discharge of raw sewage from municipal sanitary sewer systems can release untreated sewage into places such as streams, basements, and streets. EPA proposed regulations to require municipalities to reduce the number of overflows. However, these regulations have been withdrawn for further review.

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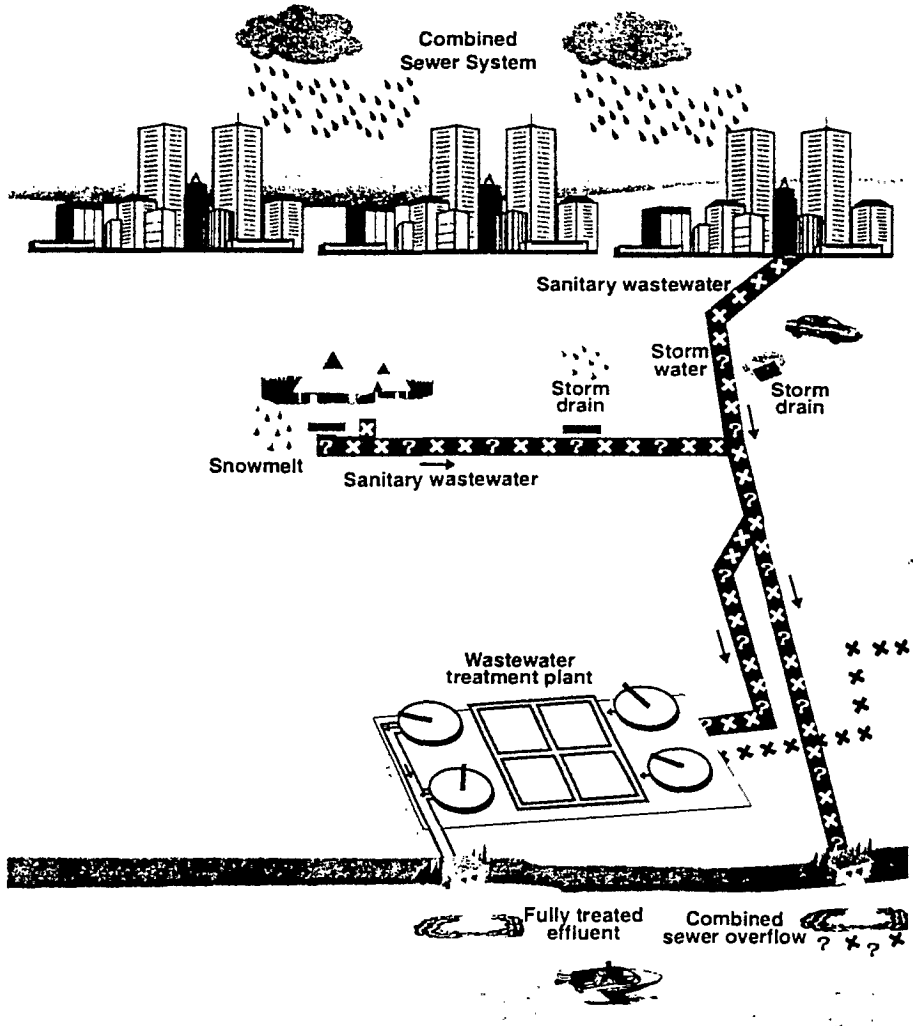
Figure 1: Urban Runoff Flows in Different Types of Sewer Systems



✖ Sanitary sewage/wastewater
? Storm water runoff with potential contaminants

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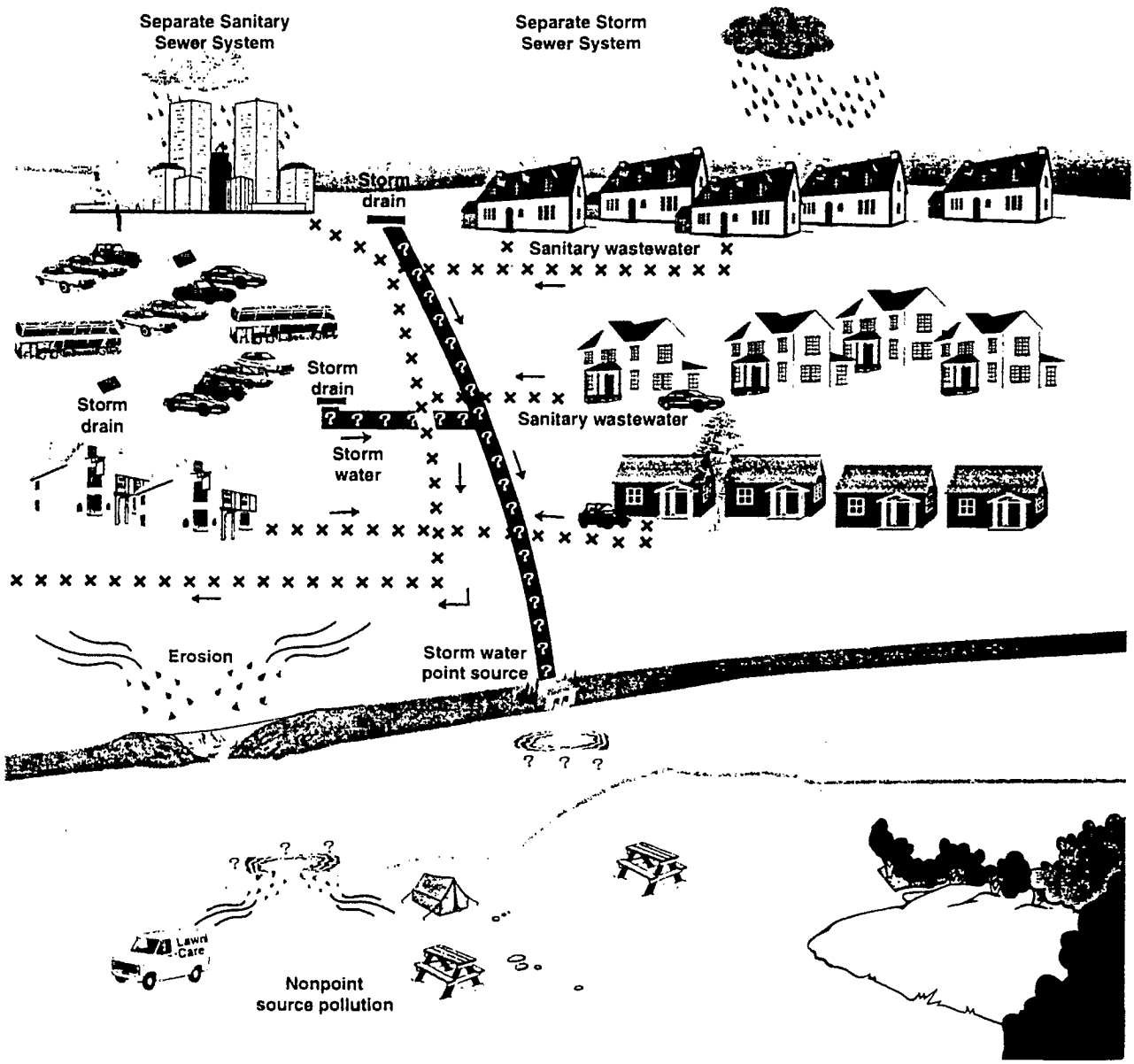

Source: GAO illustration based on EPA data.

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The Total Maximum Daily Load (TMDL) Program, established under the Clean Water Act, is intended to address water bodies that do not meet water quality standards because of pollutant loadings from point and nonpoint sources. Currently, it is unclear how and when this program will affect EPA's and states' issuance of storm water permits. A TMDL is a calculation of the maximum amount of a pollutant that a body of water can receive and still meet the water quality standard set by the state. Under EPA's regulations, the state is to allocate this "pollutant load" among the point and nonpoint pollutant sources that flow into the water body and then take steps to ensure that no source exceeds its assigned load. In 1996, EPA issued a policy that outlined an interim approach to including water quality standards in storm water permits. The policy promoted the use of BMPs in the first 5-year term permits, followed by a tailoring of BMPs in the second round of permits as necessary to comply with water quality standards. Until recently, few TMDLs had been established, and citizen organizations sued EPA for its lack of action. EPA issued a new set of regulations for the TMDL Program in 2000, but the Congress prevented EPA from spending money to implement the rule in 2000 and 2001. It is possible that establishing a TMDL for a body of water could result in the application of a numeric effluent limit to outfalls[7] that release storm water into that body of water. Some city officials we spoke with generally felt that numeric effluent limits would significantly increase the cost of managing storm water.

Volume of Urban Runoff Increases With the Expansion of Urban Development and Can Affect Water Quality

Since World War II, urban runoff has increased throughout the United States. This increase is directly related to growth in the amount of impervious surfaces due to urban and suburban development and the construction of roads, highways, and other impervious surfaces. Coinciding with this growth in impervious surfaces has been a reduction in wetlands and in the amount of storm water that infiltrates the ground to recharge aquifers. Moreover, the loss of vegetation due to development and related runoff can cause major erosion. Ultimately, much of this runoff is channeled into gutters, storm drains, and paved channels, and vegetation and sediment removed with the runoff may end up in receiving waters. EPA has identified urban storm water runoff as one of the leading sources of pollution to the nation's rivers, streams, lakes, and estuaries. Runoff from impervious surfaces picks up potentially harmful pollutants and

[7]An outfall is an outlet, such as a pipe, that allows storm water to flow into a river, lake, or other body of water

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carries them into receiving waters. Studies have shown that urban runoff and the pollutants it carries can negatively affect water quality, aquatic life, and public health.

Paved Surfaces Have Increased With Urban and Suburban Expansion and Growth in Automobile Use

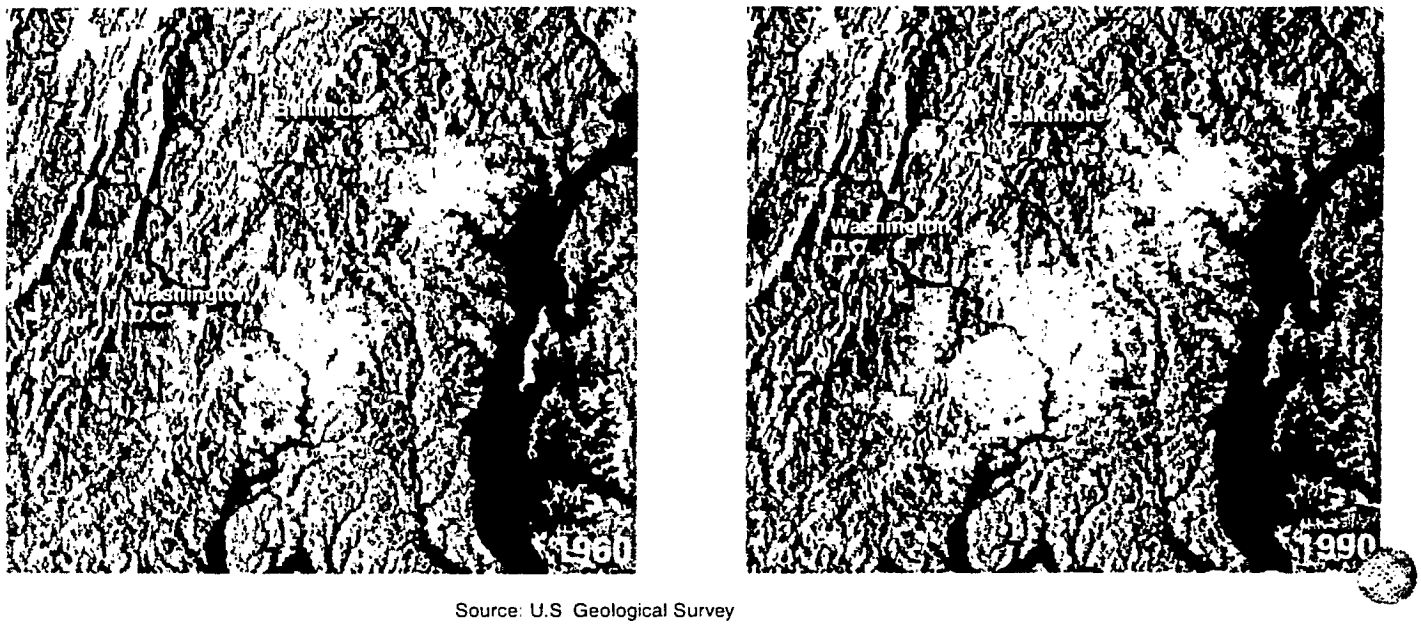
According to the U.S. Department of Agriculture, between 1945 and 1997, urban land area increased by almost 327 percent, from 15 million acres to about 64 million acres in the contiguous 48 states. From 1992 through 1997, the annual rate of development averaged about 1 million acres per year. The land developed between 1945 and 1997 came primarily from forestland and pasture and range.[8] For example, according to the Bureau of the Census, between 1960 and 1990, the amount of land used for urban purposes in Baltimore, Maryland, and Washington, D.C., grew by about 170 percent and 177 percent, respectively. As a result, urbanization, with its accompanying expansion of impervious surfaces like sidewalks, roofs, parking lots, and roads, has significantly increased the nation's total developed land and paved surface area.[9] Figure 2 demonstrates the growth in the urbanized areas of Baltimore and Washington, D.C., over the last half of the 20th century.

[8] *Agricultural Resources and Environmental Indicators, 2000.* U.S. Department of Agriculture, Economic Research Service, Resource Economics Division.

[9] *Our Built and Natural Environments, A Technical Review of the Interaction Between Land Use, Transportation and Environmental Quality,* U.S. Environmental Protection Agency (EPA 231-R-00-005, Nov 2000).

R0012747

Figure 2: Increase in Urbanized Land in Selected Cities, 1960-90



Source: U.S Geological Survey

The increase in paved surfaces has been spurred not only by urban and suburban development, but also by a steady increase in the use of automobiles, the primary mode of daily transportation for most Americans. Roads also play an important role in the economy of the United States, since trucks carry about 75 percent of the value of all goods shipped. According to EPA, paved road mileage in the United States increased by 278 percent from 1945 to 1997. In 1945, 19 percent of the public roads in the country were paved; by 1997, that percentage had increased to 61. (See fig. 3.) According to a 1999 study, motor-vehicle infrastructure, such as roads and parking lots, accounts for close to half of the land area in U.S. urban cities.[10]

[10] *Stormwater Strategies, Community Responses to Runoff Pollution*, Natural Resources Defense Council (May 1999).

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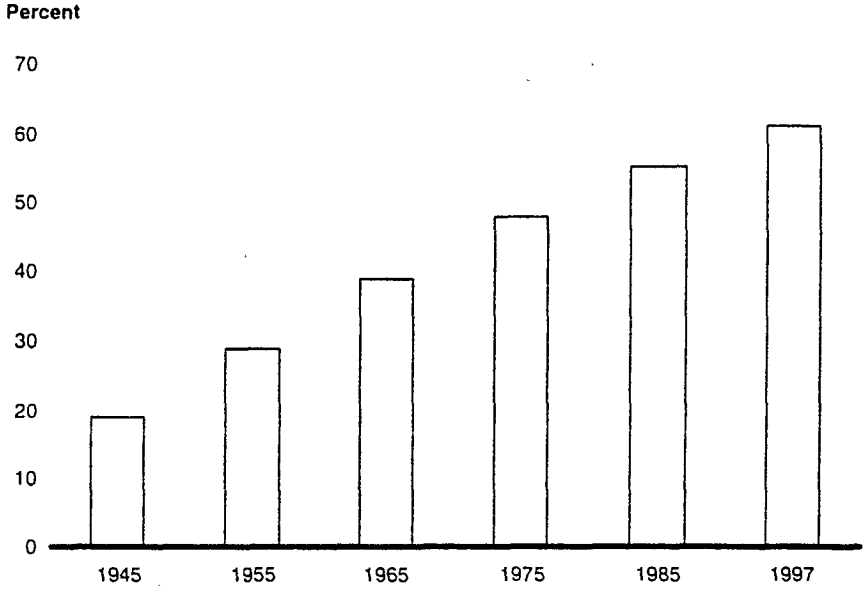
Figure 3: Percentage of Paved Public Road Miles, 1945-97



Source: EPA.

Increase in Impervious Surfaces Leads to Increased Runoff

The increase in impervious surfaces over the past several decades has led to an increase in storm water runoff. In part, this has occurred because highways and other developments have reduced the amount of wetlands and other undeveloped land. Wetlands mitigate the effects of storm water runoff by acting as a natural form of flood control, facilitating sediment replenishment, and improving water quality by removing excess nutrients and other chemical contaminants before the contaminants can affect receiving waters. According to a 2000 EPA report,[11] of the 12 states that listed wetland losses, six reported that they had significant losses due to highway construction, and 10 reported that they had significant losses due to residential growth and development. However, the effect of road building on wetland loss has been reduced in recent years. According to a Federal Highway Administration (FHWA) official, since 1996, wetlands have been replaced and restored under the Federal-Aid Highway Program

[11]See footnote 9.

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at an average rate of 2.7 acres for every acre lost to highway building. Other undeveloped land with vegetation also performs some of the roles that wetlands play in managing runoff, although to a lesser extent.

Furthermore, as impervious surfaces increase, less storm water is able to infiltrate through the soil to groundwater. Impervious areas allow only a very small amount of initial infiltration compared with unpaved areas whose infiltration capacity varies, depending on the soil type. Figure 4 demonstrates EPA's estimates of the impact of impervious surfaces on the percentages of storm water that runs off, infiltrates the ground, and is lost through evapotranspiration.[12] When natural ground cover is present over an entire site, normally 10 percent of precipitation runs off the land into nearby creeks, rivers, and lakes. In contrast, when a site is 75- to 100-percent impervious, 55 percent of the precipitation runs off into these receiving waters. However, according to an FHWA official, the runoff rates can be reduced if developers take mitigating actions to develop and implement BMPs to control flooding or runoff.

[12]Evapotranspiration represents water loss from evaporation and the absorption and eventual release into the atmosphere of water that plants and trees have collected. The extent to which evapotranspiration occurs is dependent primarily on the solar energy available to vaporize the water. As a result, the effect of evapotranspiration varies greatly across the country

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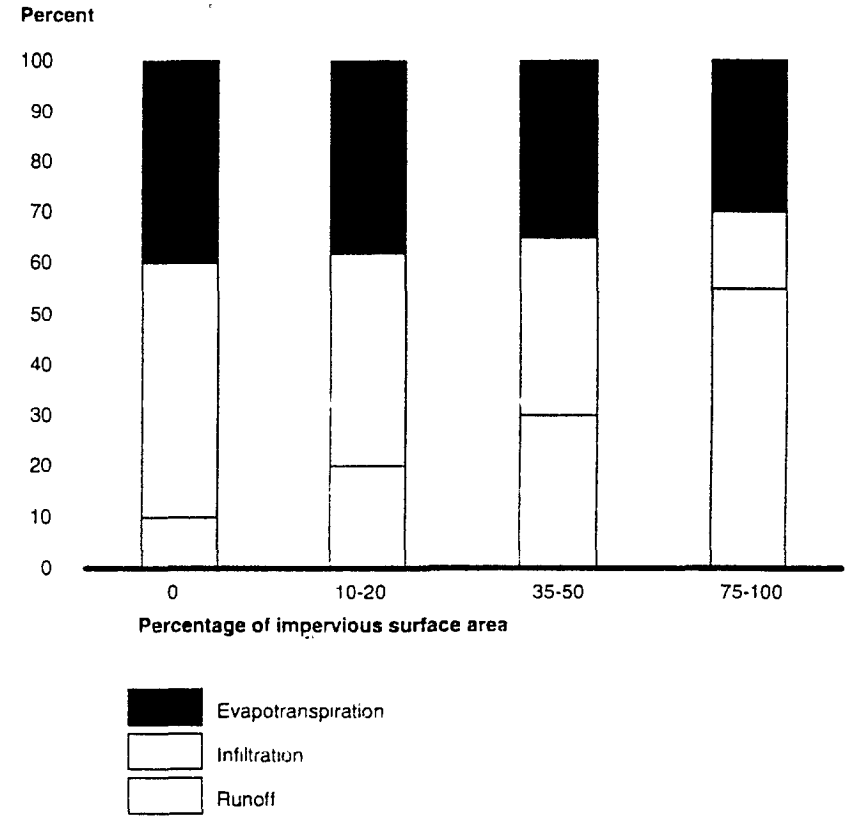
Figure 4: Impact of Impervious Surfaces on the Amount of Storm Water That Runs Off, Infiltrates, and Evapotranspires



Source. EPA

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The decrease in storm water infiltration that accompanies urbanization also reduces the amount of water that is available to recharge groundwater supplies. For this reason, reduced infiltration may lead to problems with the water table in certain urban areas. For example, a Massachusetts Department of Environmental Protection official noted that a low recharge rate affects water quality because it can result in a loss of wetlands and adversely affect aquatic habitat as water-table levels fall during dry weather.[13] In addition, officials from the Charles River Watershed Association in Massachusetts are concerned that the lack of infiltration might cause some communities to run short of drinking water in the next 20 years.

Urban Runoff Has the Potential to Impair Water Quality and Disrupt Biological Integrity

Urban runoff can adversely affect the quality of the nation's waters, and urban storm water runoff has been identified as one of the leading sources of pollution to rivers, streams, lakes, and estuaries.[14] Section 305(b) of the Clean Water Act requires states and other jurisdictions to report on the quality of their waters to EPA every 2 years. The 1998 *National Water Quality Inventory Report to Congress* showed that 35 percent of assessed river and stream miles, 45 percent of assessed lake acres, and 44 percent of assessed estuarine square miles were impaired in terms of their ability to support uses such as aquatic life, swimming, and fish consumption.[15] The report identified urban storm water runoff as one of the leading sources of impairment to the assessed waters.

[13]Dry weather is defined as a period when rainfall measuring at least 0.10 of an inch has not occurred for 72 hours.

[14]Other leading sources of pollution include agricultural runoff, municipal point sources, hydrologic modifications, and atmospheric deposition.

[15]Information contained in the 1998 report reflects only those waters assessed by states and other jurisdictions and cannot be used to characterize nationwide water quality. Furthermore, water quality standards among states are not identical, and the monitoring design used to collect data differed among states.

R0012752

Studies have shown that as the percentage of impervious cover increases within a watershed, biodiversity also declines. Research conducted by the Center for Watershed Protection found that, generally speaking, when a watershed has 10 percent or less impervious cover, the associated stream can be categorized as sensitive.[16] Sensitive streams are characterized as having high fish diversity and good water quality. Once the percentage of impervious cover exceeds 25 to 30 percent of the watershed, however, streams tend to become nonsupporting. Nonsupporting streams are highly unstable, have poor diversity of fish and aquatic life, and have poor water quality. For example, one study evaluated the relationship between the extent of impervious cover in watersheds to the number and diversity of fish populations in 47 small streams in southeastern Wisconsin between the 1970s and 1990s.[17] The results revealed that the number of fish species per site was highly variable for drainage areas that had less than 10-percent imperviousness. In contrast, sites that had greater than 10-percent imperviousness had consistently low numbers of fish species.

Other studies have associated urban runoff with basic changes in the receiving body of water. Runoff can carry sediment into surface water, and this sediment can carry contaminants, harm aquatic plants, and smother organisms. Runoff can also be warmed by the impervious surfaces it flows across. When sufficient amounts of warmed runoff enter a water body, the water temperature can rise. Less oxygen is then available for aquatic organisms because water holds less oxygen as it becomes warmer. These combined factors lead to the degradation of aquatic habitat. According to EPA, the common effects of these types of pollution on aquatic life include a decline in biodiversity and an increase in invasive species.

An increase in the volume of storm water runoff also increases the likelihood of erosion, which allows for transport of eroded sediment downstream into receiving waters. For example, during a site visit, we observed extensive erosion along the Gingerville Creek Subbasin in Anne Arundel County, Maryland, that was caused by urban runoff channeled into the creek. Figure 5 depicts the eroded banks and channel of this creek.

[16]"The Importance of Imperviousness," *Watershed Protection Techniques*, v.1:3, Fall, 1994. The article reviews 18 studies on the relationship between urbanization and stream quality.

[17]L. Wang and others, "Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams," *Journal of the American Water Resources Association*, Oct. 2000, Vol. 36, No. 5.

R0012753

Figure 5: Damage Caused by Storm Water Runoff From Urbanized Areas in the Gingerville Creek Subbasin



Source: Anne Arundel County, Maryland, Department of Public Works.

Contaminants in Urban Runoff Can Affect Aquatic Life and Human Health

There have been several efforts to characterize the chemicals and other constituents in urban runoff. The Nationwide Urban Runoff Program, conducted by EPA between 1978 and 1983, examined the characteristics of urban runoff. Another federal effort to characterize urban runoff is an ongoing joint project of the U.S. Geological Survey (USGS) and the FHWA to evaluate guidelines for highway runoff. As table 1 indicates, these studies and others have shown that the principal contaminants found in

R0012754

urban runoff include nutrients, solids, pathogens, metals, hydrocarbons, organics, salt, and trash. Water flowing over various surfaces, such as streets, parking lots, construction sites, industrial facilities, rooftops, and lawns, carries these pollutants to receiving waters. The contaminants have the potential to impair water quality, degrade aquatic ecosystems, and pose health risks to swimmers.

Table 1: Storm Water Pollutants in Urban Runoff, Including Sources and Potential Impacts

Contaminant	Source	Potential impact
Nutrients		
Nitrogen, phosphorous	Animal waste, fertilizers, failing septic systems, atmospheric deposition,[a] CSOs	Nutrient enrichment can cause an excessive growth of algae. Nuisance levels of algae are associated with dissolved oxygen deficiencies leading to fish kills, loss of submerged aquatic vegetation that serves as a habitat for aquatic organisms, and loss of natural biodiversity.
Solids		
Sediment	Construction sites, other disturbed and/or nonvegetated lands, eroding banks, road sanding	Sediment can cause infection and disease among fish, scour submerged aquatic vegetation, prevent sunlight from reaching aquatic plants, and bury bottom-dwelling aquatic organisms.
Pathogens		
Bacteria, viruses	Animal waste, failing septic systems, illicit connections and discharges to storm sewer system, CSOs	Pathogens entering waters used for recreational purposes can pose human health risks.
Metals		
Lead, cadmium, copper, zinc, mercury, chromium, aluminum, and others	Industrial processes, normal wear of automobile brake linings and tires, automobile emissions, automobile fluid leaks, metal roofs	Metals can cause acute or chronic toxicity for aquatic organisms.
Hydrocarbons		
Oil and grease, polycyclic aromatic hydrocarbons	Industrial processes, automobile wear, automobile emissions, automobile fluid leaks, waste oil	Hydrocarbons have the potential to be acutely toxic for aquatic organisms and several are suspected carcinogens.
Organics		
Pesticides, polychlorinated biphenyls (PCB), synthetic chemicals	Pesticides (herbicides, insecticides, fungicides, rodenticides, etc.), industrial processes	Low concentrations of some organics have the potential to bioaccumulate in the food chain.

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(Continued From Previous Page)

Contaminant	Source	Potential impact
Salt		
Sodium Chlorides	Road salting and uncovered salt storage	Salt can damage roadside vegetation, transport high levels of chlorides to receiving waters, and degrade aquatic ecosystems. Chloride can be harmful to some species of fish.
Trash		
	Street refuse and improperly discarded waste material	Trash impairs water quality by inhibiting the growth of aquatic vegetation and conveys nutrients, toxic substances, and other pollutants to aquatic ecosystems.

[a]Atmospheric deposition occurs when pollutants in the air fall on land or water.

Sources: Massachusetts Department of Environmental Protection Stormwater Policy; EPA reports and guidance, including *Preliminary Data Summary of Urban Storm Water Best Management Practices, Combined Sewer Overflow Control Policy, Innovative Urban Wet-Weather Flow Management Systems,* and the 1998 *National Water Quality Inventory Report to Congress*; the California Regional Water Quality Control Board; the Natural Resources Defense Council's *Stormwater Strategies: Community Responses to Runoff Pollution*; "Accretion of Pollutants in Roadway Snow Exposed to Urban Traffic and Winter Storm Maintenance Activities - Part I," Draft;[18] and USGS' National Water Quality Assessment Program.

[18]J.J. Sansalone and D.W. Glenn, "Accretion of Pollutants in Roadway Snow Exposed to Urban Traffic and Winter Storm Maintenance Activities –Part I," DRAFT.

R0012756

In our visits to cities with Phase I permits and their watersheds, we identified specific instances in which these contaminants had affected water quality. The Chesapeake Bay, for example, has been polluted with the nutrients nitrogen and phosphorus and with excess sediment caused, in part, by urban runoff. The excess nutrients cause algae blooms that block sunlight from reaching bay grasses—which are a source of food, shelter, and nursery grounds for many aquatic species. In an effort to control nutrient pollution in the Chesapeake Bay, the Executive Council of the Chesapeake Bay Program[19] established a goal to reduce the nitrogen and phosphorus entering the Chesapeake Bay by 40 percent, including through control of runoff from urban areas. In addition, an assessment of the status of chemical contaminant effects on living resources in the bay's tidal rivers found "hot spots" of contaminated sediment. As a result, the Baltimore Harbor and the Patapsco River in Maryland; the Anacostia River in Washington, D.C.; and the Elizabeth River in Virginia were designated as "regions of concern." Urban storm water runoff is a significant source of contaminants in the three regions. The Chesapeake Executive Council has committed to reduce by 30 percent the chemicals of concern in the regions of concern by 2010 through pollution prevention measures and other voluntary means.[20]

Pathogens such as bacteria and viruses, which are often present in urban runoff, can pose public health problems. For example, the Santa Monica Bay Restoration Project conducted a study to identify adverse health effects of untreated urban runoff by surveying over 13,000 swimmers at three bay beaches. [21] The study established a positive association between an increased risk of illness and swimming near flowing storm-drain outlets. Table 2 explains health outcome measures at various distances from storm drains. For example, the study found a 1-in-14 chance of fever for swimmers in front of the drain versus a 1-in-22 chance at 400 or more yards away.

[19]The Chesapeake Executive Council includes the governors of Maryland, Pennsylvania, and Virginia; the Administrator of the U.S. Environmental Protection Agency; the mayor of the District of Columbia, and the chair of the Chesapeake Bay Commission.

[20]Chesapeake Bay Program Office, *Toxics 2000 Strategy: A Chesapeake Bay Watershed Strategy for Chemical Contaminant Reduction, Prevention, and Assessment,* Dec. 2000.

[21]R.W. Haile and others, "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology,* July 1999, Vol. 10, No. 4.

R0012757

Table 2: Comparative Health Outcomes for Swimming in Front of Drains Versus 400 or More Yards Away

Health outcomes	0 yards	400 or more yards
Fever	1:14	1:22
Chills	1:26	1:42
Ear discharge	1:68	1:143
Coughing with phlegm	1:20	1:33
Significant respiratory disease (fever and nasal congestion, fever and sore throat, and cough with phlegm)	1:12	1:22

Note: This table includes the statistically significant health outcomes.

Source: GAO analysis of data from "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology*, July 1999, Vol. 10, No. 4

Metals and polycyclic aromatic hydrocarbons (PAH) in urban runoff can present a threat to aquatic life. Studies have found the following:

- Storm water runoff from an urban area proved to be toxic to sea urchin fertilization in the Santa Monica Bay, and dissolved zinc and copper were determined to be contributors to this toxicity. [22]
- Brown bullheads (a bottom-dwelling catfish) in the Anacostia River developed tumors that were believed to be caused by PAHs associated in part with urban runoff.[23]
- High PAH and heavy metal concentrations were found in crayfish tissue samples from several urban streams in Milwaukee. The study associated these contaminants with storm water runoff.[24]

[22]Southern California Coastal Water Research Project, *Study of the Impact of Stormwater Discharge on Santa Monica Bay–Executive Summary*, Nov. 1, 1999.

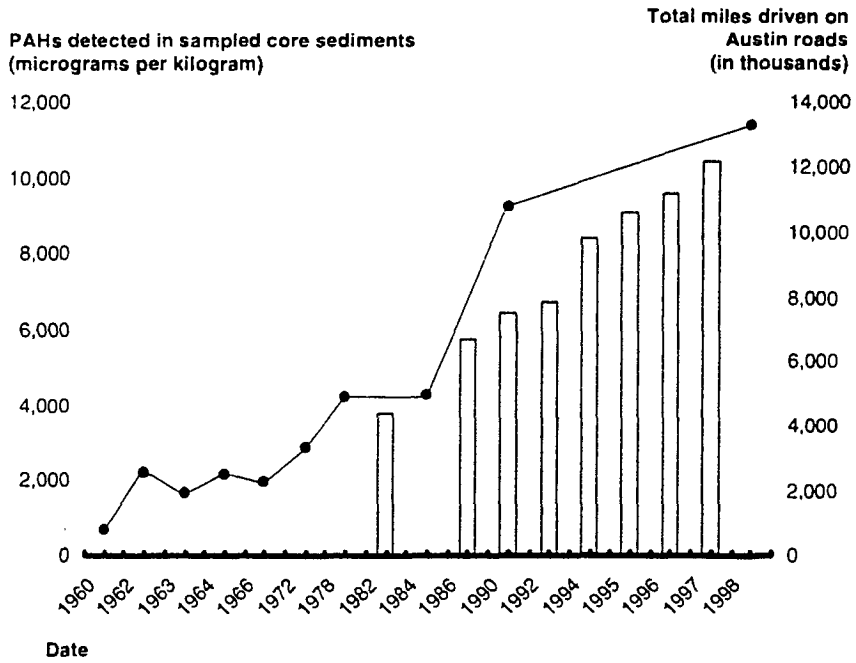
[23]Chesapeake Bay Program Office.

[24]J.P. Masterson and R.T. Bannerman, "Impacts of Stormwater Runoff on Urban Streams in Milwaukee County, Wisconsin," *National Symposium on Water Quality, American Water Resources Association*, Nov. 1994.

R0012758

In addition, USGS tracked trends in the concentrations of PAHs found in sediment in 10 lakes and reservoirs in six metropolitan areas over the last several decades. This study found that PAH concentrations in developed watersheds are increasing and that these increases may be linked to the amount of urban development and vehicle traffic in urban and suburban areas.[25] For example, from 1982 to 1996, PAH concentrations in the sediment core in Town Lake (Austin, Texas) and total miles driven in greater Austin both increased by about 2.5 times. Figure 6 illustrates this correlation.

Figure 6: Comparison of Town Lake PAHs and Traffic Trends



Note: According to USGS, irregularities in the date pattern are due to intervals at which sediment samples were collected.

Source: USGS National Water Quality Assessment Reconstructed Trends Program.

[25]P. Van Metre, B. Mahler, and E. Furlong, "Urban Sprawl Leaves Its PAH Signature," *Environmental Science and Technology,* Vol. 34, No. 19, 2000.

R0012759

Although the studies we reviewed show that certain contaminants are likely to be present in urban runoff, factors such as land development practices, climate conditions, atmospheric deposition, and traffic characteristics all can affect the characteristics of runoff from a particular area. Therefore, given the diffuse nature of many storm water discharges and the variability of other contributing factors, characterizing the concentrations of pollutants contained in storm water runoff has been challenging. Recent USGS reports also suggest that improvements are needed in the methods used to analyze sediment and metals in runoff.[26]

Local Governments Take Actions to Manage Urban Storm Water Runoff, but Information Is Limited on the Cost and Effectiveness of These Actions

To comply with federal and state storm water management for Phase I permitting requirements, permitted municipalities must create and implement storm water management programs. The three primary activities used in these programs include efforts to characterize storm water runoff; BMPs aimed at reducing pollutants in storm water runoff to the maximum extent practicable; and reporting program activities, monitoring results, and costs of implementing the program. Some BMPs are structural—meaning that they are designed to trap and detain runoff until constituents settle or are filtered out. Other BMPs are nonstructural—meaning that they are designed to prevent contaminants from entering storm water through actions like street sweeping and inspections. Many permitted municipalities use specialized BMPs tailored to address particular runoff problems in their locations. Over 1,000 cities are undertaking these efforts under the NPDES Storm Water Program, but information on the overall costs of managing urban runoff and the effectiveness of the actions taken is limited. EPA's attempts to forecast costs have not encompassed the entire program or are out of date. In addition, the permitted municipal agencies we visited estimated their annual storm water management costs and reported them to state agencies or EPA, but the approaches they used to calculate these estimates varied considerably, making it difficult to draw any conclusions. Although EPA and state agencies believe that the program will be effective in improving water quality, EPA has not made a systematic effort to evaluate the program. Without such an effort, EPA cannot tell what effect the program is having on water quality nationally.

[26]The USGS reports indicate that certain methods used to analyze sediment and metals samples can be unreliable. For example, sample collection and processing methods can have an effect on measured concentrations of metals.

R0012760

Municipalities Comply With Federal and State Requirements Through Monitoring, Best Management Practices, and Reporting

The NPDES Storm Water Program requires municipalities operating under a Phase I MS4 permit to characterize and monitor storm water runoff, implement BMPs to reduce pollutants to the maximum extent practicable, and report costs and monitoring results to the permitting authorities. Because of these requirements, local governments have generally shifted the focus of their storm water management from water quantity control or flood management to water quality concerns.

Besides following the basic federal requirements, municipalities must follow any additional regulations developed by states that have been delegated the authority to manage the NPDES Storm Water Program. For example, Wisconsin's Department of Natural Resources broadened the requirements for determining which municipalities must get permits. The state requires local governments with storm sewer systems in priority watersheds (based on the significance of storm water runoff as a pollutant source) that serve a populace of 50,000 or more[27] to obtain a permit with requirements similar to those for a Phase I permit. Wisconsin's Department of Natural Resources also requires municipalities that are located in one of the state's five Great Lakes Areas of Concern[28] to obtain a state permit. Furthermore, in line with specific criteria in Wisconsin's Administrative Code, the state requires other municipalities to obtain a permit if the municipality is found to significantly contribute storm water pollutants to waters of the state. These various requirements increased the number of municipalities that must get permits from the two under federal requirements to over 70 under the states' requirements.

The local governments we reviewed were undertaking three primary activities when applying for permits and implementing their storm water management programs. Specifically, these activities were (1) characterizing storm water runoff; (2) developing BMPs to reduce discharges of pollutants to the maximum extent practicable; and (3) reporting program activities, monitoring results, and reporting program costs.

First, to characterize runoff, applicants are to provide quantitative data that describe the volume and quality of discharges from municipal storm

[27]For example, we visited West Allis, Wisconsin, which has a permit even though its population is under 100,000.

[28]Areas of concern have persistent water quality problems, which impair beneficial uses.

R0012761

sewers. For example, cities must map all storm sewer outfalls—an undertaking that one group representing cities described as significant. After the permit application is approved, additional monitoring is required throughout the life of the permit to facilitate the design of effective storm water management programs and to document the nature of the storm water. The local governments we visited were all monitoring for a variety of purposes, including characterizing runoff from different types of land use in order to target their BMPs, testing the effectiveness of a particular BMP, or establishing a baseline for their storm water quality evaluations.

Second, the storm water management programs that local governments develop focus on implementing BMPs. While active treatment, such as sending storm water through a treatment facility, is a possible BMP, the cities we visited were generally not using active treatment. EPA's February 2000 report[29] on the Phase I program described the program as based on the "use of low-cost, common-sense solutions." The five cities we visited were generally using similar types of structural and nonstructural BMPs, as follows:

- Structural BMPs are designed to separate contaminants from storm water. For example, detention ponds temporarily hold storm water runoff to allow solids and other constituents in the runoff to settle before the water is released at a predetermined rate into receiving waters. In addition, catch-basin inserts, placed in a storm drain, catch trash and other debris, and particle separators, placed beneath the surface of an impervious area such as a parking lot, separate oils from runoff and allow sediment and debris to settle. Structural devices such as these require regular maintenance to function properly and remain effective.
- Nonstructural BMPs are primarily designed to minimize the contaminants that enter storm water. These nonstructural BMPs include
  - "good housekeeping" practices by the local government, such as oil collection and recycling, spill response, household and hazardous waste collection, pesticide controls, flood control management, and street sweeping;

[29] *Report to Congress on the Phase I Storm Water Regulations*, U.S. Environmental Protection Agency, February 2000. This report includes information on the program for local governments, industries, and construction sites.

R0012762

- public education programs, such as storm-drain stenciling, to remind the public that trash, motor oil, and other pollutants thrown into storm drains end up in nearby receiving waters;[30]
- new ordinances to control pollution sources, such as prohibiting the disposal of lawn clippings in storm drains and requiring pet owners to clean up after their pets;[31]
- requirements that developers comply with storm water regulations and incorporate erosion and sediment controls at all new development sites;
- requirements that runoff from properties owned or activities sponsored by the municipality be properly controlled; and
- efforts to identify and eliminate illicit connections and illegal discharges to the storm sewer systems, such as those from pipes carrying sewage.

We found that the NPDES Program's requirements allowed local governments to tailor their storm water management efforts to prioritize local concerns, such as a particular type of contaminant, a particular climatic condition, or a particular body of water. Some cities also developed specialized BMPs to address these concerns. The following information highlights specific storm water-related concerns in the five cities we visited and the specialized BMPs these municipalities have developed to address these particular concerns. (See apps. I to V for additional information on these cities' storm water management programs.)

[30]Other public education programs we observed included in-school education programs, partnerships with grassroots organizations concerned with water quality issues, and the identification of commercial businesses and industries to educate owners on methods to control storm water runoff.

[31]According to Worcester, Massachusetts' April 2000 *City of Worcester DPW Stormwater Management Program Annual Report*, the city has proposed ordinances that prohibit the disposal of lawn clippings and other yard waste in catch basins and that require pet owners to clean up after their pets. As of April 2001, neither ordinance had been implemented.

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- In **Baltimore, Maryland**, excessive levels of nutrients, particularly phosphorus and nitrogen, are among the city's major water quality concerns because of the city's participation in the Chesapeake Bay Program. Baltimore City agreed to assist the state in reaching the Chesapeake Bay Program's goal to reduce nutrients discharged to the bay by 40 percent by the year 2000. According to a Chesapeake Bay Program Office representative,[32] as of March 2001, the program has not met this goal but expects to reach it within the next several years.
- In **Boston, Massachusetts**, the Boston Water and Sewer Commission, which holds the permit for Boston's storm sewer system, is concerned about runoff from roadways, especially runoff containing salt and sand used in the winter months and dissolved metals (copper and zinc) from automobiles. In September 2000, the commission began a 3-year program to develop and implement a citywide catch-basin inspection, cleaning, and preventive maintenance program. The program will also include the development of a database and map that can be linked to the commission's Geographic Information System.
- **Los Angeles County, California**, is responding to a TMDL for trash in the Los Angeles River Watershed that will require the county, over a 10-year period, to eliminate trash in runoff. The county is testing a variety of devices that remove trash from runoff and specialized catch-basin devices that are designed to prevent trash from ever reaching the storm sewers.
- **Milwaukee, Wisconsin**, changed its monitoring and public education activities in its recent permit to test the effectiveness of a BMP targeting public education efforts to a specific community. The new permit also requires a monitoring program aimed at the community, its associated watershed, and city employees who work in the area.
- **Worcester, Massachusetts**, had a significant problem with illicit connections to its storm sewers and with flow in these sewers during dry weather. Worcester's Department of Public Works (DPW) screened 71 of its storm water outfalls and determined that 32 of them had drainage areas that carried both sanitary sewage and storm drainage in separate conduits through common manholes. DPW has retrofitted over 65 percent of the manholes to prevent sewage from mixing with storm water.

[32]The Chesapeake Bay Program Office, U.S. EPA Region III, was founded in 1983 with the formation of the Chesapeake Bay Program. The program is a voluntary regional partnership that leads and directs restoration of the Chesapeake Bay. Members of the Chesapeake Bay Program include Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission (a tristate legislative body), EPA, and participating citizen advisory groups.

R0012764

Third, local governments participating in the Phase I program are required to report annually to EPA or the state regulatory agency on their storm water programs. These reports are to include a status report on the program; a summary of data, including monitoring results collected during the reporting year; information on annual expenditures on the program and a budget for the coming year; and a description of any water quality improvements or degradation.

Information on the Costs of Addressing Storm Water Runoff Is Limited

Good information about the cost of implementing federal storm water requirements is limited. EPA conducted a survey to estimate the nation's future water infrastructure needs over a 20-year period—from 1996 to 2016. In its 1996 report,[33] EPA estimated that states would require over $50 billion to meet their current (as of 1996) water infrastructure needs. The estimate consists of storm water management needs (at $7.4 billion) and CSO needs (at $44.7 billion).[34] EPA noted, however, that estimated storm water management needs are likely too low and could increase following an analysis of data collected to prepare the agency's 2000 clean water needs survey—to be released in 2002. According to EPA, many cities have implemented the Phase I program since EPA reported to the Congress in 1996, and municipalities should now be better able to provide documented cost data. As a result, EPA will need to rely less on modeled storm water needs than it did in the 1996 needs survey. EPA did not project the costs and benefits of the program when it was initiated; therefore, no initial cost estimates are available. When EPA promulgated the Phase I program regulations in 1990, the agency decided that the storm water program did not meet the requirements for preparing a benefit/cost analysis.

[33] *1996 Clean Water Needs Survey Report to Congress*, U.S. Environmental Protection Agency (Sept. 1997). EPA's estimate represents the estimated capital costs for water quality projects eligible for state revolving fund support.

[34] EPA also estimates that $81.9 billion of its 20-year water infrastructure needs cost can be attributed to sanitary sewer overflows. These overflows may occur when rainwater or snowmelt leaks into sanitary sewage pipes, exceeding the pipes' capacity and causing them to overflow. This overflow can release untreated sewage from municipal sanitary sewer systems into streams, basements, and streets.

R0012765

The costs to local governments of complying with the Phase I program have generally been portrayed as high. However, because of inconsistencies in cost accounting and reporting practices, we could not determine the cost of the program to several of the cities we visited. Although municipalities are required to provide information on the expenditures that they anticipate will be needed to implement their storm water management programs for each fiscal year covered by the permit, EPA has not issued any cost reporting guidelines. Consequently, while the reported fiscal year 1999 total cost to manage and treat storm water runoff across the five municipalities in our review ranged from less than $1 million (Milwaukee) to $135 million (Los Angeles County),[35] these numbers are not comparable because the municipalities did not have consistent cost accounting and reporting practices and did not fully express storm water management costs.[36] For example, some cities reported only the costs of activities that were funded by the city department that held the permit. Significant activities funded by other city departments were not reported, even if they were important components of the storm water program. Officials in the Milwaukee Department of Infrastructure Services and the Boston Water and Sewer Commission told us that other city departments perform and fund activities such as street sweeping and flood control. The costs of these activities are not reported as storm water program costs because the activities serve other purposes besides preventing storm water pollution.

In addition, according to some city officials, these activities were in place before the permit was issued and, therefore, cannot be characterized solely as storm water costs. The cost of street sweeping can be significant—for fiscal year 1999, Baltimore City and Worcester, which did include street-sweeping costs in their storm water program's cost estimate, stated that their street-sweeping expenses totaled about $9.5 million and $1.2 million, respectively. Similarly, Milwaukee did not report the cost of a significant project related to storm water runoff because it was mostly funded by the state of Wisconsin.

[35]Los Angeles County's cost was projected by the municipal permit holder and represents the cost of the 84 cities covered by the permit.

[36]We were unable to obtain comprehensive information on the total cost to the Boston Water and Sewer Commission of managing storm water, so their fiscal year 1999 costs could not be included in this range.

R0012766

An EPA official told us that the agency had not yet made a national effort to analyze the information that Phase I permittees submitted on the costs of their storm water programs. This official cited the inconsistent formats of the annual reports as a reason that the information was not readily available at the national level and also indicated that adequate staff are not available to analyze the data. In addition, other EPA officials informed us that the Office of Wastewater Management must divide its resources among a number of issues that will challenge the agency's water program over the next decade.

Several officials in the cities we visited said that their annual costs are likely to increase. A number of factors could affect the costs. For example, a Baltimore City official explained that the anticipated, future program costs depend on several factors, including (1) requirements in watershed-management plans currently being developed, (2) pollution-reduction goals the city will be required to achieve, (3) requirements of the state regulatory agency in future permits, and (4) requirements the city may have to meet if TMDLs or numeric effluent limits are incorporated into NPDES storm water permits. Other city officials also expressed concern about the extent to which TMDLs could affect their future costs. These city officials are concerned that when and if TMDLs are established, their future storm water permits may require that storm water runoff meet specific water quality standards. For example, Los Angeles County's trash TMDL could potentially drive the county's storm water management costs upward, and the county expects additional TMDLs to be imposed. On the other hand, Worcester officials estimated that their future storm water costs would be about the same as they were at the time of our review—about $4.5 million per year.

In a separate analysis, EPA estimated in 1999 that it will cost Phase II municipalities about $848 million to $981 million per year (in 1998 dollars) to manage storm water runoff. Because Phase II permits have not been issued as of May 2001, we did not gather any cost information on them from these cities.

Funding for Managing Storm Water Runoff Is Available From Local and Federal Sources

The five cities we visited had not generally obtained federal funds for their storm water management efforts. They used local sources, including general revenues, bonds, revenue from specifically created storm water utilities, state grants, and inspection and permit fees.

R0012767

While several sections of the Clean Water Act provide funding that can be used for municipal storm water control, relatively few federal funds have been directed to these types of projects. The most significant source of funds is the state revolving loan funds administered by states.[37] These revolving loan funds provide loans for eligible storm water control projects. In some cases, nonpoint source projects may also qualify for funding when storm water permits are not required or issued. However, municipal storm water management is generally a low priority in these programs. Specifically, in the year 2000, revolving fund loans were made in the "storm sewers" category in the amount of $38.76 million for 44 different projects. These funds represented less than 1 percent of the amounts loaned from these revolving funds that year. Activities eligible for revolving fund loans include constructing BMPs to control runoff, but support for ongoing operations and maintenance is not eligible. Revolving fund loans can also be used for eligible CSO control projects. In 2000, Clean Water State Revolving Fund Program loans were made in the "CSO Correction" category of a national EPA database in the amount of $411.3 million for 69 different projects and could have been used for CSO or sanitary sewer overflow projects. This amount represented about 9 percent of the funds loaned in 2000.

According to EPA, the agency also issues grants to universities and other research institutions to help implement the storm water program. Some of these grants provide training and guidance to Phase I permittees on watershed protection and the proper selection of BMPs.

Other sources of funding may be available to local governments beginning in 2002. In December 2000, the Congress authorized programs for fiscal years 2002 through 2004 to provide grants to local governments for (1) pilot projects for managing municipal CSOs, sanitary sewer overflows, and storm water discharges on a watershed basis and for testing BMPs and (2) controlling pollutants from MS4s to demonstrate and determine cost-effective, innovative technologies for reducing pollutants from storm water discharge. EPA's proposed budget does not request funds for these programs. In addition, the Congress authorized programs for fiscal years 2002 and 2003 to provide grants to local governments for planning, designing, and constructing treatment works to intercept, transport,

[37]Under the Clean Water State Revolving Fund Program, the federal government provides grants to capitalize states' funds. States provide loans to local governments for wastewater projects.

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control, or treat municipal CSOs and sanitary sewer overflows. EPA's proposed budget requested $450 million for this program.

EPA, States, and Local Governments Believe the NPDES Storm Water Program Is Effective, but It Has Not Been Evaluated

EPA, state, and municipal officials generally believe that the NPDES Storm Water Program will improve water quality. These officials believe that the program will result in more bodies of water that meet water quality standards, improved aesthetic conditions, reduced risk from bacterial contamination, and improvements attributable to the discovery and management of pollutants in storm water that otherwise would have gone unnoticed. EPA attempted to put a dollar value on these benefits in its benefit/cost analysis prepared for the Phase II storm water regulations, estimating that such benefits could range from $672 million to $1.1 billion per year (in 1998 dollars).[38]

However, little information is currently available on the benefits of the storm water program or its general effectiveness. There is no doubt that it will take time for the results of the Phase I program to be demonstrated. As EPA notes in its February 2000 report to the Congress, pollution control efforts under water quality management programs produce long-term changes, and the agency expects water quality improvements attributable to the Phase I program to become evident in the future, as the program matures. In this report, EPA concluded that the program has improved storm water management at the local level, improved water quality, and decreased pollutant loads in storm water. However, EPA relied on a survey of only nine Phase I cities in making these conclusions and, therefore, also reported that the agency could not provide national estimates on water quality protection and improvements generated by Phase I of the program. To evaluate the entire program, EPA would have to establish goals for the program that are based on its mission; obtain information about the program's results; compare the results with the goals; and make changes to the program, if warranted, to get closer to achieving the agency's goals.

EPA and the states also have not taken advantage of information that is available to evaluate the program. Each city we visited was regularly monitoring its storm water to establish baseline information on pollutant levels and was reporting this information to EPA or the regulatory state agency each year. Although cities with Phase I permits are required to report on their storm water monitoring results and changes in water

[38]Using another method, EPA estimated the benefits at $1.6 billion per year.

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quality, overall, EPA and the states have not successfully developed measurable goals for the program or demonstrated its effectiveness through the review of municipal reports. An EPA official said that some states had requested funding to analyze program data because they did not have the resources to do so, and that EPA had provided the funding in a few cases. EPA also has not established any guidelines for how these data should be reported. Therefore, the reports may be as variable as the cost information we obtained in our five site visits.

EPA has not yet taken any of these data-analysis steps because, according to EPA officials, other program challenges within the Office of Wastewater Management compete with storm water management efforts for priority. For example, EPA officials stressed that available resources within the office must address other significant wet-weather pollution problems, such as CSOs and sanitary sewer overflows, and nonpoint source pollution problems, such as agricultural practices, forestry, and mining. One agency official noted that the highest priority is addressing needs that the agency and local governments have identified for improving wastewater infrastructure, such as sewage treatment facilities. The program also has relatively few staff assigned—about five in the headquarters office and about 10 in the regional offices—for the municipal, industrial, and construction portions of the program. In a program plan recently prepared for the storm water program, EPA estimated that nine to 10 staff would be needed in EPA headquarters to evaluate the program and implement other program requirements.

EPA officials described two efforts that may be the first steps in developing better information about the program. First, EPA intends to issue a grant to the University of Alabama in June 2001 to evaluate monitoring data submitted by a sample of municipalities with Phase I permits. This effort will (1) determine the different types of monitoring being conducted by Phase I municipalities, (2) assess water quality in and around permitted municipalities and determine any correlation between program implementation and impacts on water quality, and (3) recommend approaches for improving the effectiveness of municipal storm water monitoring programs. EPA expects the results of this study in 2003. Second, an EPA official stated that the agency would like to establish a system for analyzing program findings, incorporating necessary changes that are based on these findings, and evaluating the program's effectiveness. The agency plans to implement a pilot project in 2001 in the agency's Atlanta Region IV office for analyzing data reported in annual

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reports and developing key indicators for the program. If this project is successful and resources are available, the project could be expanded.

Conclusions

EPA regards urban runoff as a significant threat to water quality across the nation and considers it to be one of the most significant reasons that water quality standards are not being met nationwide. Prompted by the Congress, EPA has responded with a variety of programs, including the NPDES Storm Water Program, which requires more than 1,000 local governments to implement storm water management programs. Those municipalities that are currently involved in Phase I of the program have been attempting to reduce pollutants in storm water runoff for several years. It is time to begin evaluating these efforts. However, EPA has not established measurable goals for this program. In addition, the agency has not attempted to evaluate the effectiveness of this program in reducing storm water pollution or to determine its cost. The agency attributes this problem to inconsistent data reporting from permitted municipalities, insufficient staff resources, and other competing priorities within the Office of Wastewater Management. Although Phase I municipalities report monitoring and cost data to EPA or state regulatory agencies annually, these agencies have not reviewed this information to determine whether it can be of use in determining the program's overall effectiveness or cost. Our analysis shows that the reported cost information will be difficult to analyze unless EPA and its state partners set guidelines designed to elicit more standardized reporting. Better data on costs and program effectiveness are needed—especially in light of the Phase II program that will involve thousands more municipalities in 2003. EPA's planned research grant to the University of Alabama and its pilot project in the agency's Region IV to analyze data from annual reports and develop baseline indicators is a step in the right direction and could point the way for a more comprehensive approach.

Recommendation

To determine the extent to which activities undertaken through the NPDES Storm Water Program are reducing pollutants in urban runoff and improving water quality, and the costs of this program to local governments, we recommend that the Administrator, EPA, direct the Assistant Administrator for the Office of Water to

- establish measurable goals for the program;

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- establish guidelines for obtaining consistent and reliable data from local governments with Phase I permits, including data on the effects of the program and the costs to these governments;
- review the data submitted by these permittees to determine whether program goals are being met and to identify the costs of the program; and
- assess whether the agency has allocated sufficient resources to oversee and monitor the program.

Agency Comments and Our Evaluation

We provided a draft of this report to EPA and DOT for their review and comment. EPA generally agreed with the report and with the recommendation, although it did not explicitly comment on all parts of it. (EPA's comments appear in app. VI.) In response to our recommendation that EPA set measurable goals for the storm water program, EPA stated that under the second phase of the program, local governments will establish their own goals. Although this is an important activity, EPA will have difficulty evaluating the program's effectiveness at a national level without setting goals that reflect the program's mission of improving water quality. The agency (1) agreed that it should establish guidelines for obtaining consistent and reliable data from local governments about their programs and (2) plans to award grants to two universities for reviews of monitoring data reported by local governments. EPA did not comment on whether local governments should report on the costs of their programs. EPA also agreed that it and its state partners should review data reported by local governments to determine whether the program's goals are being met. In April 2001, EPA officials told us that the agency planned to undertake a project in the Region IV (Atlanta) office to evaluate the methods local governments are using to control storm water. EPA's letter indicates that the agency now plans to implement this project in three regional offices and 10 states. EPA did not comment on the part of our recommendation that the agency review the level of resources devoted to overseeing and monitoring the program. EPA also provided technical comments that we incorporated where appropriate.

DOT generally agreed with the draft report and provided technical comments that we incorporated where appropriate. In particular, DOT suggested that we revise several references in the draft report to paved surface area and its relationship to increases in urban runoff, to emphasize that impervious surfaces, of which paved surfaces are a significant subset, cause increases in runoff. We revised the language in these places.

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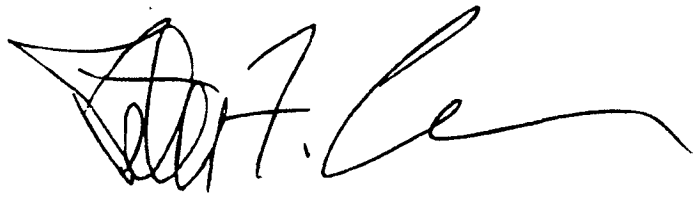
As agreed with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 7 days after the date of this report. At that time, we will send copies of this report to the Administrator, Environmental Protection Agency, and the Secretary of Transportation. We will make copies available to others on request. If you or your staff have any questions about this report, please call me at (202) 512-2834. Key contributors to this report are listed in appendix VII.



Peter F. Guerrero
Director, Physical Infrastructure Issues

R0012773

The Storm Water Program in Baltimore City, Maryland

Baltimore City's municipal separate storm sewer system (MS4) is regulated by the Maryland Department of Environment (MDE) and, according to a city official, services the entire city. The city is currently implementing its second, 5-year National Pollutant Discharge Elimination System (NPDES) permit, issued on February 8, 1999. Before obtaining the first NPDES storm water permit in 1993, Baltimore City addressed the adverse affects of storm water runoff by implementing Maryland's Storm Water Management Program and Erosion and Sediment Control Program. According to the 2000 census, Baltimore City's population is about 651,000.

Urban Runoff Problems in Baltimore City

Baltimore City's urban runoff discharges to four major areas—Gwynns Falls, Jones Falls, Herring Run, and the Patapsco River—and then ultimately to the Chesapeake Bay. In 1990, the Environmental Protection Agency's (EPA) 319(a) report[1] implicated urban runoff as the main source of pollution in these waters. Moreover, Baltimore City was one of the areas studied in EPA's Nationwide Urban Runoff Program in the 1980s. This study reported that urban runoff contributed over 60 percent of the total nitrogen, phosphorus, and organic carbon; over 70 percent of the chemical oxygen demand; and over 80 percent of the total suspended solids, lead, and zinc in local water bodies.

An MDE official told us that nutrients, zinc, and suspended solids are among the constituents most commonly found in urban runoff, but the quantitative contribution to water quality impairment in the state's waters was not known. Also, in 1996, the Chesapeake Executive Council designated the Baltimore Harbor as one of three toxic regions of concern in the Chesapeake Bay. The harbor suffers from sediment contaminated by banned substances (such as the termiticide chlordane) and contaminants currently being released (such as metals and organics). Furthermore, according to the Chesapeake Bay Program Office, data collected from Phase I permittees indicate that storm water runoff can be a significant source of metals and organics in the harbor.

A Baltimore City official told us that some portions of Maryland's waters are impaired because of unacceptable levels of nutrients, metals,

[1]Section 319(a) of the Clean Water Act requires, among other things, that states identify and report to EPA the navigable waters that cannot reasonably be expected to maintain water quality standards (e.g., established water body uses) without additional action to control nonpoint source pollution.

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suspended sediments, and chlordane. Moreover, this official noted that the state does not consider data that municipalities collect under their NPDES storm water permits during the 303(d) listing process. Therefore, he believes that streams in Maryland are much more impaired than indicated by the listing process.

Baltimore City's Use of Best Management Practices

Like other NPDES storm water permit holders, Baltimore City uses a variety of best management practices (BMP) to reduce the amount of pollutants in runoff to the maximum extent practicable. These BMPs include detention ponds, shallow marshes (which use the biological and naturally occurring chemical processes in water and plants to remove pollutants), sand filter devices, public education programs, and the identification of illicit discharges to the MS4 system. Furthermore, Baltimore City participates in Maryland's effort to reduce nutrient levels in the Chesapeake Bay. Refer to the section of this report describing local government efforts to manage storm water for details concerning this nutrient-reduction goal. One other BMP includes the following:

- Baltimore City has incorporated the *2000 Maryland Storm Water Design Manual's* management policies, principles, methods, and practices into its current NPDES storm water discharge permit. The purpose of the design manual is to (1) protect the waters of the state from the adverse effects of urban storm water runoff; (2) provide design guidance on the most effective structural and nonstructural BMPs for development sites; and (3) improve the quality of BMPs that are constructed in the state, with particular attention to their performance, longevity, safety, ease of maintenance, community acceptance, and environmental benefit.

Costs Associated With Managing Storm Water

We were not able to obtain comprehensive information on the total cost to Baltimore City of managing storm water. Therefore, we do not present that information here.

Funding Sources

Baltimore City funds its storm water management control efforts with city water and sewer user fees and with state funds.

R0012775

The Storm Water Program in Boston, Massachusetts

The Boston Water and Sewer Commission received a NPDES storm water permit in October 1999. The commission is a separate entity from the city of Boston and, therefore, does not manage some storm water controls that are common in Phase I permits, such as street sweeping, winter deicing, and many of the urban runoff controls required for new developments. Boston has combined sewer systems as well as separate sanitary sewers and storm drains. The commission maintains 206 storm water outfalls and serves approximately 33 percent of the city through its separate MS4 system. In addition to the resident population of about 589,000, this system also almost daily serves 340,000 commuting workers; 70,000 shoppers, tourists, and business people; and 75,000 commuting students. The commission's sanitary and combined flows are transported to the Massachusetts Water Resources Authority at Deer Island. The commission is also the permittee for EPA's Combined Sewer Overflow Program.

Urban Runoff Problems in Boston

The commission considers the identification and elimination of illegal sanitary sewer connections as the most effective means of improving water quality and protecting public health. It is also concerned with the washoff of animal wastes from residential and open land, which is another major contributor to the impairment of water quality because it can cause an increase in coliform levels in the storm water discharges to the receiving waters.

The commission has contracted for various studies to determine the impact of storm water runoff. The following two studies identified sources of bacterial contamination and characterized the quality of storm water discharged from different types of land uses. The studies included metering storm water flows, collecting and analyzing the storm water and receiving water quality samples, and identifying and remediating illegal sewer connections. Observations from the studies include the following:

- A 1996 study determined that pet waste, rather than sanitary sewage, was a key contributor of bacteria to the storm drain system that had possibly led to beach closings in the area.
- A 1998 study identified several illegal connections to the storm drain system. Furthermore, the study showed that deicing and sanding efforts resulted in levels of sodium, chloride, total dissolved solids, and cyanide that exceeded EPA's acute (high dose) toxicity levels.

R0012776

Boston's Use of Best Management Practices

To meet the NPDES permit's requirements, the commission, like other permittees, continued BMPs, such as identifying illegal connections, and implemented new BMPs aimed at preventing the discharge of pollutants to storm drains and receiving waters. Refer to the section of this report describing local government efforts to manage storm water for details describing the commission's citywide catch-basin inspection cleaning and preventative maintenance program. Other efforts include the following:

- The commission has placed particle separators, which remove oil, grease, and sediments from storm water flows, throughout the city. The commission requires particle separators to be installed by developers on all newly constructed storm drains that serve outdoor parking areas. Fuel-dispensing areas not covered by a canopy or other type of roof enclosure must also have a particle separator.
- The commission requires developers to consider on-site retention of storm water for all new projects, wherever feasible. On-site retention aids in controlling the rate, volume, and quality of storm water discharged to the commission's storm drainage system.

Costs Associated With Managing Storm Water

We were not able to obtain comprehensive information on the total cost to the commission of managing storm water because the commission does not separate the cost of its storm water program from the cost of its sewer operations. Therefore, we do not present that information here.

Funding Sources

The commission funds its storm water management control efforts primarily with city water and sewer user fees and bond proceeds.

R0012777

The Storm Water Program in Los Angeles County, California

Under the NPDES Storm Water Program, the Los Angeles Regional Water Quality Control Board issues 5-year permits to Los Angeles County for its municipal storm water program. The Los Angeles County permit, issued in July 1996, is the county's second storm water permit. This permit includes Los Angeles County as the principal permittee and 85 cities as permittees. According to the 2000 census, Los Angeles County's population is about 9.5 million.

Urban Runoff Problems in Los Angeles County

The effects of urban runoff on the ocean are of particular concern in southern California. Contaminated sediments, impaired natural resources, and potential human illness could threaten the county's tourism economy, estimated to be about $2 billion a year.

The following three studies have shown that urban runoff can pose health risks to swimmers near storm drains and contribute toxic metals to receiving water sediments:

- The Santa Monica Bay Restoration Project conducted a study to assess the possible adverse health effects of swimming in waters contaminated by urban runoff.[1] This study revealed that there is an increased risk of illness associated with swimming near flowing storm drain outlets and an increased risk of illness associated with swimming in areas with high concentrations of bacteria indicators. Furthermore, illnesses were reported more frequently on days when the samples were positive for enteric viruses. Refer to the section of this report describing the effects of runoff on aquatic life and human health for more details.
- The Southern California Coastal Water Research Project coordinated a study that assessed microbiological water quality and found that the majority of shoreline waters exceeded water quality standards during wet-weather conditions. Furthermore, the ocean waters near storm water outlets demonstrated the worst water quality regardless of the weather.[2]
- The Southern California Coastal Water Research Project also compared the runoff from an urban area and a nonurban area in the Santa Monica

[1]R.W. Haile and others, "The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff," *Epidemiology*, July 1999, Vol. 10, No. 4.

[2]Southern California Coastal Water Research Project, *Southern California Bight 1998 Regional Monitoring Program, Volume 3: Storm Event Shoreline Microbiology*, 2000.

R0012778

Bay Watershed.[3] The results of the study indicated that storm water plumes extended up to several miles offshore and persisted for a few days. Furthermore, the runoff from the urban area proved to be toxic to sea urchin fertilization, and dissolved zinc and copper were determined to be contributors to the toxicity. The study also found that in urban areas, sediments offshore generally had higher concentrations of contaminants such as lead and zinc.

Los Angeles County's Use of Best Management Practices

As in the other sites we visited, the county is managing its runoff through the use of conventional BMPs. These BMPs include the elimination of illicit connections and discharges to the storm sewer system, construction control measures, routine inspections, staff training, pollution prevention plans for public vehicle maintenance and material storage facilities, sweeping and cleaning public parking facilities, street sweeping, catch-basin cleaning, and public education.

The Los Angeles Regional Water Quality Control Board recently adopted a Total Maximum Daily Load (TMDL) Program to reduce trash loads to the Los Angeles River. As a result, the county is exploring a number of trash reduction BMPs, which are discussed in the section of this report describing local government efforts to manage storm water.

Costs Associated With Managing Storm Water

Table 3 indicates that the county and the other permittees have allocated significant funding for storm water management activities over the years. For example, for fiscal year 1999,[4] projected funding for storm water management activities for the county and the other permittees amounted to over $134 million.[5] The largest projections for both went toward public agency activities. For example, during fiscal year 1999, the principal permittee and the permittees together projected almost 67 percent of storm water management funds to public agency activities. The activities in this

[3]Southern California Coastal Water Research Project, *Study of the Impact of Stormwater Discharge on Santa Monica Bay–Executive Summary,* Nov. 1, 1999.

[4]The county's fiscal year begins July 1 and ends June 30.

[5]According to an official with the Los Angeles Regional Water Quality Control Board, this figure may also include activities that are outside the scope of the permit.

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program include staff training, inspections of construction projects, street sweeping, and catch-basin cleaning.

Table 3: Summary of Fiscal Resources Projected for Los Angeles County and Its Co-permittees, Fiscal Years 1997-99

(Dollars in thousands)[a]

	Fiscal year 1997		Fiscal year 1998		Fiscal year 1999	
Activity	**County**	**Others[b]**	**County**	**Others[b]**	**County**	**Others**
Program Management	$2,225	$6,195	$1,856	$4,874	$1,466	$6,187
Illicit Connection, Illicit Discharge Program	1,620	3,515	1,017	3,075	764	2,901
Development planning and construction	784	6,208	1,300	3,769	1,452	5,743
Public agency activities	38,544	40,915	40,256	31,992	43,316	46,657
Public information and participation	2,840	5,538	4,360	3,856	4,629	6,177
Monitoring	2,018	619	1,768	729	1,598	737
Other	187	13,991	490	8,656	1,318	11,834
Total	**$48,218**	**$76,981**	**$51,048**	**$56,950**	**$54,543**	**$80,237**

[a]Totals may not add up because of rounding.

[b]Does not include 17 permittees for fiscal year 1998 and 13 permittees for fiscal year 1997 for the following reasons: The permittee operated on a different budget cycle, the final document was not available at the time of the annual report, or the information submitted by the permittee was not complete.

Source: GAO's analysis of cost data provided by the Los Angeles County Department of Public Works.

As shown in table 3, the county maintains primary responsibility for monitoring activities, having projected over $2 million for storm water monitoring activities in fiscal year 1997, almost $2 million in fiscal year 1998, and over $1.5 million in fiscal year 1999. Conversely, the permittees' projected funding levels for monitoring activities amounted to only $619,000 in fiscal year 1997, $729,000 in fiscal year 1998, and $737,000 in fiscal year 1999. According to an official with the Los Angeles Regional Water Quality Control Board, the County has consistently maintained primary responsibility for monitoring activities required under the permit.

R0012780

Funding Sources

The primary source of funds for the county's storm water program is flood control assessments collected throughout the district. Although the county has not applied for any state revolving funds, it has applied for and received approval for federal funds through the Transportation Equity Act for the 21st Century (TEA-21) for a pilot study of an engineering device that would remove trash from storm water. Additionally, the county has received partial funding through Proposition A of the Safe Neighborhood Parks of 1992 and 1996[6] for two Vortex Separation Systems—a Continuous Deflective Separation unit and a Stormceptor unit. Additionally, the county received grant money from the Metropolitan Transit Authority, which partially funded catch-basin screens, a Continuous Deflective Separation unit, and 120 catch-basin inserts.[7]

[6]The Los Angeles County Regional Park and Open Spaces District (a district within the Parks Department) received this funding from Proposition A and, in turn, made grants to the Los Angeles County Department of Public Works for the BMP devices.

[7]The Metropolitan Transit Authority receives TEA-21 funds from the California Department of Transportation.

R0012781

The Storm Water Program in Milwaukee, Wisconsin

The Wisconsin Department of Natural Resources (WDNR) has the authority to regulate the discharge of storm water from municipalities, construction sites, and industries under Natural Resources Code 216. This rule identifies Wisconsin municipalities that are required to obtain a storm water discharge permit under the Wisconsin Pollutant Discharge Elimination System (WPDES). Milwaukee completed its application process in 1994, and WDNR issued a WPDES permit to the city in October 1994. This was the first municipal storm water permit issued to a municipality in EPA's Region 5 covering the midwest. In July 2000, WDNR reissued Milwaukee's storm water permit. According to the 2000 census, Milwaukee's population is about 597,000.

Urban Runoff Problems in Milwaukee

Milwaukee has a combined sewer system as well as a separate sanitary sewer system. The Milwaukee Metropolitan Sewerage District implemented a rehabilitation program that cost over $2 billion to reduce the number of combined sewer overflow (CSO) events each year. The rehabilitation program involved the construction of deep tunnels to store untreated wastewater and rainwater for later treatment at a wastewater treatment plant. Since 1996, the deep tunnels have significantly reduced the number of overflow events from an average of 50 to 60 per year before the construction to an average of two per year afterwards.

Urban runoff has been identified as a leading source of pollution to the Milwaukee River basin's streams, lakes, and wetlands and the Milwaukee River estuary. To address pollution from urban runoff, WDNR issues storm water permits to municipalities with MS4s serving areas with populations of 100,000 or more, municipalities in Great Lakes "areas of concern" where water quality has been identified as a serious problem, municipalities with populations of 50,000 or more that are located in priority watershed planning areas, and designated municipalities that contribute to the violation of a water-quality standard or are significant contributors of pollutants to state waters.

Milwaukee's Use of Best Management Practices

In addition to BMPs such as the elimination of illicit connections and discharges to the storm sewer system, the reduction of pollutants in storm water runoff from construction sites, public education, catch-basin cleaning, street sweeping, and the use of detention basins, Milwaukee has explored the use of innovative BMPs. Refer to the section of this report describing local government efforts to manage storm water for more

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details about an educational campaign directed at a specific watershed. Additional BMPs include the following:

- An innovative storm water control device was installed in a parking lot at a heavily used municipal public works yard that was found to discharge significant amounts of storm water pollutants. Termed the Multi-Chambered Treatment Tank (MCTT), this device is suitable for areas with limited space, cleans up polluted runoff close to its source, removes pollutants that are not susceptible to other treatment methods, and is hidden from view. The MCTT consists of a catch basin, a settling chamber, and a filter. Although the results of the monitoring studies have revealed that the device has a positive effect on water quality, officials with the Department of Public Works explained that it is cost-prohibitive and suitable only for sites with limited space.
- The permittee has also been working with WDNR, the Department of Transportation, the U.S. Geological Survey, and a neighborhood association in a joint effort to develop a storm water monitoring assessment program consisting of two innovative storm water treatment devices. One device removes grit, contaminated sediments, heavy metals, and oily floating pollutants from surface runoff. The other device removes a broad range of pollutants from runoff, such as bacteria, heavy metals, nutrients, petroleum hydrocarbons, and suspended solids. The devices are to be installed along a new reach of the Milwaukee Riverwalk through the third ward of Milwaukee.

Costs Associated With Managing Storm Water

Reliable data on the total cost to manage storm water in Milwaukee were not available and cannot be presented here because certain activities are not reported as program costs in the city's annual report. These activities include street sweeping; leaf collection; catch-basin and inlet cleaning; maintenance of public boulevards, parks, and public green spaces; and the recycling of waste oil and antifreeze. Therefore, the program costs reflected in the annual report do not take into account many of the nonstructural BMPs employed by the city nor do the totals include activities funded through grants. The storm water management activities that were included in the city's 2000 budget request were estimated to cost $460,000.

Funding Sources

Milwaukee's storm water program is primarily funded through the city's sewer maintenance fund. Unlike the general revenue account, which is

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based on property taxes, the sewer maintenance fund is based on water consumption. The city has also received supplemental funding from the Wisconsin Nonpoint Source Water Pollution Abatement Program in the form of WDNR grants. The city has received over $1 million since 1991 for a wide variety of storm water management activities.

R0012784

The Storm Water Program in Worcester, Massachusetts

Worcester's Department of Public Works (DPW) received a NPDES permit on November 1, 1998. The Sewer Operations Division, within the DPW, is directly responsible for operating and maintaining the city's separate storm sewer system, along with the sanitary and combined sewer system. Since 1993, the Sewer Operations Division has had a full-time storm water coordinator, reflecting Worcester's increased emphasis on meeting NPDES program requirements. Worcester has a population of about 173,000. Its water system covers an extensive area, including 371 miles of sanitary sewers, 340 miles of storm sewers, 56 miles of combined sewers, 27,000 manholes, over 14,000 catch basins, and 263 outfalls. Worcester's separate storm drain systems consist of 93 main drainage areas covering approximately 6,680 acres.

Urban Runoff Problems in Worcester

The constituents that are typically found in urban runoff in Worcester are the same as those normally found in urban runoff in older cities. Because virtually all of the paved surfaces in the Worcester area are devoted to the city's transportation infrastructure, the constituents generated include automobile-related petroleum products, such as total petroleum hydrocarbons, oil and grease, along with total suspended solids. Also, coliform, silt, and sediment have been identified in the city's runoff.

Worcester's Use of Best Management Practices

Like other permittees, the DPW has implemented BMPs under the major areas of education outreach, pollution prevention and source controls, storm-drainage system maintenance, regulatory efforts, and storm-drainage system infrastructure. Additionally, to reduce storm water pollution, the DPW has retrofitted a number of twin manholes in the city as discussed below. BMPs that are specific to Worcester include the following:

- The DPW implemented a demonstration project to determine the effectiveness of an oil and grit separator installed on a street drain. The drain is a major surface sewer main that services approximately 226 acres of heavily urbanized area with a typical mix of residential, commercial, and industrial use. The drain discharges into Lake Quinsigamond, which is a large lake used for recreational purposes such as swimming and boating. In its April 2000 annual plan submitted to EPA, the DPW noted that because of drought conditions, it currently did not have sufficient sampling data to determine the effectiveness of the project.

R0012785

- The DPW has embarked on a comprehensive program to minimize the possibility that sewage and storm water will be mixed in its twin invert manholes. Since the program began, the DPW has installed hold-down devices on over 1,680 of the approximately 2,580 twin invert manholes in the city. The DPW expects to continue the program until all of the manholes have been retrofitted.
- The DPW is also working closely with the Massachusetts Department of Environmental Protection in its ongoing tracking efforts to ensure that industries in Worcester are doing their part to reduce storm water pollution.
- To improve its storm-drainage infrastructure, the city has established a voluntary plan to reduce the number of unpaved private roads. The dirt from these roads, especially after rain storms, causes sediment to build up in the drainage system. The DPW has developed a plan to pave the streets at a lower grade than would be necessary to meet the legal requirements for a public street. Under this plan, residents would not have to pay the additional betterment taxes that are now required to cover the costs of sediment removal and less sediment would be transported in runoff.

Costs Associated With Managing Storm Water

Since 1993, the DPW has allocated significant funding from the water and sewer utility fees it collects for controlling the effects of runoff, especially through catch-basin cleaning, street sweeping, and correcting illegal connections. For example, its fiscal year 1993 budget for storm water programs included about $1.6 million for specific programs and another $1 million for capital improvement programs, such as inflow/infiltration and flood control. The DPW also spent $500,000 to develop and submit its permit application. Furthermore, as shown in table 4, Worcester made extensive capital expenditures during fiscal years 1994 through 1999 on pertinent storm water projects to improve the quality of storm water runoff emanating from the city's storm water sewer system.

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Table 4: City of Worcester's Capital Expenditures for Storm Water Management

(Dollars in thousands)

	Fiscal year					
Activity	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Sewer construction	$0	$500	$500	$300	$300	$300
Infiltration control	0	400	400	100	100	100
Pump station rehabilitation	200	200	200	200	200	200
Sewer rehabilitation	300	750	300	750	750	1,500
Landfill closeout	150	1,200	200	500	0	0
Belmont Drainage project	0	100	600	100	0	0
Beaver Brook Culvert project	0	500	100	100	300	100
Surface drain control	40	150	200	200	200	200
Geographic Information System	0	0	0	125	125	125
Other	0	70	10	0	0	0
Total	**$690**	**$3,870**	**$2,510**	**$2,375**	**$1,975**	**$2,525**

Note. The Belmont Drainage project involved enlarging the drain to eliminate surcharging and siltation and moving the outfall to eliminate stagnation. The Beaver Brook Culvert project involved repairing the culvert and conducting a study that included a detailed hydraulic analysis of the drainage basin.

Source: Worcester Department of Public Works.

Furthermore, during fiscal year 1999, the DPW spent approximately another $2.1 million to operate and maintain storm water activities. Key expenditures included about $1.2 million for street sweeping, about $617,000 for catch-basin maintenance, $52,000 for root control, and another $48,000 for street paving. Also included was $40,000 per year for sampling five outfalls around the city three times per year as required by the permit. According to a DPW official, in previous fiscal years, the DPW funded the same or similar operation and maintenance activities to help control storm water runoff. As a result, the costs since 1994 were similar to those for 1999, except for annual adjustments for inflation. Therefore, the annual operation and maintenance expenditures ranged from about $1.7 million for 1994 to about $2.1 million for 1999.

According to a DPW official, the department expects to spend from $3 million to $4.5 million annually over the next several years on storm water-

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related activities. The amount of the cost increase will depend on whether EPA asks the city to increase its spending.

Funding Sources

The DPW funds its storm water management controls effort from the water and sewer user fees it assesses to homes and businesses.

R0012788

Comments From the Environmental Protection Agency

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C 20460

JUN 14 2001

OFFICE OF WATER

Mr. Peter F. Guerrero
Director, Physical Infrastructure Issues
United States General Accounting Office
Washington, DC 20548

Dear Mr. Guerrero:

Thank you for the opportunity to review your draft report entitled "Better Data and Evaluation of Urban Runoff Needed to Assess Effectiveness." We appreciate the difficulty that assimilating and interpreting such information on an extremely complex subject must have presented. Your report provides a fair and balanced depiction of the Agency's efforts, with the assistance of our State and local partners, to implement a national urban storm water runoff control program.

As the report correctly acknowledges, the Environmental Protection Agency (EPA) believes that urban runoff is a significant threat to water quality and is actively working to control the discharge of pollutants in storm water runoff. EPA's urban storm water control program has been a very successful undertaking to date and we are taking steps to address several of the recommendations identified in the report.

One of the challenges of controlling urban storm water runoff is to be able to address a wide array of complex environmental issues, even within the boundaries of one municipality. EPA's urban storm water program is developed with the understanding that a "one size fits all" approach will not work. For example, existing municipal separate storm sewer system (MS4) permits are tailored to suit the needs of each individual municipality. In fact, the municipalities select the majority of the measures that will be implemented to control storm water runoff. Similarly, EPA's Phase II regulatory framework for small MS4s requires the municipality to identify appropriate BMPs to control runoff and establish measurable goals against which program effectiveness will be measured. These BMPs and measurable goals then become the enforceable permit conditions for that municipality. EPA expects that approximately 5,000 small MS4s will each have a unique set of measurable goals that will define expectations of a successful storm water control program.

While EPA has developed a sound regulatory basis for urban storm water control, competing initiatives have limited our ability to invest sufficient resources to fully evaluate the effectiveness of the program and the associated implementation costs. We believe that the flexibility afforded MS4 permittees provides some assurance that permit requirements do not become onerous or unjustified. Additionally, with the MS4 permits reissued every five years,

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EPA expects that dialogue between MS4s and permitting authorities will better focus on those activities found to be most beneficial.

Over the next year, we will address challenges relating to evaluating the effectiveness of municipal storm water programs. Consistent with the first recommendation, EPA will evaluate storm water monitoring data that has been collected since program inception. Two grantees (UCLA and the University of Alabama) will review monitoring data that has been submitted as part of routine discharge monitoring reports and annual reports. EPA expects these efforts will evaluate the correlation between storm water discharges and trends in water quality impairment. Another anticipated finding from these grants is a compilation of the range of monitoring activities required of municipalities in storm water permits and the identification of the monitoring that appears to be most effective in demonstrating program results.

To meet another challenge, we are evaluating MS4 permit requirements and annual reports to identify the types of storm water control activities in place and the environmental and programmatic results of these activities. Initially, this effort will evaluate MS4s in at least three EPA Regions and 10 states to gather information on the range of methods employed by permitted MS4s to control storm water discharges. Through this effort, EPA expects to determine whether program goals are being met and establish meaningful indicators of program performance. Should this effort prove useful, EPA will expand the evaluation to a national effort that will evaluate MS4 permits and annual reports in all affected EPA Regions and states. In either case, results of this effort will be disseminated nationally to ensure that findings are incorporated into other MS4 programs, as appropriate.

Enclosed are additional comments on terminology and regulatory citations provided in the report. Again, we appreciate the opportunity to review and comment on the draft report. If you have any questions about these comments or would like to discuss urban storm water runoff issues, please contact me or call Jeff Lape, Acting Director of the Water Permits Division, at (202) 564-9545.

Sincerely,

Michael B. Cook
Director
Office of Wastewater Management

Enclosure

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Enclosure

Below are several additional comments for your consideration that address terminology and regulatory citations provided in the report:

- The term "nonpoint source" throughout the report, when referring to storm water runoff, is somewhat misleading in that the federal definition of "point source" includes many of the types of storm water discharges discussed in the draft report as "nonpoint source pollution." We recommend clarifying that EPA's NPDES storm water permits regulate point source discharges that includes storm water runoff from small, medium, and large municipal separate storm sewer systems. In fact, to avoid confusion between point sources and nonpoint sources in an NPDES context, we recommend that you consider using the term "wet weather discharges" when referring to storm water runoff.

- The third sentence in the first full paragraph on page 3 states that "EPA requires cities to use 'best management practices' to reduce contamination in storm water runoff." We recommend that you change the word "requires" to "recommends." While best management practices are common for reducing storm water contamination, EPA regulations allow MS4s to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques, and system, design, and engineering methods, and such other provisions which are appropriate.

- The last sentence in the second full paragraph on page 3 states that "managing storm water runoff will reduce runoff and improve water quality." We recommend changing this sentence to indicate that "managing storm water runoff will reduce the volume and concentration of pollutants in runoff and improve water quality.

- The last sentence of the same paragraph indicates that "Neither EPA nor states have developed measurable program goals or reviewed municipal reports on the results of storm water programs to determined whether the reports provide information that could demonstrate the program's effectiveness." A similar statement is made in the first full paragraph on page 31. We recommend that these two sentences be revised to indicate that "EPA and states have generally been unsuccessful in developing measurable program goals and in demonstrating program effectiveness through the review of municipal reports." EPA and some states have attempted to determine program effectiveness through the review of municipal reports but, to date, these efforts have been unsuccessful in making this determination.

R0012791

GAO Contacts and Staff Acknowledgments

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Staff Acknowledgments

In addition to those named above, Jennifer Clayborne, Richard LaMore, Sally Coburn, Elizabeth McNally, Charles Bausell, and Timothy Guinane made key contributions to this report.

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USGS science for a changing world

U.S. Department of the Interior
U.S. Geological Survey

Comparison of NPDES Program Findings for Selected Cities in the United States

The U.S. Environmental Protection Agency, under section 402(p) of the Water Quality Act of 1987, has required municipalities with populations of more than 100,000 to obtain National Pollutant Discharge Elimination System (NPDES) permits for urban stormwater discharge. This regulation is intended to minimize pollutant loadings from urbanized areas and preserve the quality of streams that receive stormwater. To apply for a NPDES permit, a municipality must monitor the chemistry of stormwater from basins having residential, commercial, and industrial land uses, and estimate storm- and annual-pollutant loads and event-mean concentrations of 12 selected properties and constituents. The properties and constituents include biochemical oxygen demand (BOD), chemical oxygen demand (COD), suspended solids, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, total recoverable cadmium, total recoverable copper, total recoverable lead, and total recoverable zinc. These estimates will be used by the municipalities to evaluate the magnitude of pollutant loadings and the efficiency of management strategies that are intended to reduce pollutant loads.

As part of a national synthesis of the study units in the U.S. Geological Survey (USGS) NPDES program, data were compiled on concentrations of the 12 properties and constituents required for load calculations. This report presents a comparison of these data.

Data Collection

The USGS, in cooperation with local agencies, sampled stormwater from 1991 through 1996 in 13 cities and metropolitan areas that are required to obtain NPDES permits (fig. 1). For this comparison, Birmingham and Montgomery, Alabama, were considered one study unit and designated as Birmingham/Montgomery, Alabama. Samples were collected from various conveyances, such as culverts, concrete pipes, lined ditches, and unlined channels. The drainage area of sampling sites typically was small and ranged from 4.0 to 2,564 acres. Each site had a predominant land use—residential, commercial, or industrial (fig. 2). Flow and rainfall data either were collected on site or were estimated from nearby gages. Flow data are used to calculate loads from the concentration data. Samples were collected either by manually collecting discrete samples at timed intervals and flow-weighting volumes of these discrete samples or by collecting flow-weighted composite samples using an automatic sampler. Flow-weighted samples were collected during the first 3 hours of the storm or until the stream returned to pre-storm levels. Samples were collected at a particular site about 30 or more days apart and after approximately 72 hours of less than 0.1 inch of rain.

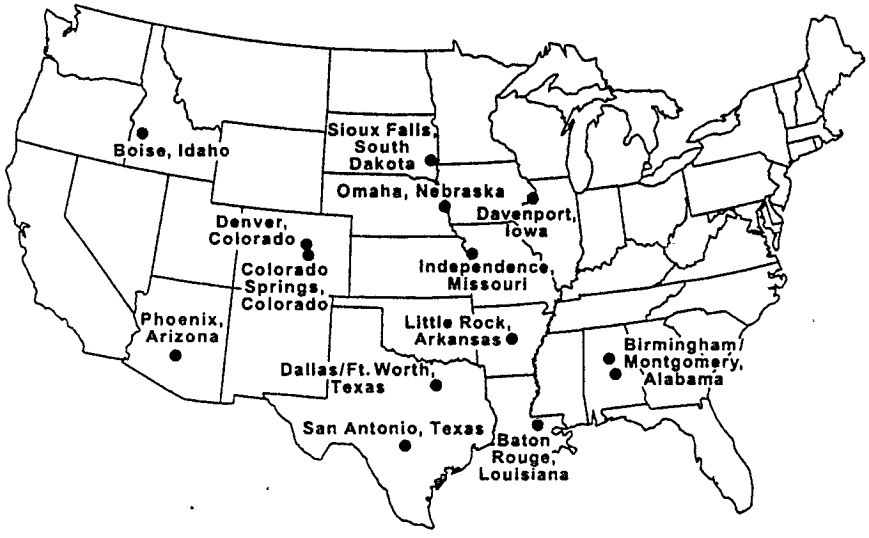

Figure 1. Cities and metropolitan areas where NPDES constituents were sampled in urban stormwater, 1991–96.

Data Analysis

Analyses of the flow-weighted composite samples were done at the USGS National Water-Quality Laboratory with the exception of the Sioux Falls, South Dakota, and BOD analyses. These analyses were done at the individual USGS offices or at contract laboratories.

Nationwide Data Comparison

In an effort to compare storm loads for different land uses, concentration and flow data were compiled from study units in the USGS NPDES data bases. Concentration data and flow volumes were combined along with a unit-conversion factor to obtain storm loads in pounds for each storm. The storm loads then were divided by the area of the individual basins to obtain storm load per unit area, in pounds per acre. Mean storm loads for all constituents then were calculated for the three land uses in each city or metropolitan area (table 1). This manipulation allows direct comparison of the storm loads for each land use.

R0012794

Table 1. Mean storm loads in pounds per acre for 11 NPDES properties and constituents in the United States, 1991–96
[— not analyzed for; ND, 50 percent or more of values below detection limit]

Study unit	Biochemical oxygen demand	Chemical oxygen demand	Suspended solids	Dissolved solids	Total nitrogen	Total ammonia plus organic nitrogen	Total phosphorus	Dissolved phosphorus	Total recoverable copper	Total recoverable lead	Total recoverable zinc
Residential land use											
Birmingham / Montgomery, Alabama	—	7.3	1.1	1.2	0.034	0 025	0.022	0.022	5.1×10^{-2}	1.3×10^{-4}	9.6×10^{-4}
Phoenix, Arizona	0.30	1.6	4.1	1.2	.061	.050	.0067	.0030	2.7×10^{-4}	6.0×10^{-4}	3.0×10^{-3}
Little Rock, Arkansas	.41	2.6	11	1.2	.091	.060	.017	.011	1.9×10^{-4}	4.2×10^{-4}	1.5×10^{-3}
Colorado Springs, Colorado	.75	2.0	3.1	.86	.025	.022	.0048	.0018	8.3×10^{-5}	5.6×10^{-4}	1.3×10^{-3}
Denver, Colorado	.60	2.4	5.9	1.6	.068	.052	.013	.0035	6.0×10^{-4}	6.6×10^{-5}	2.9×10^{-3}
Boise, Idaho	.08	.36	.28	.17	.0013	.0064	.0009	.0006	3.1×10^{-5}	8.3×10^{-5}	4.4×10^{-4}
Davenport, Iowa	—	—	—	—	.013	.0085	.0027	.0028	—	—	—
Baton Rouge, Louisiana	.57	5.5	63	4.3	.36	.34	.059	.021	2.8×10^{-3}	1.1×10^{-2}	2.6×10^{-2}
Independence, Missouri	.49	3.0	6.3	2.4	.032	.020	.0074	.0024	9.4×10^{-4}	1.2×10^{-3}	4.8×10^{-3}
Omaha, Nebraska	.23	1.1	2.6	1.1	.042	.028	.0083	.0035	1.5×10^{-4}	3.5×10^{-4}	1.4×10^{-3}
Sioux Falls, South Dakota	.09	.35	1.5	1.3	.030	.025	.0030	.0010	ND	ND	6.2×10^{-4}
Dallas/Fort Worth, Texas	.22	2.9	3.3	2.8	.068	.047	.013	.0089	2.7×10^{-4}	5.8×10^{-4}	2.3×10^{-3}
San Antonio, Texas	.46	6.8	12	3.8	.11	.092	.022	.012	7.6×10^{-4}	2.6×10^{-3}	8.9×10^{-3}
Commercial land use											
Birmingham / Montgomery, Alabama	—.	4.9	.45	.74	.019	.014	.0031	.0020	1.4×10^{-4}	2.0×10^{-4}	2.0×10^{-3}
Phoenix, Arizona	2.2	14	6.7	7.2	.33	.26	.034	.027	1.1×10^{-3}	6.8×10^{-4}	1.3×10^{-2}
Little Rock, Arkansas	.81	4.4	5.1	1.8	.076	.049	.0097	.0072	6.8×10^{-4}	1.5×10^{-3}	7.6×10^{-3}
Colorado Springs, Colorado	.89	6.3	8.8	2.8	.075	.050	.0081	.0036	3.6×10^{-4}	3.1×10^{-3}	6.1×10^{-3}
Denver, Colorado	10	15	4.5	3.2	.099	.065	.0082	.0037	2.7×10^{-3}	1.5×10^{-3}	7.7×10^{-3}
Boise, Idaho	1.4	3.6	2.2	.68	.21	.21	.0079	.0043	6.3×10^{-4}	9.0×10^{-4}	4.6×10^{-3}
Davenport, Iowa	—	—	—	—	.030	.020	.0033	.0041	—	—	—
Baton Rouge, Louisiana	1.8	14	33	12	.32	.25	.034	.017	2.4×10^{-3}	9.1×10^{-3}	4.2×10^{-2}
Independence, Missouri	1.8	14	11	3.1	.13	.094	.018	.0059	1.1×10^{-3}	4.6×10^{-3}	1.4×10^{-2}
Omaha, Nebraska	.43	1.6	4.5	1.8	.046	.028	.0061	.0037	2.1×10^{-4}	5.1×10^{-4}	2.3×10^{-3}
Sioux Falls, South Dakota	.23	.49	1.3	1.6	.024	.019	.0022	.0012	ND	ND	1.1×10^{-3}
Dallas/Fort Worth, Texas	.49	4.7	4.0	4.8	.11	.068	.012	.0058	8.9×10^{-4}	2.4×10^{-3}	7.2×10^{-3}
San Antonio, Texas	.73	8.9	15	5.5	.15	.12	.028	.012	1.2×10^{-3}	4.9×10^{-3}	1.8×10^{-2}
Industrial land use											
Birmingham / Montgomery, Alabama	—	3.4	2.2	1.5	.024	.017	.0067	.0045	9.9×10^{-4}	1.7×10^{-3}	7.2×10^{-3}
Phoenix, Arizona	5.9	5.8	7.7	2.2	.099	.062	.014	.0050	1.4×10^{-3}	1.6×10^{-3}	7.2×10^{-3}
Little Rock, Arkansas	.88	4.6	3.0	2.3	.22	.19	.047	.016	5.3×10^{-4}	1.1×10^{-3}	9.4×10^{-3}
Colorado Springs, Colorado	.25	1.4	3.1	.52	.016	.011	.0017	.0010	2.0×10^{-4}	1.0×10^{-3}	3.7×10^{-3}
Denver, Colorado	5.4	9.2	22	2.4	.13	.092	.021	.0084	5.9×10^{-3}	1.2×10^{-2}	4.0×10^{-2}
Boise, Idaho	—	—	—	—	—	—	—	—	—	—	—
Davenport, Iowa	—	—	—	—	.036	.034	.0009	.0001	—	—	—
Baton Rouge, Louisiana	2.9	37	41	33	.54	.43	.074	.044	6.3×10^{-3}	3.9×10^{-2}	8.3×10^{-2}
Independence, Missouri	3.1	5.5	20	250	.033	.019	.014	.0024	8.8×10^{-4}	1.5×10^{-2}	1.1×10^{-1}
Omaha, Nebraska	1.7	6.7	66	6.5	.16	.11	.025	.012	2.2×10^{-3}	5.3×10^{-3}	2.2×10^{-2}
Sioux Falls, South Dakota	.05	.17	.62	.52	.017	.013	.0027	.0010	ND	ND	4.9×10^{-4}
Dallas/Fort Worth, Texas	.53	5.6	19	5.4	.11	.064	.020	.010	7.5×10^{-3}	4.8×10^{-3}	1.5×10^{-2}
San Antonio, Texas	.50	6.3	10	6.0	.10	.061	.025	.018	7.4×10^{-4}	1.1×10^{-3}	1.5×10^{-2}

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Physical Properties

BOD, COD, suspended solids, and dissolved solids were compared for all the cities with the exception of Davenport, Iowa; Boise, Idaho; and Birmingham/Montgomery, Alabama. Samples from Davenport, Iowa, were not analyzed for these properties and constituents. An industrial land-use basin was not sampled in Boise, Idaho. Samples from Birmingham/Montgomery, Alabama, were not analyzed for BOD.

BOD and COD are determined by measurement of the quantity of oxygen utilized by organic matter and chemicals in stormwater samples and are used to indicate pollution (Hem, 1992). Mean storm loads of BOD varied by two orders of magnitude, from 0.05 to 10 pounds per acre. The largest mean storm loads of BOD were associated with industrial land-use basins, except for the maximum that occurred in commercial land-use basins in Denver, Colorado. Mean storm loads of COD varied by two orders of magnitude, from 0.17 to 37 pounds per acre. The largest mean storm loads of COD were associated with commercial land-use sites, except for the maximum that occurred in industrial land-use basins in Baton Rouge, Louisiana.

Concentrations of suspended solids and dissolved solids are measures of solids loads in stormwater and also may be used as indicators of pollution. Mean storm loads of suspended solids varied by more than two orders of magnitude, from 0.28 to 66 pounds per acre. The largest mean storm loads of suspended solids were associated with the industrial land-use basins; the maximum occurred in Omaha, Nebraska. Mean storm loads of dissolved solids varied by more than three orders of magnitude, from 0.17 to 250 pounds per acre. The largest mean storm loads of dissolved solids were associated with industrial land-use basins; the maximum occurred in Independence, Missouri.

Nutrients

Four nutrient constituents—total nitrogen, total ammonia plus organic nitrogen, total phosphorus, and dissolved phosphorus—are being analyzed by the USGS NPDES program. These constituents were compared for all land uses in selected cities, with the exception of industrial land-use basins in Boise, Idaho. An industrial land-use basin was not part of the sampling program in Boise.

Nutrients are essential components in plant growth; however, an overabundance of these constituents will cause undesirable algal blooms in bodies of water that are used for urban drinking-water supplies (Hem, 1992). These algal blooms cause adverse effects on the taste and odor of drinking water and have the potential to cause more serious health problems.

Mean storm loads of total nitrogen varied by more than two orders of magnitude, from 0.0013 to 0.54 pounds per acre. The largest mean storm loads of total nitrogen are associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

Mean storm loads of total ammonia plus organic nitrogen varied by almost two orders of magnitude, from 0.0064 to 0.43 pounds per acre. The largest mean storm loads of total ammonia plus organic nitrogen were associated with industrial and commercial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

Mean storm loads of total phosphorus varied by almost two orders of magnitude, from 0.0009 to 0.074 pounds per acre. The largest mean storm loads of total phosphorus were associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

Mean storm loads of dissolved phosphorus varied by more than three orders of magnitude, from 0.0001 to 0.044 pounds per acre. The largest mean storm loads of dissolved phosphorus were associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

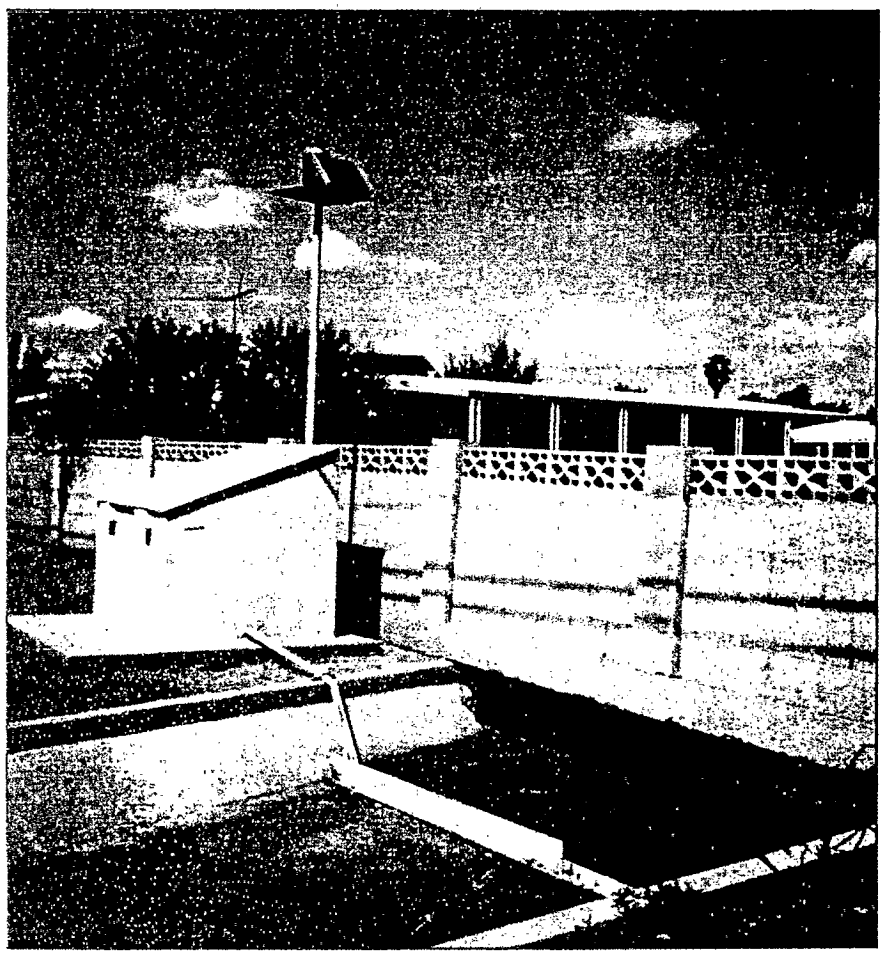

Figure 2. National Pollutant Discharge Elimination System (NPDES) residential land-use site at Glendale, Arizona.

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Trace Metals

Concentrations of four trace-metal constituents—total recoverable copper, total recoverable zinc, total recoverable cadmium, and total recoverable lead are being analyzed by the USGS NPDES program. These constituents were compared for all land uses in the selected cities with the exception of Davenport, Iowa, and Boise, Idaho. Concentrations of these constituents were not determined in Davenport, Iowa, and an industrial land-use basin was not sampled in Boise, Idaho.

Copper and zinc are essential to plant and animal metabolism and are needed in small amounts by all plants and animals. Large amounts of these metals in drinking water, however, can cause adverse effects on the taste and odor of drinking water.

Mean storm loads of total recoverable copper varied by more than three orders of magnitude, from 3.1×10^{-5} to 5.1×10^{2} pounds per acre. The largest mean storm loads of total recoverable copper were associated with commercial and industrial land-use basins. The exception was the maximum that occurred in a residential land-use basin in Birmingham/Montgomery, Alabama.

Mean storm loads of total recoverable zinc varied by almost three orders of magnitude, from 4.4×10^{-4} to 1.1×10^{-1} pounds per acre (fig. 3). The largest mean storm loads of total recoverable zinc were associated with industrial land-use basins; the maximum occurred in Independence, Missouri.

Cadmium and lead tend to bioaccumulate in plants and animals. Large concentrations of these metals lead to toxicity and health problems in plants and humans (Hem, 1992).

Concentrations of total recoverable cadmium were considered in this analysis of data, but more than 70 percent of the analyses were below detection limits. No mean storm loads of cadmium were included in the data tables.

Mean storm loads of total recoverable lead varied by almost three orders of magnitude, from 8.3×10^{-5} to 3.9×10^{-2} pounds per acre. The largest mean storm loads of total recoverable lead were associated with industrial land-use basins; the maximum occurred in Baton Rouge, Louisiana.

The majority of minimum mean storm loads occurred in residential land-use basins and the majority of maximum mean storm loads occurred in industrial land-use basins. The information contained in this fact sheet is part of ongoing studies and may be updated upon completion of the NPDES program.

—Kenneth D. Fossum and Dawn S. McDoniel

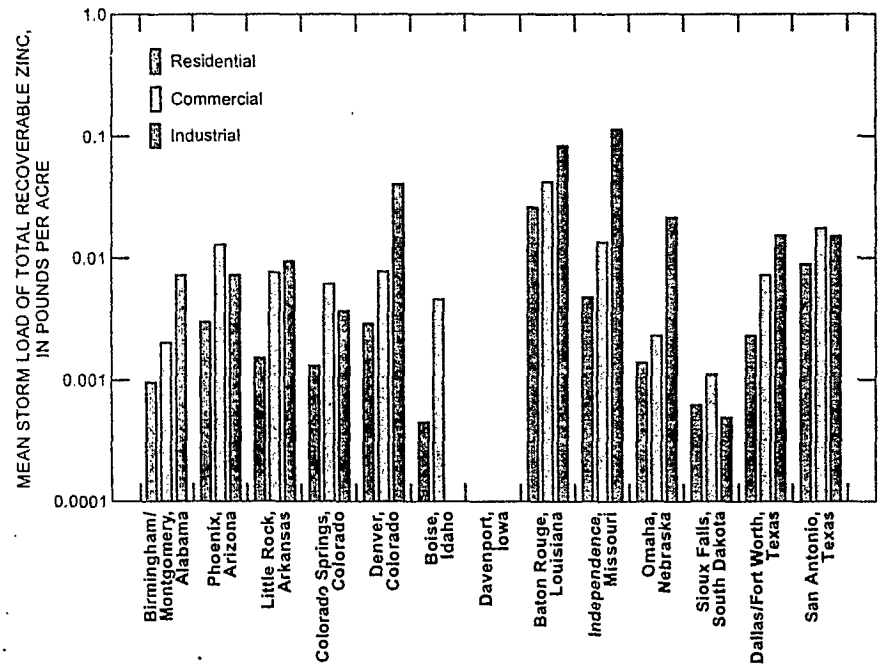

Figure 3. Mean storm loads of total recoverable zinc.

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USGS

Quantity and Quality of Urban Stormwater Runoff from Selected Drainage Basins

By Abraham H. Chen and Francis J. Jelinek

U.S. Geological Survey
Water-Resources Investigations Report 98-4168
Lincoln, Nebraska
1998

ABSTRACT

The U.S. Geological Survey, in cooperation with the City of Omaha and the Papio-Missouri River Natural Resources District, Nebraska, conducted a study to describe stormwater-runoff quantity and quality from selected basins in Omaha. The study was done to meet technical data requirements for the City of Omaha to obtain a National Pollutant Discharge Elimination System Permit from the U.S. Environmental Protection Agency.

Stormwater-runoff quantity and quality from five sites located in residential, commercial, and industrial land-use basins were monitored from May to November 1992 and April through August 1993. Sites 1 and 4 were representative of residential land use; sites 2 and 5 were representative of commercial land use; and site 3 was representative of industrial land use.

Total rainfall, runoff volume, runoff-rainfall ratio, peak discharge, rainfall and runoff duration, and number of dry hours between storms were calculated and compiled. Mean rainfall during the study was slightly greater in the residential basins (0.60 inch) than in the commercial (0.45 inch) and industrial (0.46 inch) basins. However, mean runoff-rainfall ratio for the industrial (0.32) and commercial (0.38) basins was more than twice the runoff-rainfall ratio of the residential basins (0.15).

Grab samples and flow-weighted composite samples were collected at each of the five sites during six storms and were analyzed for 147 chemical, physical, and biological characteristics. Grab samples, collected within the first 30 minutes of each storm, represented the storm's first-flush effects, and were analyzed for pH, water temperature, residual chlorine, volatile organic compounds, cyanide, total phenols, biological oxygen demand, fecal coliform and fecal streptococcus bacteria, and oil and grease. Flow-weighted samples were composited during the first 3 hours of a storm and were analyzed for acid and base/neutral organic compounds, pesticides and polychlorinated biphenyls, trace elements, chemical oxygen demand, suspended solids, dissolved solids, nutrients, major ions, alkalinity, pH, specific conductance, and total organic carbon.

The volatile organic compounds-chloro-form, dichlorobromomethane, methyl chloride, and toluene-were detected in concentrations ranging from 0.4 to 7.0 micrograms per liter. Toluene was detected only in the residential basins. Eleven base/neutral compounds with concentrations ranging from 9 to 150

micrograms per liter were detected in a commercial basin (site 5) during a storm-runoff event May 22, 1993. Eleven of 12 base/neutral compounds sampled for were detected at five sites. Concentrations of six of the compounds exceeded U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Levels (MCLs) for drinking water.

No pesticide or polychlorinated biphenyl concentrations exceeded MCLs. The trace elements-total beryllium and total lead-exceeded MCLs for drinking water. Total lead also exceeded treatment action levels established by the USEPA for drinking water. Median concentrations of lead from the industrial basin were about 6 times greater than in the residential and commercial basins. Median concentrations of total copper, total nickel, and total zinc were about 3 times greater in samples collected from the industrial basin than from the residential and commercial basins.

Stormwater-runoff constituent loads for 12 constituents were estimated using three methods. The 12 constituents were biochemical oxygen demand, chemical oxygen demand, suspended solids, dissolved solids, total nitrogen as nitrogen (N), total ammonia plus organic nitrogen as N, total phosphorus, dissolved phosphorus, total cadmium, total copper, total lead, and total zinc. The first method used was direct computation of observed data. The second method used was the USEPA simple method for calculating annual pollutant loads. The third method used was a statistical regression method, adjusting the regional models by using local monitoring data. The regression models estimated stormwater-runoff constituent loads.



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Business Inspection Program

Seattle's waterways are vulnerable to pollution from a wide variety of human activities. Some businesses within Seattle drain to a creek, lake or bay. Spills or debris may be washed from properties into a public storm system and flow to these aquatic habitats.

Seattle Public Utilities is inspecting commercial and industrial properties to improve stormwater pollution prevention practices in the City of Seattle. The intent of this program is to work with local businesses to improve stormwater quality in Seattle's creeks, lakes and Puget Sound.

Business inspections are part of the City's stormwater pollution prevention program, a requirement of the Washington State Department of Ecology administered through the City's National Pollutant Discharge Elimination System (NPDES) permit for municipal stormwater discharges.

Stormwater Pollution Prevention Requirements

Under the Seattle Stormwater, Grading, and Drainage Control Code (SMC 22.800), all businesses are required to implement certain operational and structural source controls to reduce stormwater pollution.

- **Operational stormwater source controls consist of management practices that prevent or reduce the amount of pollutants in stormwater runoff.** Best Management practices include simple housekeeping activities such as regularly sweeping parking lots and sidewalks, maintaining existing drainage systems, training employees about stormwater pollution prevention practices, and maintaining spill control supplies onsite to prevent and cleanup accidental spills.
- **Structural stormwater source controls are physical, structural, or mechanical devices or facilities that are constructed to prevent pollutants from entering stormwater.** Examples of structural source controls include: enclosing and/or containing the pollutant source; constructing berms, curbs, or dikes to prevent unpolluted stormwater from entering an area where pollution-generating activities take place; and containing and/or treating runoff from contaminated areas.

Check the Director's Rules to see what the new requirements are for public property. If your property drains are connected to the city stormwater system, then you are responsible for maintaining your drainage structures:

- conveyance systems, detention systems and treatment systems
- maintaining streets, driveways, parking lots and sidewalks
- identifying and eliminating illicit connections to the drainage control system.

Business Inspection Program FAQs

More Information for business owners
Four Director's Rules describe City requirements for stormwater flow control, treatment, and construction-related drainage requirements for new and redevelopment projects. They also cover stormwater pollution source control

requirements for existing and new or redevelopment projects.

- DR 16-2000 (5.7MB PDF), Volume 2, Construction Stormwater Control Technical Requirements Manual
  Describes requirements for construction projects (temporary erosion and sedimentation control and control of other pollutants).
- DR 17-2000 (1.6MB PDF), Volume 1, Source Control Technical Requirements Manual
  Describes the operational and structural source controls that are required to reduce stormwater pollution.
- DR 26-2000 (1.9MB PDF), Volume 3, Flow Control Technical Requirements Manual
  Describes requirements for controlling peak flow rates for new and redevelopment projects.
- DR 27-2000 (3.7MB PDF), Volume 4, Stormwater Treatment Technical Requirements Manual
  Describes requirements for treating stormwater from new and redevelopment projects.

Paper copies of these rules are also available at the DCLU Applicant Services Center, Key Tower, 700 5th Avenue, 20th Floor. However, due to their considerable length, a fee is being charged to cover production costs.

If you have questions or concerns regarding the business inspection process, please contact:

Ellen Stewart at 206-615-0023 or ellen.stewart@seattle.gov

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Frequently Asked Questions about Business Inspection

Why are we inspecting businesses at this time?
The intent of this program is to work with local businesses to improve stormwater quality. However not all businesses in the City of Seattle will be inspected. If your business is selected to be inspected, you will receive a letter of notification. Business inspections will be conducted to ensure that local businesses understand and implement the requirements of the new code. The goal of this program is to reduce the amount of pollutants entering private and public storm drains, because these systems eventually discharge untreated water to nearby streams, lakes, and Puget Sound. To protect water quality and promote a healthy aquatic ecosystem, we must all make an effort to prevent pollutants such as sediment, oil, soap, and other chemicals from reaching local waters.

When will an inspection take place?
If your business had been selected for an inspection, you will receive a letter of notification within one month of the inspection date. You are welcome to set up an appointment with the inspector prior to the inspection. The inspector will make every effort to contact the responsible party on-site and then commence the inspection. (see contact information)

What will happen on the day of an inspection?
Business inspections are conducted to ensure that local businesses understand and implement the requirements of the new stormwater code. An SPU surface water quality inspector will visit your business to identify potential sources of pollutants to the drainage system and will also observe your general housekeeping practices to make sure that you are using appropriate controls to prevent pollutants from entering any storm drains.

Where will the inspector be looking?
The inspector will mainly need to check the outdoor areas on your property where chemicals, waste, or equipment are stored and where manufacturing or other possible pollution-generating activities take place. In addition, the inspector will look at the drainage system on your property to make sure that it is in good shape. In some cases, the inspector may need to check indoor areas to confirm whether or not they are connected to the drainage system. Inspectors will provide you with information on best management practices that are effective in reducing stormwater pollution.

What if there are corrective actions?
As the property owner, you are responsible for making any corrections needed to comply with the City Code. If any corrective actions are needed, they will be described in the letter sent to you within two weeks after the inspection. The letter will include a brief description of the problem(s), recommendations for correcting the problem(s), information about how to minimize the amount of pollutants discharged from your property, and will also specify a date when the inspector will return to re-inspect your property. Re-inspections will be scheduled as needed to ensure those necessary improvements or corrective actions are completed. The re-inspection date will be determined based on the severity of the problem(s) found during the inspection. Corrective actions should be completed before the re-inspection.

What happens if corrective action is not taken?
As the property owner, you are responsible for any corrections needed to comply with the City Code. If compliance is not achieved within a timely manner, a Notice of Violation may be issued that could result in a fine of up to $500 for each day the violation continues.

If I have other questions about business inspections not covered here, who can I contact?

North of Yesler Way
Tasha Bassett
phone: (206) 615-0550
e-mail:
Tasha.Bassett@ci.seattle.wa.us

South of Yesler Way
Ryean-Marie Woods
phone: (206) 386-4024
e-mail:
RyeanMarie.Woods@ci.seattle.wa.us

Free stormwater information and on-site assistance are also available through the Business and Industry Resource Venture, a partnership between Seattle Public Utilities and the Greater Seattle Chamber of Commerce at (206) 389-7304 or **http://www.resourceventure.org/**

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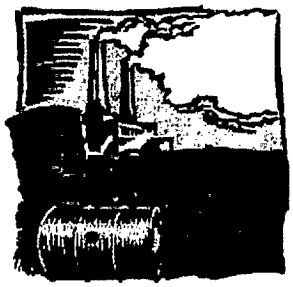
Last Updated. 04/18/01

CITY OF FORT WORTH, TEXAS
STORM DRAIN MONITORING PROGRAM



Fort Worth's Industrial Inspection Program

The City's Industrial Inspection Program was created as a requirement of the City's NPDES Storm Water Permit with the EPA. For the purposes of compliance with the permit, the City must inspect (1) SARA Title III Section 313 industrial facilities, (2) hazardous waste treatment, disposal or recovery facilities, (3) municipal facilities under NPDES regulations and (4) industries that discharge, or have the potential to discharge, substantial pollutant loadings to the storm drain system. Each of these facilities must be inspected once every five years, at a minimum. These inspections are based upon EPA criteria and primarily include a review of the facility's Storm Water Pollution Prevention Plan (SWPPP) and a physical inspection of the facility to identify any potential sources of storm water pollution.

The City of Fort Worth Department of Environmental Management (DEM) has taken a unique approach in performing these inspections. As a regulatory agency, the City has the authority to impose fines and initiate state and federal investigations upon non-compliant industries. However, the federal storm water regulations are not only complicated, they are new to many industries.

DEM is cognizant of this and has taken an approach of education and cooperation with the industries, as opposed to enforcement. When our inspectors visit an industry for the first time, they will perform a comprehensive review of the industry's SWPPP. Any deficiencies in the SWPPP are noted and the industry is given 30 days to make appropriate corrections. During this initial phase, the inspector is willing to assist the industry gain compliance with its permit. This assistance may be in the form of supplying EPA paperwork, answering questions, performing plan reviews, interpreting data, or anything else needed by the industry.

At the end of the 30 day period, the inspector reviews the SW3P again and notes whether the facility is in compliance. In some cases, the industry may not be in compliance at the end of the 30 day period. DEM recognizes that in some special cases, 30 days may not be enough time to make major changes. In such cases, DEM will continue to work with the industry until the industry is in compliance. Industries that do not obtain permits or make reasonable efforts to implement SWPPPs are referred to the EPA for possible federal enforcement action.

For additional information on the inspection process, please call 817-871-5451 and ask for an Industrial Inspector.

Return to Storm Water Discharges Associated With Industrial Activity

FORT WORTH

This page was last modified on February 22, 2001.

In cooperation with the San Antonio Water System

The Edwards aquifer is one of the most productive carbonate aquifers in the Nation. The dissolution-modified, faulted limestone aquifer is the sole source of public water supply for San Antonio, Texas (fig. 1) and is the major source of water for Bexar County. In addition to providing public water supply to more than 1 million people, the Edwards aquifer supplies large quantities of water for agriculture, industry, and military installations. Major springs discharging from the aquifer support recreational activities and businesses, provide water to downstream users, and provide habitat for several threatened or endangered species.

The Edwards aquifer recharge zone is approximately coincident with the stratigraphic units that constitute the Edwards aquifer outcrop; however, the recharge zone includes outcrops of other stratigraphic units in proximity to the units of the Edwards aquifer outcrop where caves, sinkholes, faults, fractures, or other permeable features create a potential for recharge. For this report, areas that are immediately adjacent to the Edwards aquifer outcrop and that drain to the outcrop are considered to be in the recharge zone.

In Bexar County, the area of the Edwards aquifer outcrop is about 119 square miles (mi^2). Most of the land (about 72 percent) on the outcrop is undeveloped (fig. 2). Residential use is about 10 percent of the outcrop land use.

Residential and commercial development on the Edwards aquifer recharge zone in Bexar County is increasing. Urban development can have an appreciable influence on water quality. Impervious cover in developed areas can result in increased stormwater runoff, conveying contaminants from nonpoint sources to local streams or geologic features such as

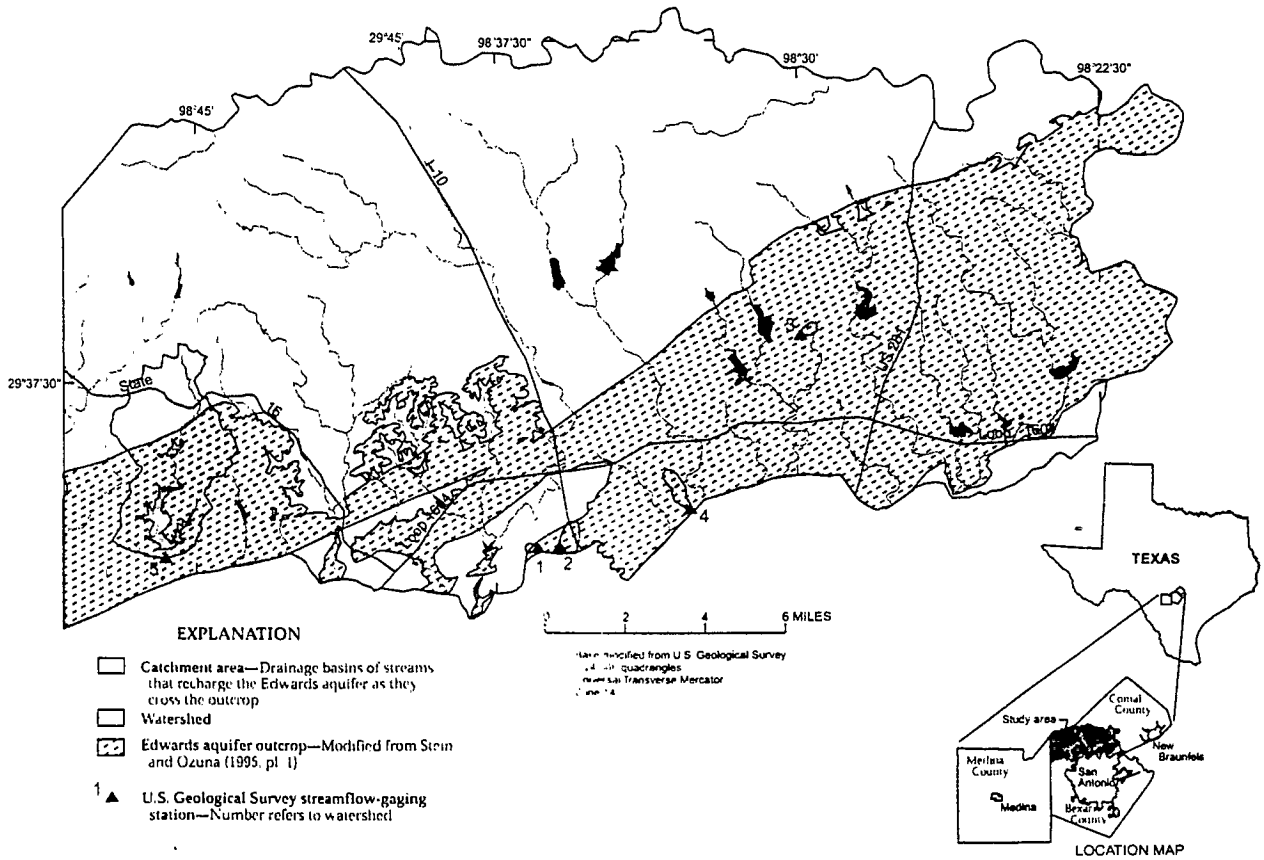


Figure 1. Location of selected watersheds and streamflow-gaging stations in the Edwards aquifer recharge zone, Bexar County, Texas.

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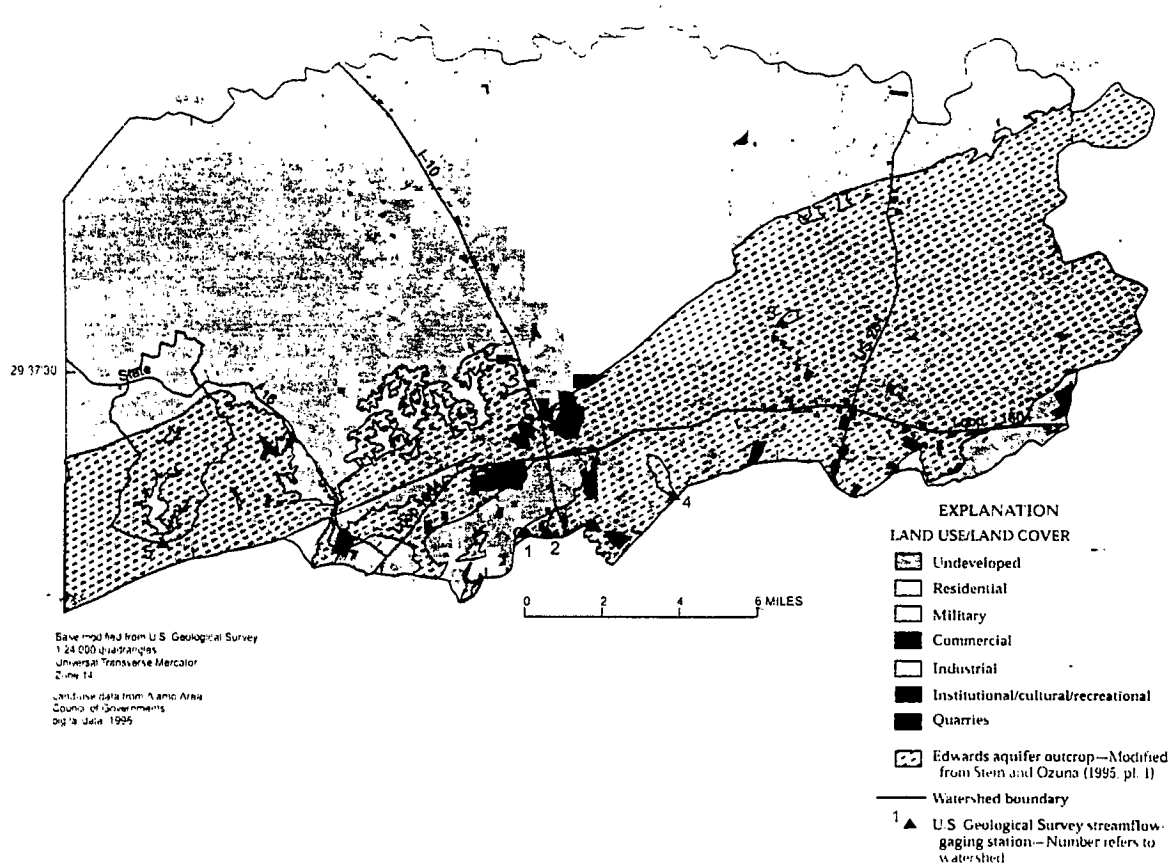

Figure 2. Land use/land cover in the Edwards aquifer recharge zone, Bexar County, Texas, 1996.

caves and fractures where infiltration into the aquifer can occur.

In 1996, the U.S. Geological Survey (USGS), in cooperation with the San Antonio Water System, began a study to monitor the quality and quantity of stormwater runoff of five selected watersheds in the Edwards aquifer recharge zone. The purpose of the study is to further the understanding of relations between stormwater and land use and to help resource managers assess the effects of development on the Edwards aquifer recharge zone. Land use is relatively commercial in two of the watersheds and predominantly residential in two of the watersheds; one watershed is largely undeveloped (table 1). This fact sheet provides an overview of the data-collection methods and selected results of analysis.

Data Collection and Analysis

Rainfall and runoff data and stormwater samples were collected during June 1996–October 1998 from streamflow-gaging stations at the outlets of the five selected watersheds in the Edwards aquifer recharge zone. At each station, rainfall and gage height (stream water level) were measured during storm-runoff events. A computer recorded instrument readings, calculated stream discharges (and runoff), and activated automatic water samplers on the basis of calculated runoff. During each storm-runoff event, the autosamplers were programmed to collect numerous

Table 1. Characteristics of selected watersheds in the Edwards aquifer recharge zone, Bexar County, Texas, 1996–98

[<, less than]

Watershed (fig. 1)	Drainage area (acres)	Impervious cover (percent)	Land use/ land cover	Remarks
1	19	50	Commercial	No stormwater-control structures.
2	315	45–65	Commercial	Watershed includes section of I–10; stormwater-control structures required for businesses; ongoing construction during study period.
3	75	40–50	Residential	Medium density, single-family homes.
4	250	<5	Residential	3- to 5-acre lots; septic tanks.
5	6,880	<2	Undeveloped	Upper 2,450 acres of watershed is upstream of recharge zone; runoff events are rare.

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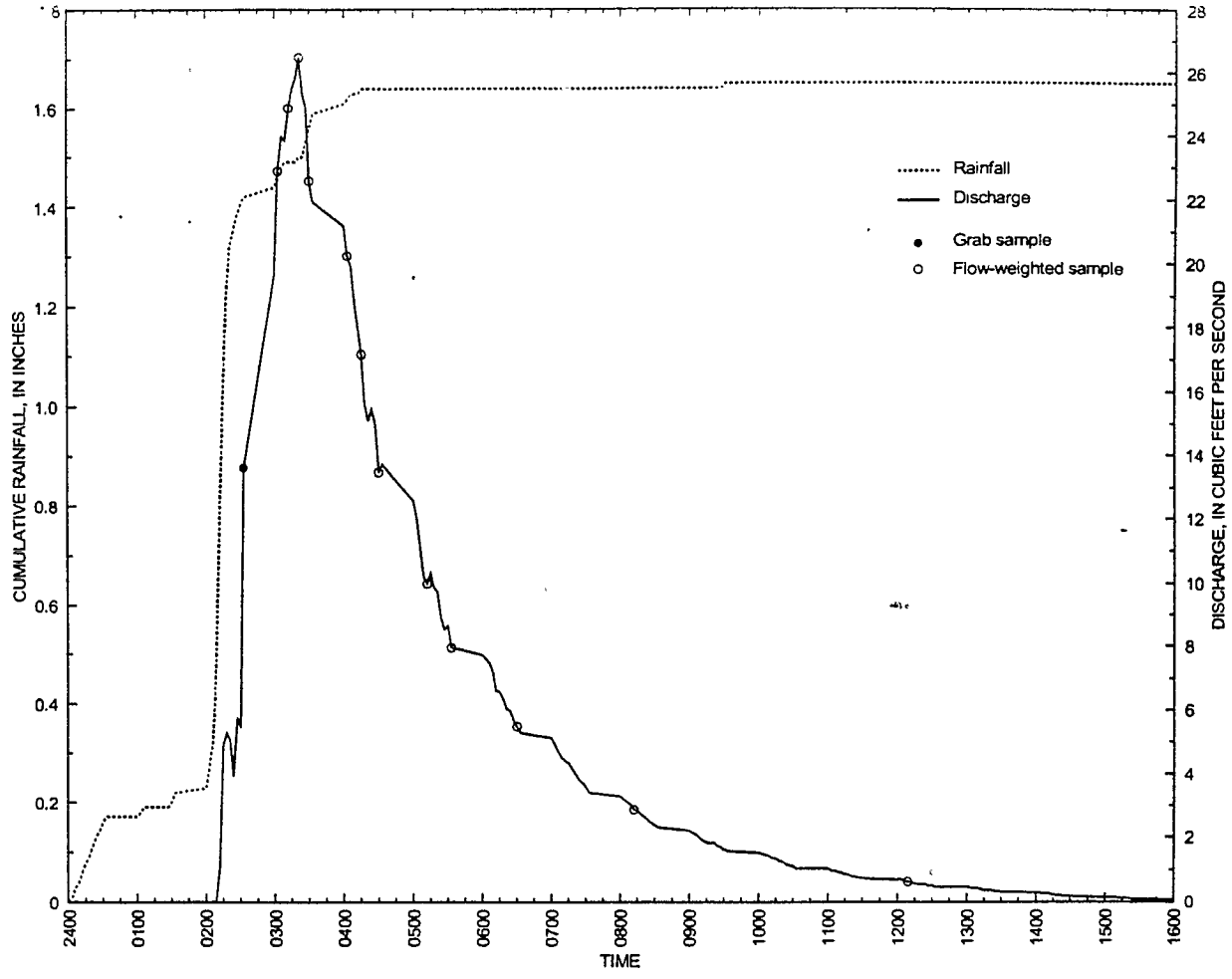

Figure 3. Rainfall, discharge, and times of flow-weighted and grab sample collection during a storm-runoff event at watershed 4, Bexar County, Texas, March 16, 1998.

flow-weighted samples. At the end of a storm-runoff event, the samples were composited, packaged, and shipped to the USGS National Water Quality Laboratory in Arvada, Colo., for analysis. The composite samples were analyzed for common inorganic constituents, chemical oxygen demand (COD), biochemical oxygen demand (BOD), nutrients, trace elements, selected organic compounds, and pesticides.

Analyses of the composite samples yielded event-mean concentrations (EMC), which represent average water-quality conditions during a runoff event. EMCs are useful for comparing concentrations from different sites or from different runoff events at the same site, and for estimating the mass of a chemical constituent exiting the watershed during an event. The mass of a constituent exiting the watershed in runoff can be estimated by multiplying the EMC by the runoff (and appropriate conversion factor).

Discrete grab samples also were collected during each storm-runoff event and analyzed for specific conductance, pH, fecal coliform and fecal streptococcus bacteria, cyanide, phenols, oil and grease, and volatile organic compounds (VOC). Generally, grab samples are collected during the early stages of a runoff event and indicate the presence of constituents in the "first flush" of a runoff. As the constituent concentrations might not represent the average concentrations during a runoff event, estimates of mass of these constituents are uncertain. Rainfall, discharge, and times of flow-weighted and grab sample collection for an example storm-runoff event at watershed 4 on March 16, 1998, are graphed in figure 3.

Selected Water-Quality Property and Constituent Concentrations

Thirty-two composite storm-runoff samples (representing 32 storm-runoff events) were collected at the five selected watersheds during June 1996–October 1998. The watersheds with the larger percentages of impervious cover (1 and 2, table 1) yielded more runoff per acre than the less developed watersheds (4 and 5, table 1). More samples were collected from the watersheds with more impervious cover (1 and 2) because runoff occurred with as little as 0.05 inch (in.) of rainfall in the watershed, whereas runoff in watersheds 4 and 5 occurred only during intense rainfall with totals of at least 1.5 in. The median EMCs of selected constituents for each watershed are listed in table 2.

Boxplots were constructed to show example comparisons of concentrations

R0012807

Table 2. Median event-mean concentrations of selected properties and constituents by watershed, Bexar County, Texas, 1994–95

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; mg/L, milligrams per liter; cols./100 mL, colonies per 100 milliliters; $CaCO_3$, calcium carbonate; <, less than; µg/L, micrograms per liter; --, insufficient data]

Property or constituent	Watershed (fig. 1)				
	1	2	3	4	5
Number of composite storm-runoff samples collected	10	2	12	4	4
Specific conductance (µS/cm)	91	106	88	114	200
Chemical oxygen demand (mg/L)	38	39	31	27	30
Fecal coliforms (cols./100 mL)	10,000	27,000	13,000	4,900	4,300
Fecal streptococci (cols./100 mL)	5,600	64,000	38,000	67,000	5,180
Calcium, dissolved (mg/L)	12	13	11	16	35
Magnesium, dissolved (mg/L)	.4	4.0	.4	.8	2.1
Sodium, dissolved (mg/L)	2.2	1.3	1.3	1.2	1.7
Potassium, dissolved (mg/L)	1.6	2.6	1.6	3.0	2.4
Alkalinity (mg/L as $CaCO_3$)	45	54	48	57	102
Sulfate, dissolved (mg/L)	4.9	4.0	2.3	2.2	4.0
Chloride, dissolved (mg/L)	1.5	1.0	1.8	1.6	2.5
Dissolved solids, sum of constituents (mg/L)	52	60	52	98	119
Suspended solids (mg/L)	114	111	54	42	48
Nitrogen, nitrite plus nitrate, dissolved (mg/L)	.41	.20	.28	.20	.44
Nitrogen, ammonia, dissolved (mg/L)	.10	.10	.08	.03	<.02
Nitrogen, ammonia plus organic, total (mg/L)	.60	.80	1.0	.80	1.02
Nitrogen, ammonia plus organic, dissolved (mg/L)	.30	.30	.40	.40	.39
Phosphorus, total (mg/L)	.20	.18	.19	.14	.07
Arsenic, total (µg/L)	2	2	12	3	--
Cadmium, total (µg/L)	<1	<1	<1	<1	<1
Chromium, total (µg/L)	4	6	1	2	<1
Copper, total (µg/L)	7	6	6	3	2.1
Lead, total (µg/L)	9	10	3	10	2.2
Mercury, total (µg/L)	<.1	<.1	<.1	<.1	<.1
Nickel, total (µg/L)	3	4	2	2	--
Zinc, total (µg/L)	100	45	37	16	<10
Organic carbon, total (mg/L)	14	13	10	12	10
Cyanide, total (mg/L)	<.01	<.01	<.01	<.01	<.01
Phenols, total (µg/L)	4	--	<1	4	<1
Oil and grease, total (mg/L)	3	--	2	<1	<1
DDD, total (µg/L)	<.1	<.1	<.1	<.1	<.1
DDE, total (µg/L)	<.04	<.04	<.04	<.04	<.04
DDT, total (µg/L)	<.1	<.1	<.1	<.1	<.1
Diazinon, total (µg/L)	<.05	<.05	.5	<.05	<.05

of selected trace elements (chromium, copper, lead, and zinc) by land use (fig. 4). Water-quality data from watersheds with similar land uses (1 and 2; 3 and 4) (table 1) were grouped together. Boxplots with data less than the laboratory minimum reporting levels were truncated at the reporting level. The numbers of samples with concentrations less than the reporting levels are shown in brackets in figure 4. In most cases, less than 25 percent of the data were below the reporting levels and the interquartile range is plotted. Boxplots for the undeveloped land-use category were not constructed because only four samples were collected

Total chromium, lead, and zinc concentrations were significantly larger, at the 95-percent confidence level, for commercial land use than for residential land use on the basis of one-sided Mann-Whitney tests (Helsel and Hirsch, 1992). The statistical test for total copper concentrations did not show significant difference between commercial and residential land use. Statistical comparisons of concentrations in samples from the undeveloped watershed were not included because of the small data set (four samples).

Example of Mass Yields

The effect of land use and percent impervious cover of a watershed in generating stormwater-runoff pollutants is evident when examining the annual mass

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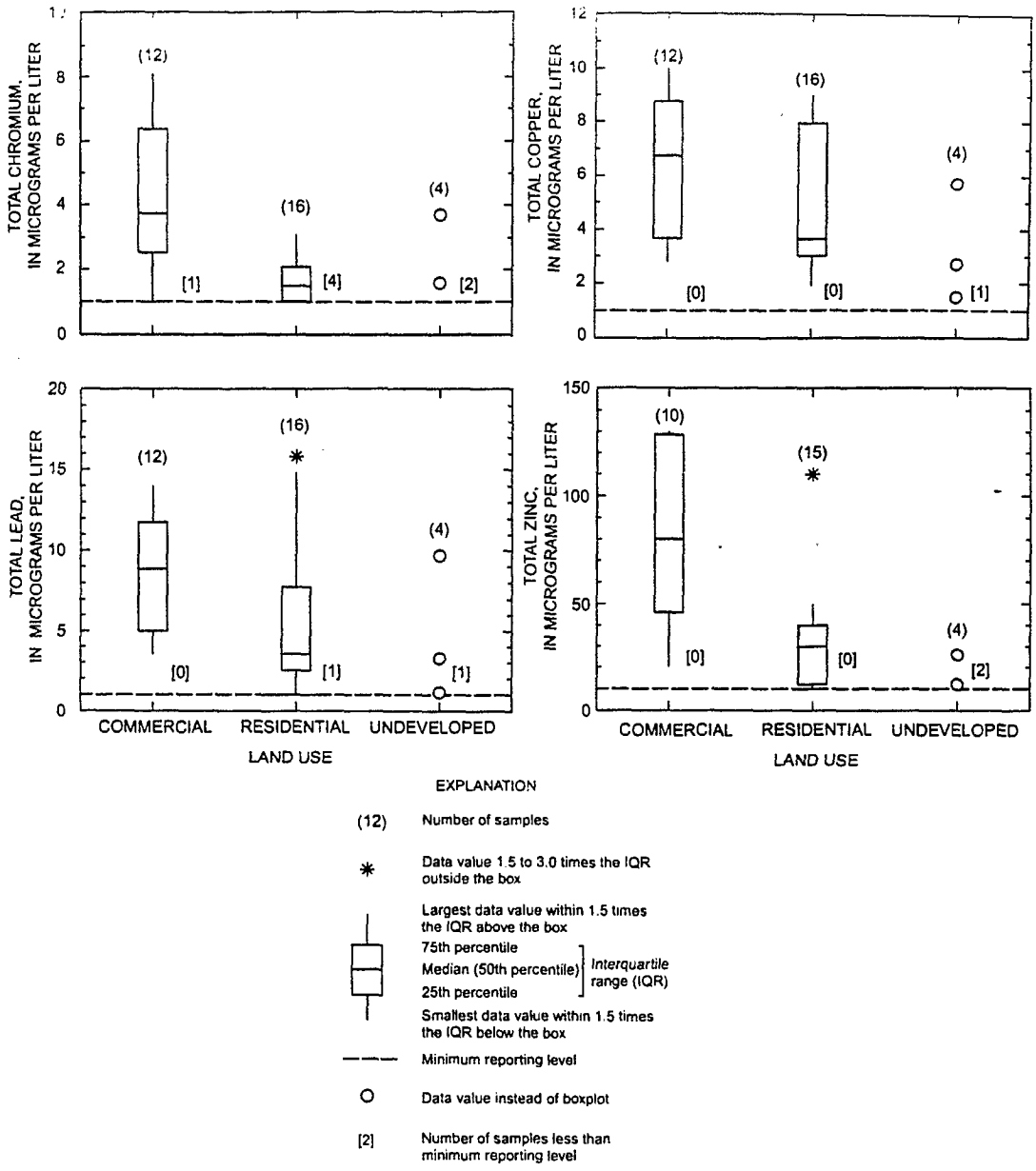

Figure 4. Distributions of total chromium, copper, lead, and zinc concentrations by land use, Bexar County, Texas, 1996–98.

yield of total lead, for example, for the watersheds. Annual mass yields for 1997 were computed for total lead for each watershed using the equation:

$$Y = \frac{QC}{A} \cdot cf,$$

where

Y = annual mass yield in pounds per year per acre;

Q = annual runoff in acre-feet per year;

C = flow-weighted average of EMCs in micrograms per liter;

A = watershed area in acres; and

cf = conversion factor (0.00272).

Annual runoff, flow-weighted averages of EMCs, and mass yields of total lead for the five watersheds are listed in table 3. All samples collected from June 1996 through October 1998 (some watersheds had limited runoff during 1997) were used to compute the flow-weighted average of total lead EMCs, except for watershed 5. In 1997, all of the runoff for watershed 5 occurred during a single event. Samples collected for watershed 5 during the event yielded total lead concentrations that were less than the laboratory minimum reporting level, so a value equal to the reporting level was used as the average EMC to calculate a maximum for the annual yield. The magnitude of differences in annual mass yields among the watersheds is illustrated in figure 5.

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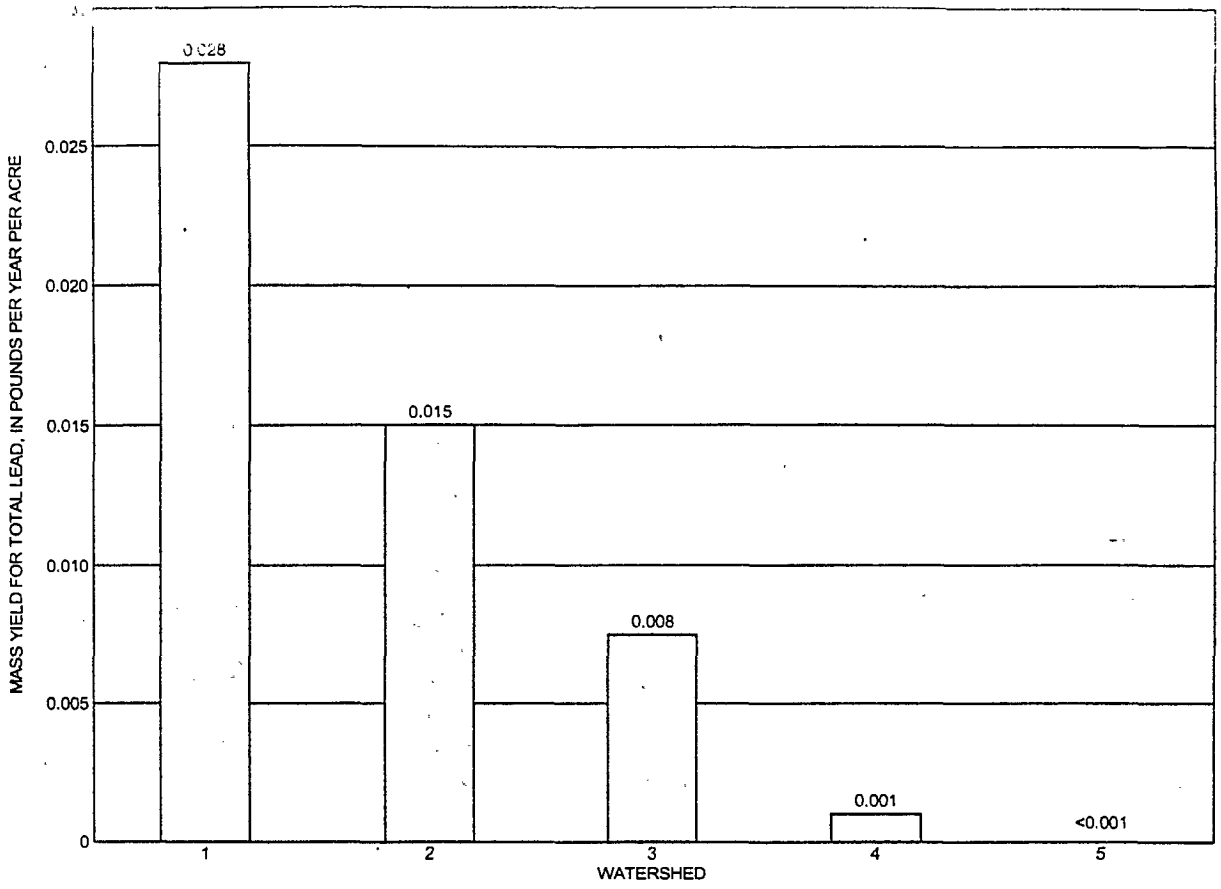

Figure 5. Annual mass yields for total lead by watershed, Bexar County, Texas, 1997.

References

Helsel, D.R., and Hirsch, R.M., 1992, Studies in environmental science 49—Statistical methods in water resources: Amsterdam, Elsevier, 522 p.

Stein, W.G., and Ozuna, G.B., 1995, Geologic framework and hydrogeologic characteristics of the Edwards aquifer recharge zone, Bexar County, Texas: U.S. Geological Survey Water-Resources Investigations Report 95–4030, 8 p., 1 pl.

Table 3. Runoff, flow-weighted averages of event-mean concentrations of lead, and mass yields by watershed, Bexar County, Texas, 1997

[µg/L, micrograms per liter; <, less than]

Watershed	Runoff (acre-feet per year)	Flow-weighted average of event-mean concentrations of total lead (µg/L)	Mass yield of total lead (pounds per year per acre)
1	24.5	8	0.028
2	149	12	.015
3	41.5	5	.008
4	39.6	3	.001
5	2,650	<1	<.001

—D.J. Ockerman, B.L. Petri, and R.N. Slattery

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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E-mail: gbozuna@usgs.gov
World Wide Web: http://tx.usgs.gov

R0012810

PERMIT NO. FLS000004
Major MS4

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IV

AUTHORIZATION TO DISCHARGE UNDER THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Clean Water Act, 33 U.S.C. 1251 et seq., as amended by the Water Quality Act of 1987, P.L. 100-4, the "Act",

Sarasota County - Municipal Separate Storm Sewer System Permittees:

Sarasota County
Engineering Department
Sarasota, Florida

Town of Longboat Key
Department of Public Works
Longboat Key, Florida

City of North Port
Roads and Drainage Department
North Port, Florida

City of Sarasota
Department of Public Works
Sarasota, Florida

City of Venice
Department of Public Works
Venice, Florida

Florida Department of Transportion
District One
Bartow, Florida

are authorized to discharge, in accordance with the approved Storm Water Management Program(s), effluent limitations, monitoring requirements, and other provisions as set forth in Parts I, II, III, IV, V, VI, VII, and VIII herein, from all portions of the

Municipal Separate Storm Sewer System owned or operated by any Permittee listed above,

to waters of the United States and all tributaries thereto.

This permit shall become effective on January 1, 1995.

This permit and the authorization to discharge under the National Pollutant Discharge Elimination System shall expire at midnight, on December 31, 1999.

DEC 21 1994
Date Issued

Robert F. McGhee, Acting Director
Water Management Division

R0012811

SARASOTA COUNTY PERMITTEES
NPDES PERMIT FOR
MUNICIPAL SEPARATE STORM SEWER SYSTEMS

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SARASOTA COUNTY PERMITTEES
NPDES PERMIT FOR
MUNICIPAL SEPARATE STORM SEWER SYSTEMS

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PART I.

DISCHARGES AUTHORIZED UNDER THIS PERMIT

A. **Permit Area.** This permit covers all areas located within the political boundary of Sarasota County and the portion of the Town of Longboat Key within Manatee County served by municipal separate storm sewer systems owned or operated by the permittees identified in Part I.C.

B. **Authorized Discharges.** Except for discharges prohibited under Part I.D., this permit authorizes all existing or new storm water point source discharges to waters of the United States from those portions of the Municipal Separate Storm Sewer System (MS4) owned or operated by the permittees.

C. **Permittees.**

The following entities are permittees subject to the conditions of this permit:

- **Sarasota County**
- **Town of Longboat Key***
- **City of North Port**
- **City of Sarasota**
- **City of Venice**
- **Florida Department of Transportation, District One**

* ***Permit coverage includes the entire Town of Longboat Key which is located in both Sarasota and Manatee Counties***

References to "permittee" in this permit includes each of the entities above.

1. Each permittee is individually responsible for:

   a. Compliance with permit conditions relating to discharges from portions of the MS4 where they are the operator;

   b. Storm water management program implementation on portions of the MS4 where they are the operator;

   c. Where permit conditions are established for specific portions of the MS4, the permittee need only comply with the permit conditions relating to those portions of the MS4 for which they are the operator; and

   d. A plan of action to assume responsibility for implementation of storm water management and monitoring programs on their portions of the MS4 should inter-jurisdictional agreements allocating responsibility between permittees be dissolved or in default. (See Part II.G.3., page 20 of this permit also.)

2. Each permittee is jointly responsible for:

   a. Submission of annual reporting requirements as specified in Part V.C. (ANNUAL REPORT), page 49;

   b. Collection of monitoring data as required by Part V.B., page 47, according to such agreements as may be established between permittees;

   c. Insuring implementation of system-wide management program elements, including any system-wide public education efforts.

3. Specific permittees are jointly liable for permit compliance on portions of the MS4:

   a. Where operational or storm water management program implementation authority over portions of the MS4 has been transferred from one permittee to another in accordance with legally binding interagency or inter-jurisdictional agreements, both the owner and operator are jointly responsible for permit compliance on those portions of the MS4, unless specific responsibility provisions have been otherwise outlined in said agreements.

D. **Limitations on Coverage.** Section 402(p)(3)(B)(ii) of the Clean Water Act specifically requires EPA to include within this permit an effective prohibition on non-storm water entering the MS4. The following discharges are not authorized by this permit:

1. *Non-storm Water:* discharges of non-storm water, except where such discharges are:

   a. in compliance with a separate NPDES permit (or the discharger has applied for such permit); or

   b. identified by and in compliance with Part II.A.7.a., page 9 of this permit.

2. *Spills*: discharges of material resulting from a spill, except where such discharges are:

   a. the result of an Act of God where reasonable and prudent measures have been taken to minimize the impact of the discharge; or

   b. an emergency discharge required to prevent imminent threat to human health or prevent severe property damage, provided reasonable and prudent measures have been taken to minimize the impact of the discharge.

PART II.

STORM WATER POLLUTION PREVENTION & MANAGEMENT PROGRAMS

Each permittee covered by this permit shall contribute to the development, revision, and implementation of a comprehensive Storm Water Management Program (SWMP) including pollution prevention measures, treatment or removal techniques, storm water monitoring, use of legal authority, and other appropriate means to control the quality of storm water discharged from the Municipal Separate Storm Sewer System (MS4). The SWMP shall be implemented in accordance with Section 402(p)(3)(B) of the Clean Water Act and 40 CFR Part 122.26.

Controls and activities in the SWMP shall identify areas of permittee jurisdiction, applicability, or specific area basis. The SWMP shall include controls necessary to effectively prohibit the discharge of non-storm water into municipal separate storm sewers and reduce the discharge of pollutants from the MS4 to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream. Compliance with this SWMP shall be reported annually in the ANNUAL REPORT discussed in Part V.C. on page 49 of this permit.

The SWMP shall cover the term of the permit and shall be updated as necessary, or as required by the Director, to ensure compliance with this statutory requirement of Clean Water Act Section 402(p)(3)(B). Modifications to the SWMP shall be made in accordance with Part II.G. of this permit. Compliance with the SWMP and the compliance schedules in Part III shall be deemed in compliance with Parts II.A. and II.B. of the permit. **The Storm Water Management Program submitted by the permittees in the July 23, 1993, Part 2 Application, and all approved updates, are hereby incorporated into this permit by reference and thus are conditions of this permit. FDOT's *Statewide Storm Water Management Program for Part 2 EPA NPDES-MS4 Permit Application* dated June 1993 and all approved updates, are hereby incorporated into this permit by reference and thus are conditions of this permit.** Specific components from these Storm Water Management Programs are identified in Parts II and III to serve as measurable enforcement permit conditions. Compliance dates specified in Part III of the permit shall take precedence over compliance dates which may have been proposed in Part 1 or Part 2 of the municipal applications from the permittees.

Implementation of the SWMP may be achieved through participation with other permittees, public agencies, or private entities in cooperative efforts to satisfy the requirements of Part II and Part III of the permit in lieu of creating duplicate program elements for each individual permittee. The SWMP, taken as a whole, shall achieve the "effective prohibition" and "MEP" standards from Section 402(p)(3)(B) of the Clean Water Act, and shall not cause or contribute to violations of State water quality standards of the receiving stream pursuant to the Florida Administrative Code (FAC)§62-40.420(1)-(4).

A. Storm Water Management Program (SWMP) Requirements.

1. *Structural Controls and Storm Water Collection System Operation:* The MS4 and any storm water structural control shall be operated in a manner to reduce the discharge of pollutants to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream.

   a. The permittees listed in Table II.A.1.a. on pages 4 and 5 own and/or operate the structural controls identified. The maintenance activities identified for the structural controls in Table II.A.1.b. on page 6 of this permit represent suggested maintenance practices that can be implemented on an as needed basis. In addition, each shall maintain an internal record keeping system to track inspections and maintenance activities performed during the permit term. If these activities are performed by others under a contractual agreement, then the permittee shall retain copies of the contractual agreement which specifies the maintenance activities to be performed and the schedule of frequency. Inspection and maintenance records shall be retained by the permittees in accordance with Part V.G. on page 58 of this permit. Annual evaluations shall be made to assess the appropriateness of the inspection and maintenance schedule and to ensure the optimization of equipment use. A summary of the annual evaluation shall be included within each ANNUAL REPORT required under Part V.C. on page 49 of this permit.

PERMITTEE / LABOR SOURCE(S)	STRUCTURAL CONTROL	TOTAL NO. MAINTAINED
SARASOTA COUNTY / Prison Labor and Contract Staff	Wet Retention Areas (Maintained Lakes)	85
	Storm Water Treatment Ponds	62
	Channel Control Structures	51
	Channels	500 miles
CITY OF SARASOTA / Interlocal agreement with Sarasota County	Wet Retention Areas (Maintained Lakes)	4
	Storm Water Treatment Ponds	11
	Channels	30 miles

TABLE II.A.1.a.		
PERMITTEE / LABOR SOURCE(S)	**STRUCTURAL CONTROL**	**TOTAL NO. MAINTAINED**
CITY OF VENICE / City of Venice Parks Dept. and Maintenance Dept.	Storm Water Treatment Ponds	7
	Channels	5 miles
CITY OF NORTH PORT / Maintenance Dept.	Wet Retention Areas (Maintained Lakes)	1
	Storm Water Treatment Ponds	190
	Channel Control Structures	10
	Channels	76 miles
FDOT / Maintenance Management System	Storm Water Treatment Ponds	2

TABLE II.A.1.b.
MAINTENANCE SCHEDULE FOR STRUCTURAL CONTROLS

STRUCTURAL CONTROL	FREQUENCY OF INSPECTION	FREQUENCY OF MAINTENANCE	MAINTENANCE ACTIVITY
Dry Retention Areas	Semi-Annually	As Needed	oMowing and invasive plant species removal oSediment and grass clippings removal, including proper sediment disposal oAeration of bottom (dry/infiltration-type ponds) oStabilization of eroded bank areas oLitter and debris removal oBack flush underdrains (where applicable)
Wet Retention Areas (Mantained Lakes) ~~Treatment Ponds~~	Semi-Annually	As Needed	oMowing and invasive plant species removal oStabilization of eroded bank areas oLitter and debris removal
		As necessary to ensure that the depth of sediments does not exceed 1/3 of the design storage volume	oSediment and grass clippings removal, including proper sediment disposal oMonitor sediment accumulations and remove when 1/3 of the storage volume is filled
	Every 18 Months	As Needed	oBack flush underdrains (where applicable)
Channel Control Structures	Quarterly	As Needed	oLitter and debris removal oSediment removal with proper sediment disposal
Channels	Annually - to determine priority	As Needed	oLitter and debris removal oMowing and invasive plant species removal oStabilization of eroded bank areas
		5 Year Revolving Schedule	oSediment removal with proper sediment disposal provided the original cross-section is not exceeded

R0012819

1. *Structural Controls and Storm Water Collection System Operation:* (continued)

   b. Additionally, to satisfy the requirements of this section, the permittees shall develop and implement the Storm Water Management Programs identified in Part III.A.1. on pages 21 and 22 of this permit.

2. *Areas of New Development and Significant Redevelopment:* A comprehensive master planning process (or equivalent) shall be implemented to reduce, to the MEP, the discharge of pollutants from MS4s, which receive discharges from areas of new development and significant redevelopment, after construction is completed. The master planning process shall limit the increases in the discharge of pollutants in storm water as a result of new development, and shall reduce the discharge of pollutants in storm water from redeveloped areas, and shall not cause or contribute to violations of State water quality standards of the receiving stream.

   a. To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.2. on page 23 of this permit.

3. *Roadways:* Public streets, roads, and highways shall be operated and maintained in a manner to reduce to the MEP the discharge of pollutants and shall not cause or contribute to violations of State water quality standards of the receiving stream.

   a. As per the schedule identified in Part III.A.3. on page 24 of this permit, the permittees shall develop and implement standard road repair practices to reduce the pollutants in storm water runoff from areas associated with road repair and maintenance. The program developed shall include practices such as limiting the amount of soil disturbance to the immediate area under repair and scheduling potential pollutant-causing routine repair work during dry seasons, when possible. The program shall establish procedures that address spill prevention, material management practices, and good housekeeping measures at all municipal equipment yards & maintenance shops that support road maintenance activities.

   b. Additionally, to satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.3. on pages 24 and 25 of this permit.

4. *Flood Control Projects:* Water quality impacts on receiving water shall be assessed for all flood management projects identified in the basin master planning process (or comparable planning process). The feasibility of retrofitting existing structural flood control devices to provide additional pollutant removal from storm water shall be evaluated.

   a. To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.4. on page 26 of this permit.

5. *Municipal waste treatment, storage, or disposal facilities not covered by an NPDES storm water permit:* The permittees shall implement a program to identify measures to monitor and reduce pollutants in storm water discharges from facilities that handle municipal waste, including sewage sludge.

   a. To satisfy the requirements of this section, the permittees shall develop and implement a program to reduce pollutants in the storm water discharges from municipally-operated solid waste transfer stations, maintenance and storage yards for waste transportation fleets and equipment, publicly owned treatment works (POTWs), and sludge application and/or disposal sites which are not covered by NPDES storm water permits. This program shall be developed and implemented in accordance with the schedule identified in Part III.A.5. on page 27 of this permit. The initial phase of the program developed shall contain procedures to evaluate, inspect, and monitor these sites. Based upon the evaluations, inspections and monitoring performed, priorities and procedures for implementing control measures for pollutant reduction at these sites shall be developed. Monitoring methodology used during the initial investigative period may be relaxed from standard protocol and may be based on experience gained during actual field activities. The goal of this investigative portion is to actively identify areas within these sites with poorer quality discharges during storm events, so that those areas will be given priority when implementing control measures.

6. *Pesticide, Herbicide, and Fertilizer Application:* Each permittee shall implement controls to reduce, to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream, the discharge of pollutants related to the storage and application of pesticides, herbicides, and fertilizers applied, by employees or contractors, to public right of ways, parks, and other municipal property. Permittees with jurisdiction over lands shall implement programs to encourage the reduction of the discharge of pollutants related to application and distribution of pesticides, herbicides, and fertilizers.

   a. To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.6. on pages 28 and 29 of this permit.

7. *Illicit Discharges and Improper Disposal:* The permittees shall implement an ongoing program to detect and eliminate (or require the discharger to the MS4 to eliminate) illicit discharges and improper disposal into the storm sewer system.

a. *Inspection, Ordinances, and Enforcement Measures:* Non-storm water discharges to the MS4 shall be effectively prohibited by the permittees through the use of inspections, ordinances, and enforcement. The permittees, however, may allow the following non-storm water discharges to the MS4 where they are not identified as a source of pollutants to waters of the United States:

- water line flushing;
- landscape irrigation;
- diverted stream flows;
- rising ground waters;
- uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers;
- uncontaminated pumped ground water;
- discharges from potable water sources;
- foundation drains;
- air conditioning condensate;
- irrigation water;
- springs;
- water from crawl space pumps;
- footing drains;
- lawn watering;
- individual residential car washing;
- flows from riparian habitats and wetlands;
- dechlorinated swimming pool discharges;
- street wash waters; and
- discharges or flows from emergency fire fighting activities.

To satisfy the requirements of this section, the permittee(s) identified in Part III.A.7.a. on pages 30 and 31 of the permit shall:

(1) Identify those of the non-storm water discharges listed under Part II.A.7.a. (above), as well as any other non-storm water discharges, which will be allowed to be discharged to the MS4. Describe any conditions to be placed on these allowable discharges.

(2) Enforce ordinances which prohibit illicit connections and illegal dumping into the MS4. As per the schedule in Part III.A.7.a. on page 30 of this permit (page 31 for FDOT), the permittees shall develop a random inspection program to uncover illicit connections. The program shall include a schedule for inspections and an allocation of staff and resources. A description of the enforcement procedures shall be detailed within the program developed. Because the potential for illicit discharges and improper disposal is generally higher for areas of older development, areas with many automobile-related industries, and areas with significant numbers of heavy industrial facilities, the permittees shall consider the specific land use and age of development when determining inspection priorities and inspection schedules for this program component. Facility inspections may be carried out in conjunction with other municipal programs (e.g. pretreatment inspections of industrial users, health inspections, fire inspections, etc.). The permittees shall maintain an internal log documenting the inspections performed.

(3) Provide in the first ANNUAL REPORT, a photocopy of the signed adopted ordinance(s) identified in Table II.A.7.a.(3) below.

Table II.A.7.a.(3)

PERMITTEE	ORDINANCE
Sarasota County	93-038
Town of Longboat Key	Chapters 33, 52, and 158.102 of the Ordinances of the Town of Longboat Key
City of Sarasota	93-3699 and Section 2-314 of the City of Sarasota Code

(4) As per the schedule in Part III.A.7.a. on page 31 of this permit, the permittees in Table II.A.7.a.(4) shall amend the identified ordinances to change the citation for the definition of *"industrial activity,"* contained within these ordinances, to 40 CFR 122.26(b)(14) from the incorrect citation of 40 CFR 122.26(a)(14).

Table II.A.7.a.(4)	
PERMITTEE	ORDINANCE
City of Sarasota	93-3699
City of North Port	93-15, Section 180-21
City of Venice	93-14, Section 9-74

b. *Dry Weather Field Screening Program:* The permittees shall continue ongoing efforts to detect the presence of illicit connections and improper discharges to the MS4.

(1) To satisfy the requirements of this section, the permittees shall implement a dry weather field screening program to locate and eliminate illicit discharges and improper disposal into the MS4 in accordance with the schedule provided in Part III.A.7.b. on page 32 of this permit. This program shall include the dry weather screening activities identified in Table II.A.7.b. The minimum level of effort for the field screening program shall be based upon a 0.50-mile grid system, with each grid area containing at least one field screening location. In industrial and heavy commercial areas, the minimum level of effort shall be based upon a 0.25-mile grid system, with each grid area containing at least one field screening location. Under this program, all grid areas of the MS4 must be screened once during the permit term. Some grid areas may require more than one field screening location or a more frequent inspection schedule. In lieu of the grid system, the permittees may choose to field screen at all outfalls. Follow-up activities to eliminate illicit discharges and improper disposal may be prioritized on the basis of magnitude and nature of the suspected discharge; sensitivity of the receiving water; and/or other relevant factors. Screening methodology may be modified based on experience gained during actual field screening activities. While performing field screening activities, the permittees shall collect information on outfalls and portions of the MS4 which are not mapped, and this updated information shall be entered into the database system on an ongoing basis. An internal log documenting the results of all field screening performed shall be maintained.

Table II.A.7.b.	
GRID MAP COVERING AREA SERVED BY MS4 or ALL OUTFALLS	**FREQUENCY OF FIELD SCREENING**
Industrial Land Use	0.25-mile Grid or All Outfalls Once / 3 years
Heavy Commercial Land Use	0.25-mile Grid or All Outfalls Once / 3 years
All Other Land Uses	0.50-mile Grid or All Outfalls Once / 5 years
Entire MS4 System	⅓ of the Outfalls or ⅓ of the Grid Areas Screened During Permit Years Three, Four, & Five with the Entire MS4 Screened Once / 5 years

c. *Investigation of Suspected Illicits and/or Improper Disposal:* The permittees shall develop and implement standard procedures to be followed to investigate portions of the MS4 that, based on the results of the field screen or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water. Notification to EPA of any illicit connection shall be an element of the investigative standard procedures.

(1) To satisfy the requirements of this section, the permittees identified in Part III.A.7.c. on page 32 shall develop and implement standard investigative procedures to identify and terminate the source of the illicit connection or discharge in accordance with the schedule provided. The procedures developed shall require proper training for the field personnel involved in identifying conditions that may indicate the presence of illicit discharges. Upon the verification of responsible parties, the standard procedures developed shall require the immediate cessation of improper disposal practices and the elimination of the illicit connection as expeditiously as possible. Where the elimination of an illicit connection or the submittal of an NPDES application to EPA is not possible within a specified time frame determined by the permittee, the standard procedures developed shall require that the responsible parties submit for approval a written compliance schedule for the removal of the discharge. In the interim, the permittees shall require the operator of the illicit discharge to take all reasonable and prudent measures to minimize the discharge of pollutants to the MS4.

(2) To satisfy the requirements of this section, FDOT shall develop and implement standard investigative procedures to identify the source of the illicit connection or discharge to the FDOT MS4, in accordance with the schedule provided in Part III.A.7.c. on page 33 of this permit. Upon the identification of responsible parties, the standard procedures developed shall require the timely reporting of water quality violations to Florida Department of Environmental Protection (FDEP) and EPA. Until such time that the illicit connection has been eliminated or the responsible parties have submitted an NPDES application for the discharge to EPA, FDOT shall require the operator of the illicit discharge to take all reasonable and prudent measures to minimize the discharge of pollutants to the MS4. Where measures to minimize the discharge are not taken, the developed procedures shall consider the termination of the connecting entity's FDOT drainage connection permit.

d. *Spill Prevention and Response:* The permittees shall implement procedures to prevent, contain, and respond to spills that may discharge into the MS4.

(1) To satisfy the requirements of this section, the permittees shall adopt Sarasota County's *Hazardous Materials Emergency Plan*, FDOT's *Emergency Operations Procedures*, or a comparable plan and procedures which effectively mitigate potential pollutant discharges to surface waters. These documents shall be adopted in accordance with the schedule provided in Part III.A.7.d. on page 33 of this permit.

e. *Public Notification:* The permittees shall develop and implement a program to promote, publicize, and facilitate public reporting of illicit discharges of water quality impacts associated with discharges from the MS4.

(1) To satisfy the requirements of this section, the permittees shall develop and implement programs to facilitate public reporting of illicit discharges and improper disposal of materials into the MS4 in accordance with the schedule provided in Part III.A.7.e. on page 34 of this permit. The program shall inform the public about what to look for and how to report incidents. The program shall also enhance public awareness of the problems associated with illicit discharges and may include programs such as educating school students, using inserts in utility bills, and public service announcements in newspaper, on television, or on radio.

f. *Oils, Toxics, and Household Hazardous Waste Control:* The permittees shall effectively prohibit the discharge or disposal of used motor vehicle fluids, household hazardous wastes, grass clippings, leaf litter, and animal wastes into the MS4.

(1) To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.7.f. on page 35 of this permit.

g. *Limitation of Sanitary Sewer Seepage:* The permittees shall prevent (or require the operator of the sanitary sewer to eliminate) unpermitted discharges of dry and wet weather overflows from sanitary sewers into the MS4. Each permittee shall eliminate the infiltration of seepage from sanitary sewers into the MS4.

(1) To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.7.g. on page 36 of this permit.

8. *Industrial and High Risk Runoff:* The permittees shall develop and implement a program to identify and control pollutants, to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream, in storm water discharges to the MS4 from the municipal landfill(s); hazardous waste treatment, storage, disposal and recovery facilities; facilities that are subject to EPCRA Title III, Section 313; and any other industrial or commercial discharge in which the permittees determine is contributing a substantial pollutant loading to the MS4.

To satisfy the two (2) requirements of this section, the permittees shall:

a. *Identify priorities and procedures for inspections:* Identify all targeted facilities and determine priority sites in accordance with the schedule provided in Part III.A.8.a. on pages 37 and 38 of this permit. Inspection schedules and procedures for the identified facilities shall be developed and implemented. Also, the permittees shall provide a listing in each ANNUAL REPORT of additionally identified industrial facilities which discharge storm water into the MS4 which have not been previously reported. The industrial storm water discharges that must be included in this inventory fall into the eleven (11) classes of industrial activities as defined in the November 1990 regulations under 40 CFR 122.26(b)(14).

b. *Monitoring for High Risk Industries:* Develop and implement a monitoring (or self monitoring) program for facilities identified under this section in accordance with the schedule provided in Part III.A.8.b. on page 38 of this permit. The monitoring program shall include the collection of quantitative data on the following constituents:

- any pollutants limited in an existing NPDES permit for an identified facility;
- oil and grease;
- chemical oxygen demand (COD);
- pH;
- biochemical oxygen demand, five-day (BOD_5);
- total suspended solids (TSS);
- total phosphorous;
- total Kjeldahl nitrogen (TKN);
- nitrate plus nitrite nitrogen; and
- any information on discharges required under 40 CFR 122.21(g)(7)(iii) and (iv).

Data collected by the industrial facility to satisfy the monitoring requirements of an NPDES or State discharge permit may be used to satisfy this requirement. Permittees may require the industrial facility to conduct self-monitoring to satisfy this requirement.

9. *Construction Site Runoff:* The permittees shall develop and implement a program to reduce the discharge of pollutants from construction sites to the MEP, and to shall not cause or contribute to violations of State water quality standards of the receiving stream.

a. *Site Planning and Non-structural & Structural Best Management Practices:* The permittees shall require the use and maintenance of appropriate structural and non-structural best management practices to reduce pollutants discharged to the MS4 during the time of construction.

(1) To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.9.a. on page 39 of this permit.

b. *Inspection and Enforcement:* The permittees shall develop and implement a program for inspecting construction sites and for enforcing the requirement for control measures.

(1) To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Programs identified in Part III.A.9.b. on pages 40 and 41 of this permit.

c. *Site Operator Training:* The permittees shall conduct appropriate education and training measures for construction site operators and those associated with the implementation of proper sediment & erosion control measures at construction sites.

(1) To satisfy the requirements of this section, the permittees shall implement the Storm Water Management Program(s) identified in Part III.A.9.c. on pages 41 and 42 of this permit.

B. Area-specific Storm Water Management Program Requirements.

Reserved pending additional requirements which may be included as a result of State Certification of the permit. (See Section 401 of the CWA.)

C. Deadlines for Program Compliance. Except as provided in Part III, compliance with the storm water management program shall be required 90 days from the effective date of the permit.

D. Roles and Responsibilities of Permittees. The Storm Water Management Program, together with any attached interagency agreements or interagency agreements developed subsequent to the effective date of the permit, shall clearly identify the roles and responsibilities of each permittee. Following the effective date of the permit, interagency agreements developed and implemented must be included in the ANNUAL REPORT covering the permit year in which the agreement became effective.

E. Legal Authority. To the extent allowed by law, each permittee shall ensure legal authority to control discharges to and from those portions the MS4 over which it has jurisdiction. This legal authority may be a combination of statute, ordinance, permit, contract, order or inter-jurisdictional agreements between permittees with adequate existing legal authority to accomplish Items 1 - 6 below. This legal authority for FDOT may be a combination of State statutes administered and enforced by sister agencies within the State of Florida government system which have adequate existing legal authority to accomplish Items 1 - 6 below.

1. Control the contribution of pollutants to the MS4 by Storm Water Discharges Associated with Industrial Activity and the quality of storm water discharged from sites of industrial activity;

2. Prohibit illicit discharges to the MS4;

3. Control the discharge of spills and the dumping or disposal of materials other than storm water (e.g. industrial and commercial wastes, trash, used motor vehicle fluids, leaf litter, grass clippings, animal wastes, etc.) into the MS4;

4. Control through interagency or inter-jurisdictional agreements among permittees the contribution of pollutants from one portion of the MS4 to another;

5. Require compliance with conditions in ordinances, permits, contracts or orders; and

6. Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance with permit conditions.

F. Storm Water Management Program Resources. Each permittee shall provide adequate finances to implement their activities under the Storm Water Management Program. Each permittee shall also have a source of funding for implementing all other requirements included within this NPDES storm water permit.

G. Storm Water Management Program Review and Modification.

1. *Program Review:* Each permittee shall participate in an annual review of the current Storm Water Management Program (SWMP) in conjunction with preparation of the ANNUAL REPORT required under Part V.C. of the permit.

2. *Program Modification:* The permittee(s) may modify the SWMP during the life of the permit in accordance with the following procedures:

   a. Modifications adding (but not subtracting nor replacing) components, controls, or requirements to the approved SWMP may be made by the permittee(s) at any time. A description of the modification shall be included within the subsequent ANNUAL REPORT.

   b. Modifications replacing an ineffective or unfeasible BMP specifically identified in the SWMP with an alternate BMP may be made by the permittee(s) at any time. A description of the replacement BMP shall be included in the subsequent ANNUAL REPORT along with the following information:

      (1) an analysis of why the former BMP was ineffective or infeasible (including cost prohibitive);

      (2) expectations on the effectiveness of the replacement BMP; and

      (3) an analysis of why the replacement BMP is expected to achieve the goals of the BMP which was replaced.

   c. Modifications to adjust the schedule for maintenance activities or the frequency of inspections or monitoring identified in the SWMP may be made by the permittee(s) on an annual basis. The permittees must include in the subsequent ANNUAL REPORT a description of the schedule adjustment along with the following information:

      (1) an analysis of why the former schedule was ineffective or infeasible;

      (2) expectations on the effectiveness of the replacement schedule; and

      (3) an analysis, if applicable, of why the replacement schedule will ensure the optimization of equipment use.

d. Modifications subtracting components, controls, or requirements of the SWMP may not be made by the permittee(s) UNLESS it can be clearly demonstrated that with the elimination of this component, the SWMP will continue to achieve a reduction in pollutants to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream. In the case where this type of modification is appropriate, the permittee(s) may make the required modification and shall include in the subsequent ANNUAL REPORT a description of the component which has been eliminated along with the following information:

(1) an analysis of why the component was ineffective or infeasible, and

(2) a detailed explanation of why, with the elimination of this component, the SWMP will continue to achieve a reduction in pollutants to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream.

e. Modifications included within the ANNUAL REPORT shall be signed in accordance with Part VI.H. by all directly affected permittees, and shall include a certification that all affected permittees were given an opportunity to comment on proposed changes.

3. *Transfer of Ownership, Operational Authority, or Responsibility for Storm Water Management Program Implementation:* The permittee(s) shall implement the SWMP on all new areas added to their portion of the municipal separate storm sewer system (or for which they become responsible for implementation of storm water quality controls) as expeditiously as practicable. Implementation of the program in any new area shall consider the plans in the SWMP of the previous MS4 ownership.

Prior to land annexation, the permittee shall include a schedule for extending the SWMP to the annexed areas. At least 30 days prior to transfer of operational authority or responsibility for SWMP implementation, all parties shall prepare a schedule for transfer of responsibility for SWMP implementation on the affected portions of the MS4. This schedule shall be included in the ANNUAL REPORT.

PART III. SCHEDULES FOR IMPLEMENTATION AND COMPLIANCE

The permittee(s) shall comply with the following schedules for Storm Water Management Program implementation and augmentation, and for permit compliance.

A. IMPLEMENTATION AND AUGMENTATION OF STORM WATER MANAGEMENT PROGRAMS

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
1. *Operation and Maintenance of Structural Controls and Storm Water Collection System*	Sarasota County City of Sarasota City of Venice City of North Port FDOT	Perform inspections and maintenance of structural controls. Maintain an internal record keeping system to track inspections and maintenance activities performed during the permit. Conduct an annual assessment of the effectiveness of inspection & maintenance schedule and provide a summary of the assessment in each ANNUAL REPORT.	Annual Requirement
	ALL	Identify and inventory each privately-owned and maintained storm water management facility which discharges into the MS4.	Within 12 Months of the Effective Date of the Permit
		Develop a revolving inspection program for privately-owned and maintained storm water treatment systems which discharge into the MS4 to determine compliance with local permit conditions and/or local ordinances. Program developed shall include a description of the enforcement provisions for non-compliance. Following development, include a summary of the inspection program & schedule in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 12 Months of the Effective Date of the Permit
		Implement revolving inspection program for privately-owned and maintained storm water treatment systems which discharge into the MS4.	Within 24 Months of the Effective Date of the Permit.

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
1. *Operation and Maintenance of Structural Controls and Storm Water Collection System* (continued)	Sarasota County	Complete Florida Water & Pollution Control Operators Association (FW&PCOA) course or equivalent.	5 employees / year
	ALL OTHERS **except for** FDOT		1 employee / permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
2. *Control of Discharges from Areas of New Development and Significant Redevelopment*	ALL **except for** City of North Port and FDOT	Adopt as local ordinances storm water quality treatment criteria consistent, but not necessarily similar to the State of Florida Storm Water Treatment Regulations (F.A.C. 40D-4, 40D-40, 62-25).	Prior to the end of the Permit Term
	FDOT	Employ new FDOT Drainage Connection Permit requirements which include a "certification of water quality" to be provided by the connecting entity.	Effective Date of Permit
	ALL **except for** FDOT	Continue on the current schedule to perform master basin studies on the major watersheds identified in Table 1 on page 4A-34 of Appendix A. Develop a course of action for each as they are completed. Include in each ANNUAL REPORT a brief summary of each basin study completed during the permit year and the resulting course of action.	Effective Date of the Permit
	ALL **except for** City of North Port and FDOT	Evaluate land development practices to reduce the amount of impervious surfaces in future development. After completing the evaluation, include a summary of the resulting course of action in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 36 Months of the Effective Date of Permit
		Implement appropriate land development practices & incentives for the reduction of impervious surfaces.	As Determined by the Evaluation - Prior to the end of the Permit Term

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
3. *Operation and Maintenance of Public Streets, Roads, and Highways*	Sarasota County City of Sarasota City of Venice	Provide a description of the municipally-operated Litter Control Program(s) for highways and streets within jurisdictional area for incorporation into the permit.	Provide in First ANNUAL REPORT
	ALL **except for** City of North Port and FDOT	Implement Litter Control Program(s) for highways and streets within jurisdictional area and properly dispose of collected material.	Effective Date of the Permit
	FDOT	Implement Litter Control Program for highways and streets within jurisdictional area and properly dispose of collected material. Report in each ANNUAL REPORT the approximate frequency of litter collection services performed under contractual agreements during the permit year.	Effective Date of the Permit
	ALL **except for** North Port WCD City of North Port & FDOT	Implement street sweeping program within jurisdictional area and properly dispose of collected material.	Effective Date of the Permit
	FDOT	Implement street sweeping program within jurisdictional area and properly dispose of collected material. Report in each ANNUAL REPORT the approximate frequency of street sweeping services performed under contractual agreements during the permit year.	
	Sarasota County	Provide the maintenance schedule for storm water structures (i.e., catch basins) and roadside ditches.	Provide in First ANNUAL REPORT

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
3. *Operation and Maintenance of Public Streets, Roads, and Highways* (continued)	ALL	Perform scheduled maintenance on catch basins, grates, and other storm water structures and roadside ditches and properly dispose of accumulated sediments. Maintain an internal log documenting maintenance activities.	Effective Date of the Permit
	ALL **except for** City of North Port	As described in Part II.3.a. on page 7 of the permit, develop practices to reduce to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream regarding the pollutants from road repair and from all municipal equipment yards & maintenance shops. After development, include a summary of the practices in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 12 months of the Effective Date of the Permit
		Implement developed practices to reduce to the MEP pollutants from road repair and municipal yards.	Within 24 months of the Effective Date of the Permit
	FDOT	Coordinate the "Adopt A Highway" program for local organizations to be identified with specific highway cleanup and beautification projects.	Within 24 months of the Effective Date of the Permit
		Conduct annual routine inspections of each FDOT maintenance facility to ensure that BMPs are operational. The FDOT NPDES Coordinator or his/her representative shall perform this activity.	

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
4. *Ensure Flood Control Projects Comply With State Storm Water Quality Requirements*	ALL **except for** FDOT	Develop a priority list and construction schedule for the retrofit projects recommended by the master basin studies completed to date.	Within 12 Months of the Effective Date of the Permit
		Include a copy of the prioritized project list and construction schedule in the ANNUAL REPORT for incorporation into the permit. Provide updates to this list in future ANNUAL REPORTS as additional master basin studies are completed.	
	FDOT	Present a retrofitting program to the local Metropolitan Planning Organizations (MPO) for consideration which focuses on water quality improvement.	Within 12 Months of the Effective Date of the Permit
		Submit within the ANNUAL REPORT the list of approved retrofit projects in the MPO's work program for District One. Also provide the construction schedule for these approved projects. Provide updates to this list in future ANNUAL REPORTS as additional projects are approved.	Within 24 Months of the Effective Date of the Permit
		Begin retrofit priority projects as per the construction schedule in the approved work program for District One.	

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
5. *Identification, Monitoring, and Control of Discharges from Municipal Waste Treatment, Storage, or Disposal Facilities not covered by an NPDES Storm Water Permit*	Sarasota County City of Sarasota City of North Port	Develop program to evaluate, through inspections and monitoring, the municipally-operated solid waste transfer station(s), maintenance and storage yards for waste transportation fleets, POTWs, and sludge application and/or disposal sites. The goals of the evaluation program shall be to identify these facilities, determine the necessary control measures & procedures to be employed at each, and administer an appropriate implementation schedule. After developing the evaluation program, submit a program summary in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 30 Months of the Effective Date of the Permit
		Implement developed program to reduce pollutants in storm water discharges to the MEP and shall not cause or contribute to violations of State water quality standards of the receiving stream from these facilities.	Within 36 Months of the Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
6. *Control of Pollutants Related to Application of Pesticides, Herbicides, and Fertilizers*	ALL	Provide the details, for incorporation into the permit, of the specific public education program(s) designed to encourage the public to reduce their use of pesticides, herbicides and fertilizers.	Provide in First ANNUAL REPORT
		Implement public education program(s).	Effective Date of the Permit
	ALL **except for** FDOT	Evaluate current training requirements & certification procedures for employees who handle pesticides, herbicides and fertilizers. After completing the evaluation, include a summary of the results in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
		Implement any revised procedures for the training & certification of these employees.	As Necessary - Within 36 Months of the Effective Date of the Permit
	ALL	Require evidence of proper certification and licensing for all applicators contracted to apply pesticides, herbicides, and fertilizers on municipal and FDOT property.	Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
6. *Control of Pollutants Related to Application of Pesticides, Herbicides, and Fertilizers* (continued)	ALL **except for** FDOT	Develop a program with procedures to minimize the use of pesticides, herbicides, and fertilizers and to properly store and mix these products. The program developed should also consider including components such as providing xeriscape planning assistance and promoting voluntary use of native Florida plantings and slow-release fertilizers. After development, include a summary of the procedures in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
	ALL **except for** FDOT	Employ program procedures to minimize the use of pesticides, herbicides, and fertilizers and to properly store and mix these products.	Within 36 Months of the Effective Date of the Permit
	FDOT		Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal*			
a.) *Inspections, ordinances, and enforcement measures*	ALL **except for** City of North Port and FDOT	Complete the assessment of non-storm water discharges allowed to be discharged to the MS4 as detailed on page 9 of the permit. After completing the assessment, include a summary of the results in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 18 Months of the Effective Date of the Permit
	ALL **except for** City of North Port and FDOT	Develop an inspection program to enforce ordinances which prohibit illicit connections and illegal dumping into the MS4. After development, include a summary of the inspection program in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 30 Months of the Effective Date of the Permit
	Sarasota County	Implement inspection program to enforce ordinances which prohibit illicit connections and illegal dumping into the MS4. Maintain an internal log documenting inspections and enforcement actions performed and provide a summary of these reports in each ANNUAL REPORT.	Within 36 Months of the Effective Date of the Permit
	ALL OTHERS **except for** City of North Port and FDOT		Within 36 Months of the Effective Date of the Permit

R0012843

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal*			
a.) Inspections, ordinances, and enforcement measures (continued)	FDOT	Develop a program to inspect drainage connections after project completion to ensure continued compliance with drainage connection permit requirements and to ensure that no illicit or non-permitted connections have been made. In cases where another regulatory agency requires a periodic certification of compliance, the program developed may allow FDOT to accept this certification of compliance in lieu of further inspections by FDOT. After development, include a summary of the inspection program in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 21 Months of the Effective Date of the Permit
		Implement developed program to inspect drainage connections after project completion. Maintain an internal log documenting inspections and enforcement actions performed and provide a summary of these records in each ANNUAL REPORT.	Within 30 Months of the Effective Date of the Permit
	Sarasota County Longboat Key City of Sarasota	Provide photocopies of signed adopted storm water ordinances as identified in Table II.A.7.a.(3) on page 10 of the permit.	Provide in First ANNUAL REPORT
	City of North Port City of Sarasota City of Venice	Amend ordinances as identified in Table II.A.7.a.(4) on page 11 of the permit to reflect correct citation for *"industrial activity"* {40 CFR 122.26(b)(14)} Include a copy of the amended ordinances in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 12 Months of the Effective Date of the Permit

R0012844

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal* (continued)			
b.) Field Screening	ALL	Conduct field screening of the MS4 for illicit discharges and improper disposal as shown in Table II.A.7.b. on page 12 of this permit. Collect inventory information on outfalls and on portions of MS4 not mapped and update database system on an ongoing basis. Maintain an internal log documenting the results of all field screening performed.	At least ⅕ of Grid Areas Screened in Permit Years Three, Four and Five with Entire MS4 Screened Once / 5 years
c.) Investigation of Suspected Illicits and/or Improper Disposal	ALL **except for** FDOT	Develop standard investigative procedures to identify and terminate the source(s) of illicit connections or discharges to the MS4. After development, include a summary of the investigative procedures in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
		Implement standard investigative procedures to identify and terminate the source(s) of illicit connections or discharges to the MS4.	Within 30 Months of the Effective Date of the Permit

R0012845

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal* (continued)			
c.) *Investigation of Suspected Illicits and/or Improper Disposal* (continued)	FDOT	Develop standard investigative procedures to identify and report the source(s) of illicit connections or discharges. These procedures shall include notification to FDEP and EPA of illicit connections. After development, include a summary of the investigative procedures in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
		Implement standard investigative procedures to identify the sources(s) of illicit connections or discharges to the MS4.	Within 30 Months of the Effective Date of the Permit
d.) *Spill Prevention and Response*	Sarasota County FDOT	Provide a copy of the applicable portions of Sarasota County's *Hazardous Materials Emergency Plan* and FDOT's *Emergency Operations Procedures* which effectively mitigate potential pollutant discharges to surface waters.	Provide in First Annual Report
	ALL **except for** Sarasota County and FDOT	Adopt Sarasota County's *Hazardous Materials Emergency Plan*, FDOT's *Emergency Operations Procedures*, or a comparable plan and procedures which effectively mitigate potential pollutant discharges to surface waters.	Within 12 Months of the Effective Date of the Permit

R0012846

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal* (continued)			
e.) Public Notification	ALL	Develop a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges and improper disposal of materials into the MS4. After development, include a summary of the public program in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 30 Months of the Effective Date of the Permit
		Implement public reporting program.	Within 36 Months of the Effective Date of the Permit
		Maintain a citizen complaint log documenting all reports of illicit discharges and what actions were taken to investigate and resolve the problem. Include a summary of this log in each ANNUAL REPORT.	Within 36 Months of the Effective Date of the Permit
	FDOT	Establish a direct dial local telephone number at the District Office to be used for the reporting of illicit connections, accidental spills, illegal dumping, or other water quality violations and action as needed. This requirement may be satisfied through cooperative efforts with other permittees.	Within 36 Months of the Effective Date of the Permit

R0012847

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal* (continued)			
f.) Oils, Toxics, and Household Hazardous Waste Control	ALL **except for** FDOT	Support and promote on a regular basis the six (6) oil recycling site locations within Sarasota County and the two (2) permanent collection centers for household hazardous waste materials. Continue Amnesty Days program. Document the total annual amount of household hazardous waste materials collected.	Effective date of Permit
		Actively promote and support a voluntary stenciling program for all storm sewer inlets which discharge directly or indirectly into surface waters.	Within 12 Months of the Effective Date of the Permit
	FDOT	With each FDOT Drainage Connection Permit, include information on used oil recycling, proper hazardous waste disposal, storm water regulations, and spill reporting.	Within 12 Months of the Effective Date of the Permit

R0012848

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
7. *Illicit Discharges and Improper Disposal* (continued)			
g.) *Limitation of Sanitary Sewer Seepage*	ALL **except for** City of North Port and FDOT	Develop procedures to limit the infiltration of sanitary seepage into the MS4, in areas where wastewater infiltration is suspected. After development, include a summary of the procedures in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 30 Months of the Effective Date of the Permit
		Implement developed procedures to limit the infiltration of sanitary seepage into the MS4.	Within 36 Months of the Effective Date of the Permit
	ALL	Advise appropriate utility owner of violation if constituents common to wastewater contamination are discovered in the MS4 during dry weather field screening.	Effective Date of the Permit
		Identify areas served by septic tanks. Advise appropriate State Agency of violation if constituents common to wastewater contamination due to malfunctioning septic tank systems are discovered in the MS4 during dry weather field screening.	Within 12 Months of the Effective Date of the Permit

R0012849

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
8. *Industrial and High Risk Runoff*			
a.) Identification of Priorities and Procedures for Inspections	ALL	Develop an inventory of all existing high risk facilities discharging into the MS4. This inventory shall identify the outfall and surface waterbody into which each high risk facility drains.	Within 24 Months of the Effective Date of the Permit
		Based upon historical information and available monitoring & screening data, prioritize the identified high risk facilities.	Within 24 Months of the Effective Date of the Permit
	ALL **except for** FDOT	Develop procedures for inspecting high risk facilities and establish an inspection schedule. After development, include a summary of the procedures & inspection schedule in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
	FDOT	Develop procedures for the inspection of high risk facilities which hold FDOT drainage connection permits to ensure compliance with permit requirements. In cases where another regulatory agency requires a periodic certification of compliance, the program developed may allow FDOT to accept this certification of compliance in lieu of further inspections by FDOT. After development, include a summary of the procedures & inspection schedule in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
	ALL	Begin inspections of identified high risk facilities. Maintain an internal log documenting the results of the inspections performed.	Within 36 Months of the Effective Date of the Permit

R0012850

STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
8. *Industrial and High Risk Runoff* (continued)			
a.) *Identification of Priorities and Procedures for Inspections* (continued)	ALL	Maintain a list of all industrial storm water sources discharging to MS4 & update in ANNUAL REPORTS.	Effective Date of the Permit
b.) *Monitoring for High Risk Industries*	ALL **except for** FDOT	Develop a monitoring (or self monitoring) program for high risk industrial facilities. Include a description of the specific enforcement steps to be taken to require compliance with local storm water ordinances if violations are identified. After development, include a summary of the monitoring program in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
	FDOT	Develop a monitoring (or self monitoring) program for high risk industrial facilities which hold FDOT drainage connection permits. Include a description of the specific enforcement steps to be taken to require compliance with permit conditions if violations are identified. After development, include a summary of the monitoring program in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
	ALL	Implement the monitoring program for high risk industrial facilities.	Within 36 Months of the Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
9. *Construction Site Runoff*			
a.) Site Planning & Structural and Non-structural Controls	ALL **except for** City of North Port and FDOT	Review erosion and sediment control requirements to determine modifications necessary to correlate with SWFWMD's requirements and EPA's NPDES Construction Activity General Permit. Summarize the necessary modifications in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 12 Months of the Effective Date of the Permit
		Incorporate necessary modifications to the erosion and sediment control requirements.	Within 36 Months of the Effective Date of the Permit
		In land development regulations, incorporate guidelines and recommendations for reducing the amount of sediment leaving construction sites.	Within 36 Months of the Effective Date of the Permit
		Track construction projects required to install erosion and sediment controls. Document the installation, maintenance, and effectiveness of the controls. Integrate these records with the education program for training the site contractors.	Within 18 Months of the Effective Date of the Permit
	FDOT	Employ new FDOT Drainage Connection Permit requirements which direct connecting entities subject to the NPDES storm water regulations to submit a copy of their NPDES Storm Water Pollution Prevention Plan to FDOT.	Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
9. *Construction Site Runoff* (continued)			
b.) *Inspection and Enforcement*	ALL **except for** City of North Port and FDOT	Review existing inspection policies and code enforcement programs to first identify all agencies conducting site inspections and then to determine which agency is responsible for issuing enforcement actions for which code violations. Summarize results and include in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
		Train inspectors (regardless of specialty) who are likely to be on-site during earth moving activities in erosion control techniques.	1 Inspector / Year
		Implement the use of an erosion & sediment control checklist for all inspectors. Include verification that construction sites subject to the NPDES Storm Water Regulations have NPDES permit coverage and a Storm Water Pollution Prevention Plan on site. Include developed checklist in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
	ALL **except for** City of North Port	Develop a program to inspect construction projects for compliance with local storm water ordinances and/or local permits.	Within 24 Months of the Effective Date of the Permit
	ALL **except for** City of North Port and FDOT	Implement program developed to inspect construction projects for compliance with local storm water ordinances and/or local permits.	Within 36 Months of the Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
9. *Construction Site Runoff* (continued)			
b.) Inspection and Enforcement (continued)	FDOT	Implement program developed to inspect construction projects that propose to directly discharge storm water to the FDOT MS4 and have been granted an FDOT drainage connection permit for compliance with FDOT permit conditions. Require connection entities, who are found or suspected of discharging storm water of unacceptable quality during or following construction, to sample and test the discharge to prove compliance with FDOT permit conditions.	Within 36 Months of the Effective Date of the Permit
c.) Site Operator Training	ALL **except for** City of North Port and FDOT	Implement an annual NPDES workshop for design professionals, land developers, inspectors and contractors, including earth moving contractors. Topics to include are measures to reduce pollutants from sites, awareness of the NPDES program requirements for construction activities, and solutions to erosion and sediment problems commonly found by the inspectors during construction.	Within 24 Months of the Effective Date of the Permit
		Evaluate the feasibility of an erosion & sediment control certification program for construction site operators (contractors and developers), plan reviewers, and inspectors that work on sites that discharge to the MS4. Upon conclusion of the evaluation, include a summary of the findings in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 30 Months of the Effective Date of the Permit
		If certification program is deemed feasible, implement program for construction site operators, plan reviewers, and inspectors.	If Deemed Feasible - Within 36 Months of the Effective Date of the Permit

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STORM WATER MANAGEMENT PROGRAM	PERMITTEE(S)	ACTIVITY	DATE DUE / FREQUENCY
c.) *Site Operator Training* (continued)	ALL **except for** City of North Port and FDOT	Develop a procedure to notify building permit applicants in developments which, because of the amount of land area disturbed, are subject to the NPDES storm water regulations of their application responsibilities under the NPDES permitting program for construction site runoff. After development, include a summary of procedures in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit
		Implement developed procedures to notify building permit applicants in developments which, because of amount of land area disturbed, are subject to the NPDES storm water regulations of their application responsibilities under the NPDES permitting program for construction site runoff.	Within 30 Months of the Effective Date of the Permit
		Conduct presentations to local professional organizations which are associated with the construction industry to discuss proper construction site management for water quality.	Ongoing

R0012855

B. COMPLIANCE WITH EFFLUENT LIMITATIONS.

NONE

PART IV. NUMERIC EFFLUENT LIMITATIONS

NONE

A. Seasonal Loadings and Event Mean Concentrations.

1. As per 40 CFR 122.26(d)(2)(iii)(C), the permittees shall provide estimates of the seasonal pollutant load and of the event mean concentration of a representative storm for the parameters listed in Table V.A.1. for each "major outfall" within the MS4. These constituents were detected in the sampling data reported in the Part 2 application. The location of all known major outfalls shall be inventoried in the ANNUAL REPORT for Year One of the permit, with updates describing any additionally identified major outfalls in each sequent ANNUAL REPORT. The seasonal pollutant load and event mean concentration for each major outfall may be estimated from the representative monitoring locations, from regional NURP or State data, or from pooling results from other nearby Florida MS4 monitoring activities and shall take into consideration land uses and drainage areas for the outfall. The estimates of seasonal loadings and event mean concentrations shall be included in the ANNUAL REPORT for Year Four of the permit. For the purposes of this permit, a "major outfall"is defined as follows:

   - a pipe (or closed conveyance) system with a cross-sectional area equal to or greater than 7.07 square feet (e.g., if a single circular pipe system, an inside diameter of 36 inches or greater);
   - a single conveyance other than a pipe, such as an open channel ditch, which is associated with a drainage area of more than 50 acres;
   - a pipe (or closed conveyance) system, draining *"industrial land use,"* with a cross-sectional area equal to or greater than 0.79 square feet (e.g., if a single circular pipe system, an inside diameter of 12 inches or greater); or
   - a single conveyance other than a pipe, such as an open channel ditch, which is associated with an *"industrial land use"* drainage area of more than 2 acres;

TABLE V.A.1.	
PARAMETERS	
Biochemical Oxygen Demand (BOD_5) (mg/l)	Oil & Grease (mg/l)
Chemical Oxygen Demand (COD) (mg/l)	Total Recoverable Cadmium (mg/l)
Total Suspended Solids (TSS) (mg/l)	Total Recoverable Chromium (mg/l)
Total Dissolved Solids (TDS) (mg/l)	Total Recoverable Copper (mg/l)
Total Kjeldahl Nitrogen (as N) (mg/l)	Total Recoverable Lead (mg/l)
Nitrate plus Nitrite (as N) (mg/l)	Total Recoverable Zinc (mg/l)
Total Phosphorus (mg/l)	Dissolved Phosphorus (mg/l)

2. The permittees listed in Table V.A.2. below shall conduct an investigation of the identified drainage basins to determine the sources of the following organic pollutants detected in the Part 2 application sampling data. A report summarizing the conclusions of this investigation shall be included in the ANNUAL REPORT for Year Three of the permit.

TABLE V.A.2.		
PARAMETERS	BASIN	PERMITTEE(S)
Benezo(a)anthracene	Indian Ave. - Site #5	City of Venice
Benezo(k)fluoranthene	Indian Ave. - Site #5	City of Venice
3,4-Benzofluoranthene	East Ave. - Site #2	City of Sarasota
	Indian Ave. - Site #5	City of Venice
Bis(2-ethylhexyl)phthalate	Longboat Key - Site #1	Longboat Key
	East Ave. - Site #2	City of Sarasota
	Indian Ave. - Site #5	City of Venice
	Richardson Rd. - Site #3	Sarasota County
Chrysene	East Ave. - Site #2	City of Sarasota
	Indian Ave. - Site #5	City of Venice
4,4'-DDE	East Ave. - Site #2	City of Sarasota
	Indian Ave. - Site #5	City of Venice

B. Monitoring Data Collection. According to the agreements established between permittees, the following monitoring program shall be developed and implemented:

1. *Monitoring:* Establish local monitoring stations in conjunction with the State of Florida's *Surface Water Ambient Monitoring Program.* (See definition of the *Surface Water Ambient Monitoring Program* in Part VIII for description of program goals and monitoring strategies.) The selection of the monitoring stations shall be the result of a cooperative effort between the permittees, EPA, and the Bureau of Surface Water Management, Florida Department of Environmental Protection (FDEP). Acceptance of the monitoring program components proposed by the permittees in the July 23, 1993, Part 2 application submittal shall be explored before any alternative monitoring programs are introduced. The number of monitoring stations as well as the type of sampling performed shall be established in accordance with the following:

   a.) The costs associated with the monitoring program developed shall not exceed the projected costs for the monitoring program proposed by the permittees in the July 23, 1993, Part 2 application submittal.

   b.) The monitoring program developed shall assist in determining the impact of storm water discharges on receiving waters located in the geographical area covered by this permit.

   c.) The monitoring program developed shall assist in determining the effectiveness of the storm water management programs being implemented under this permit and shall assist in identifying and prioritizing portions of the MS4 requiring additional controls.

   d.) The monitoring program developed shall be designed to help identify local sources and impacts of specific pollutants considered a problem in the geographic area covered by this permit. Once the source and the impacts are identified, these pollutants may be more effectively reduced or eliminated.

   e.) The selection of the monitoring stations and sampling program schedule shall be agreed upon by the permittees and the Bureau of Surface Water Management, FDEP and EPA. The monitoring program developed shall be implemented by the permittees within 24 months of the effective date of this permit or within 12 months of the date of program development, whichever is later. The details of the monitoring program shall be submitted to EPA in the subsequent ANNUAL REPORT; status reports shall be given in any Annual Reports prior to this one.

It is the intent of EPA to use the monitoring information collected to evaluate any trends in the reduction in pollutant loads discharged to waters of the U.S during the term of the permit. The pollutant loading trends will be used to evaluate the effectiveness of the permittees' Storm Water Management Program to reduce the discharge of pollutants to the MEP and to shall not cause or contribute to violations of State water quality standards of the receiving stream.

2. *Monitoring Data:* For Part V.B.1., records shall be maintained of all analytical results. Additionally, for the monitoring program developed under Part V.B.1. which involves storm event sampling, the records maintained shall include: the date and duration (in hours) of the storm event(s) sampled; rainfall measurements or estimates (in inches or centimeters) of the storm event which generated the sampled runoff; the duration (in hours) between the storm event sampled and the end of the previous measurable (greater than 0.1 inch or 0.25 centimeter rainfall) storm event; and an estimate of the total volume (in gallons or liters) of the discharge sampled.

3. *Sample Analysis:* All samples collected for Part V.B.1. shall be analyzed in accordance with the methods specified at 40 CFR Part 136.

4. *Sampling Waiver.* When a discharger is unable to collect samples required by Part V.B.1. due to adverse climatic conditions, the discharger must submit in lieu of sampling data, a description of why samples could not be collected, including available documentation of the event. Adverse climatic conditions which may prohibit the collection of samples include weather conditions that create dangerous conditions for personnel (such as local flooding, high winds, hurricane, tornadoes, electrical storms, etc.) or otherwise make the collection of a sample impracticable (drought, etc.).

C. Annual Report. Each permittee shall contribute to the preparation of an annual system-wide report to be submitted by no later than six months following the period covered by the report. The ANNUAL REPORT shall cover the 12 month period beginning on the effective date of this permit and annually thereafter.

The preparation and submittal of a system-wide ANNUAL REPORT shall be coordinated by a *"committee."* The *"committee"* shall include a member or designated representative from each municipal entity covered by this permit. Each permittee shall be individually responsible for providing information on the portions of the MS4 for which they are the operator and for providing information for the system-wide report in a timely manner. Joint responsibility for the ANNUAL REPORT submission shall be limited to the following: (1) participation in preparation of the overview for the entire system; and (2) inclusion of the identity of any permittee who failed to provide input to the report. Each permittee shall sign and certify the ANNUAL REPORT in accordance with Part VI.H. & VI.I. of this permit, and shall include a statement or resolution that the permittee's governing body or agency (or delegated representative) has reviewed or has been appraised of the content of the ANNUAL REPORT.

The ANNUAL REPORT shall include the following sections:

- Contacts List
- SWMP Evaluation
- Summary Table
- Narrative Report
- Monitoring Section
- Summary of SWMP and Monitoring Modifications
- Fiscal Analysis
- FDOT District Report
- Appendices

The following items describe in more detail the specific requirements for the ANNUAL REPORT.

1. Provide a list of contacts and responsible parties (e.g.: agency, name, phone number) who had input to and are responsible for the preparation of the ANNUAL REPORT.

2. Provide an overall evaluation of the Storm Water Management Program including: Objective of Program; Major Findings (e.g.: water quality improvements or degradation); Major Accomplishments; Overall Program Strengths / Weaknesses; and Future Direction of Program.

3. Provide a Summary Table of Storm Water Management Program Elements.

a. A Summary Table of appropriate SWMP annual activities for each permittee shall be provided. The purpose of the Summary Table is to document in a concise form the program activities and permittees' compliance status with quantifiable permit requirements. Program elements that are administrative (e.g.: planning procedures, program development and pilot studies) are inappropriate for the summary table and shall be discussed in the narrative section of the ANNUAL REPORT. The following are examples of SWMP activities to be included in the Summary Table:

(1) Structural Controls - maintenance and/or inspection activities of existing structural controls

(2) Roadway Maintenance - street sweeping, litter control activities, and maintenance on storm water structures & roadside ditches

(3) Municipal Waste TSD Facilities - inspections, monitoring, and implementation of control measures

(4) Pesticide, Herbicide, and Fertilizer Application - certification training and public education

(5) Illicits - facility inspections, investigations, enforcement actions, illicit (dry weather) screening, illicit public reporting, oil/household hazardous waste collection, and storm sewer inlet stencilling

(6) High Risk Industrial Facilities - inspection activities and monitoring

(7) Construction - training of inspectors, certification of construction site operators, inspections, and enforcement actions

(8) Storm Water Treatment Projects - description of municipal storm water treatment projects that have been completed, including a brief description of the affected drainage basin

b. The Summary Table shall indicate each permittee's SWMP activities and accomplishments. The format for this information shall adhere to the example shown in Table V.C.1. on page 55. Items to be reported include:

(1) Activity description;

(2) Number of activities (with frequency) that were scheduled for implementation and/or accomplishment in program element discussion (i.e., once/6 months, 100%/5 years, 6 sites monitored once/year, all sites inspected/permit term). Enter "Not Applicable" (N/A) if no specific schedule was specified;

(3) Status of schedule for year ("yes" for schedule was adhered to, or "no" for schedule was not adhered to);

(4) Number of activities which were accomplished; and

(5) The availability of documentation (i.e., inspection reports) for those activities which were accomplished and comments describing the reason(s) for any non-compliance.

4. The ANNUAL REPORT shall contain a Narrative Report to succinctly discuss the SWMP Elements which were not included within the SWMP Summary Table. Those SWMP Elements required to be developed under Parts II and III of the permit shall be discussed within this section of the ANNUAL REPORT following development.

a. The permittees shall include a brief discussion of the following applicable SWMP Elements:

(1) Structural Controls Maintenance
(2) Development Planning Procedures
(3) Roadway Maintenance
(4) Flood Management
(5) Municipal Facilities
(6) Pesticides, Herbicides, and Fertilizers
(7) Illicits Inspection/Investigation/Enforcement
(8) Field Screening
(9) Spill Response

(10) Public Reporting of Illicit Discharges
(11) Oil and Household Hazardous Waste
(12) Sanitary Sewer Seepage
(13) High Risk Industrial Facility Inspection
(14) Construction Planing Procedures
(15) Construction Inspections
(14) Education Activities
(15) Monitoring Activities
(16) Any additional elements of Storm Water Management Program

b. The format for the Narrative Report section of the ANNUAL REPORT shall be a brief discussion of the SWMP Element. The aspects of each permittee's activities concerning a SWMP Element shall be succinctly discussed in the section of the Narrative Report dedicated to that Element. The discussion shall include the following:

(1) Objective of SWMP Element,

(2) SWMP Element activities completed and those in progress,

(3) General discussion of Element. Explanation of all Element activity deficiencies (e.g.: activities described in the program that have not been fully implemented or completed). Results of activities shall be summarized and discussed (e.g.: maintenance caused by inspection, pollutants detected by monitoring, investigations as a result of dry and wet weather screening, number and nature of enforcement items, education activities participation),

(4) Status of SWMP Element with compliance, implementation, and augmentation schedules in Part III of the permit,

(5) SWMP Element strengths and weaknesses,

(6) Assessment of controls, and

(7) Discussion of Element revisions that are summarized elsewhere in the ANNUAL REPORT.

5. The ANNUAL REPORT shall contain a Monitoring Section which discusses the progress and results of the monitoring programs required under Part V of the permit.

   a. The Monitoring Section of the ANNUAL REPORT shall include a summary of the monitoring program developed and implemented under Part V.B.1. of the permit. The details to be discussed include:

      (1) Brief summary statement of the objective of each monitoring project included under the program,

      (2) Summary chart of the data from the monitoring completed,

      (3) Discussion of any results or conclusions derived from the monitoring completed,

      (4) Status of monitoring with respect to the compliance schedule in Part V.B.1. of the permit, and

      (5) Discussion of monitoring program revisions that are summarized elsewhere in the ANNUAL REPORT.

   b. The Monitoring Section of the ANNUAL REPORT shall include the following information as required in Part V.A. of the permit:

      (1) The ANNUAL REPORT for Year One of the permit shall contain an inventory of all known major outfalls, with updates describing additionally identified major outfall in each sequent ANNUAL REPORT.

      (2) The ANNUAL REPORT for Year Three of the permit shall include the investigation of the sources of the organic pollutants detected in the Part 2 application sampling data as required in Part V.A.2. of the permit.

      (3) The ANNUAL REPORT for Year Four of the permit shall include estimates of seasonal pollutant loadings and event mean concentrations (EMC) for each major outfall required by Part V.A.1.

6. Provide a summary of SWMP and Monitoring Modifications made during the permit year.

7. Provide a complete fiscal analysis for each permittee's program implementation, both for the past calendar year and the next. The analysis shall indicate budgets and funding sources.

8. FDOT shall report on the status of the FDOT statewide Storm Water Management Program elements as shown in Table V.C.8.a. on page 56 and shall indicate whether the resulting program modifications have been implemented at the District Office. In addition, FDOT shall also indicate the number of District employees included in the training courses described in Table V.C.8.b. on page 57.

9. The following information shall be included as Appendices within the ANNUAL REPORT for Year Five of the permit:

   a. Analytical data collected from the monitoring program.

   b. Results of illicit connections screening or dry weather screening.

   c. Any other data specifically requested by EPA to substantiate statements and conclusions reached in the ANNUAL REPORTS.

Table V.C.1. - EXAMPLE Summary Table for Storm Water Management Program Element Status/Compliance (EXAMPLE ONLY)

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
Structural Controls	Permittee 1	Major Channels Inspected	15 Channels, once/6 mos.	YES	15 Channels, once/6 mos	Copies of Inspection Report Forms - Available Upon Request
		Major Channels Maintained	As needed	N/A	7 Channels maintained	
		Grate Inlets Inspected	1500 Inlets, once/year	NO	1000 Inlets	Ambitious projection. Reducing to 1000 next year due to resources.
	Permittee 2	Detention Ponds Maintained	1 Pond, once/month	YES	1 Pond once/month	Sediment removed after spring rains
		Storm Drain Inlets Inspected	35 Inlets, once/6 mos.	YES	35 Inlets once/6 mos.	Copies of Inspection Report Forms Available Upon Request
Monitoring	Permittee 1	Municipal - Landfills	2 Facilities, once/6 mos.	YES	2 Facilities once/6 mos.	Copies of Monitoring Data - Available Upon Request
		POTW	3 Facilities, once/year	NO	2 Facilities	Copies of Monitoring Data - Available Upon Request
		Industrial - Hazardous	5 Facilities, once/6 mos.	YES	5 Facilities, once/6 mos.	Copies of Monitoring Data - Available Upon Request
		Title III	3 Facilities, once/6 mos.	YES	3 Facilities, once/6 mos.	Copies of Monitoring Data - Available Upon Request
		Others	2 Facilities, once/year	YES	2 Facilities	Copies of Monitoring Data - Available Upon Request
		Dry Weather Screening	100% system, once/5 yrs.	YES	20% system	Copies of Screening Field Reports - Appendix B.
		Floatable Assessment	100 sections surveyed/yr.	YES	140 sections surveyed	Copies of Field Survey - Available Upon Request

R0012868

Table V.C.8.a. - Table for FDOT Statewide Storm Water Management Program Element Status

FDOT STATEWIDE STORM WATER MANAGEMENT PROGRAM ELEMENT (To Be Conducted at State Office)	ACTIVITY ACCOMPLISHED DURING THE PERMIT YEAR?	DESCRIPTION OF RESULTING PROGRAM MODIFICATIONS	PROGRAM POLICY INCORPORATED AT DISTRICT OFFICE?
Evaluate the feasibility of the FDOT drainage connection permit becoming an operating permit requiring long-term storm water facility management by the connecting entity.	YES / NO (If no, list anticipated completion date)		YES / NO (If no, list reason and/or anticipated implementation date.)
Add information specific to storm water runoff protection and reduction of chemical usage to the FDOT's *Turf Management Manual* and *Chemical Weed and Grass Control Manual.*	YES / NO (If no, list anticipated completion date)		YES / NO (If no, list reason and/or anticipated implementation date.)
Evaluate, on an ongoing basis, innovative structural and non-structural BMPs and new technologies as they evolve to determine their efficiency and cost effectiveness in the field. Comment on those which are found suitable & adopted for use in FDOT projects in the District.	ONGOING ACTIVITY		Describe new BMPs adopted for use in the District.
Identify those of the non-storm water discharges listed under Part II.A.7.a. on page 9 of the permit, as well as any other non-storm water discharges, which will be allowed to be discharged into the FDOT MS4.	YES / NO (If no, list anticipated completion date)		YES / NO (If no, list reason and/or anticipated implementation date.)

R0012869

Table **V.C.8.b.** - Table for FDOT Statewide Storm Water Management Program Training Status

FDOT STATEWIDE STORM WATER MANAGEMENT PROGRAM TRAINING (Conducted through State Office)	TRAINING CONDUCTED DURING THE PERMIT YEAR?	DESCRIPTION OF TRAINING COURSE	NO. OF DISTRICT EMPLOYEES COMPLETING TRAINING COURSE?
Conduct training for FDOT maintenance and construction inspectors in the identification and detection of potential storm water related problems, signs of illegal dumping and illicit connections, proper containment methods, and reporting procedures.	YES / NO (If no, give anticipated schedule.)		
Conduct training for the FDOT Emergency Coordinator assigned to each FDOT maintenance facility. Training shall not only educate the FDOT Emergency Coordinator in the proper containment of spills and spill reporting procedures, but shall include storm water remediation activities, storm water regulations, and storm water retrofitting necessary to eliminate polluted storm water discharges from FDOT maintenance facilities.	YES / NO (If no, give anticipated schedule.)		
Conduct training for all FDOT personnel involved in the chemical weed and grass control program to ensure a safe and effective program. Incorporate into the training of these applicators an emphasis on storm water implications of the use of pesticides, herbicides, and fertilizers.	YES / NO (If no, give anticipated schedule.)		
Conduct training for all FDOT personnel involved in hazardous waste handling. Incorporate into the training a segment on the identification, detection, and reporting of illicit storm water connections and potential storm water related problems such as visible water quality degradation and signs of illegal dumping.	YES / NO (If no, give anticipated schedule.)		

R0012870

D. Certification and Signature of Reports.

All reports required by the permit and other information requested by the Director shall be signed and certified in accordance with Parts VI.H. & VI.I. of the permit.

E. Reporting: Where and When to Submit.

1. As required by Part V.C., monitoring results obtained during the reporting period running from the 12 month term beginning on the effective date of this permit and annually thereafter shall be submitted on Discharge Monitoring Report Form(s) in the ANNUAL REPORT for Year Five of the permit. A separate Discharge Monitoring Report Form is required for each event monitored.

2. Signed copies of the ANNUAL REPORT required by Part V.C. and all other reports required herein, shall be submitted to:

U.S. EPA, Region IV
Water Management Division
Water Permits and Enforcement Branch (WPEB-7)
345 Courtland Street, N.E.
Atlanta, Georgia 30365

F. Additional Notification.

In addition, the permittees shall provide a copy of each ANNUAL REPORT to:

Florida Department of Environmental Protection
Bureau of Surface Water Management
Storm Water Section
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

G. Retention of Records.

The permittees shall retain the latest version of the Storm Water Management Program developed in accordance with Part II of this permit for at least three years after the expiration date of this permit. The permittees shall retain all records of all monitoring information, copies of all reports required by this permit, and records of all other data required by or used to demonstrate compliance with this permit, until at least three years after the expiration date of this permit. This period may be explicitly modified by alternative provisions of this permit or extended by request of the Director at any time.

PART VI. STANDARD PERMIT CONDITIONS

A. Duty to Comply. The permittees must comply with all conditions of this permit insofar as those conditions are applicable to each permittee, either individually or jointly. Any permit noncompliance by a permittee constitutes a violation of the CWA and is grounds for enforcement action, for permit termination, revocation and reissuance, or modification, or for denial of a permit renewal application for the non-complying permittee.

B. **Penalties for Violations of Permit Conditions.**

1. Criminal

a. Negligent Violations The CWA provides that any person who negligently violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than 1 year, or both.

b. Knowing Violations The CWA provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or both.

c. Knowing Endangerment The CWA provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act and who knows at that time that he is placing another person in imminent danger of death or serious bodily injury is subject to a fine of not more than $250,000, or by imprisonment for not more than 15 year, or both.

d. False Statement The CWA provides that any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed or required to be maintained under the Act or who knowingly falsifies, tampers with, or renders inaccurate, any monitoring device or method required to be maintained under the Act, shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 2 years, or by both. If a conviction is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or by both. (See Section 309(c)(4) of the Clean Water Act).

2. Civil Penalties - The CWA provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a civil penalty not to exceed $25,000 per day for each violation.

3. Administrative Penalties - The CWA provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to an administrative penalty, as follows:

   a. Class I penalty Not to exceed $10,000 per violation nor shall the maximum amount exceed $25,000.

   b. Class II penalty Not to exceed $10,000 per day for each day during which the violation continues nor shall the maximum amount exceed $125,000.

C. **Duty to Reapply.** If a permittee(s) wishes to continue an activity regulated by this permit after the permit expiration date, the permittee(s) must apply for and obtain a new permit. The application shall be submitted at least 180 days prior to expiration of this permit. The Director may grant permission to submit an application less than 180 days in advance but no later than the permit expiration date. Continuation of expiring permits shall be governed by regulations promulgated at 40 CFR 122.6 and any subsequent amendments.

D. **Need to Halt or Reduce Activity Not a Defense.** It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

E. **Duty to Mitigate.** Each permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

F. **Duty to Provide Information.** Each permittee shall furnish to the Director, within a time specified by the Director, any information which the Director may request to determine compliance with this permit. The permittees shall also furnish to the Director upon request copies of records required to be kept by this permit.

G. **Other Information.** When a permittee becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in any report to the Director, he or she shall promptly submit such facts or information.

H. Signatory Requirements. All Discharge Monitoring Reports, storm water management programs, reports, certifications or information either submitted to the Director or that this permit requires be maintained by the permittees, shall be signed by:

1. Either a principal executive officer or ranking elected official; or

2. A duly authorized representative of that person. A person is a duly authorized representative only if:

   a. The authorization is made in writing by a person described above and submitted to the Director, and

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of manager, operator, superintendent, or position of equivalent responsibility or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position.)

   If an authorization is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new written authorization satisfying the requirements of this paragraph must be submitted to the Director prior to or together with any reports, information, or applications to be signed by an authorized representative.

I. Certification. Any person signing documents under this section shall make the following certification:

   "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

J. Penalties for Falsification of Reports. Section 309(c)(4) of the Clean Water Act provides that any person who knowingly makes any false material statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including reports of compliance or noncompliance shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or by both.

K. Penalties for Falsification of Monitoring Systems. The CWA provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by fines and imprisonment described in Section 309 of the CWA.

L. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittees from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under section 311 of the CWA or section 106 of CERCLA.

M. Property Rights. The issuance of this permit does not convey any property rights of any sort, nor any exclusive privileges, nor does it authorize any injury to private property nor any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

N. Severability. The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

O. Requiring an Individual Permit.

1. The Director may require any permittee authorized by this permit to obtain an individual NPDES permit. Any interested person may petition the Director to take action under this paragraph. The Director may require any owner or operator authorized to discharge under this permit to apply for an individual NPDES permit only if the owner or operator has been notified in writing that a permit application is required. This notice shall include a brief statement of the reasons for this decision, an application form (as necessary), a statement setting a deadline for the owner or operator to file the application, and a statement that on the effective date of the individual NPDES permit, coverage under this permit shall automatically terminate. Individual permit applications shall be submitted to the address of the appropriate Regional Office shown in Part V.E.2. of this permit. The Director may grant additional time to submit the application upon request of the applicant. If an owner or operator fails to submit in a timely manner an individual NPDES permit application as required by the Director, then the applicability of this permit to the individual NPDES permittee is automatically terminated at the end of the day specified for application submittal.

2. Any owner or operator authorized by this permit may request to be excluded from the coverage of this permit by applying for an individual permit. The owner or operator shall submit an individual application as specified by 40 CFR 122.26(d) with reasons supporting the request to the Director. Individual permit applications shall be submitted to the address of the appropriate Regional Office shown in Part V.E.2. of this permit. The request may be granted by the issuance of a individual permit if the reasons cited by the owner or operator are adequate to support the request.

P. **State/Environmental Laws.**

1. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by Section 510 of the Act.

2. No condition of this permit shall release the permittee from any responsibility or requirements under other environmental statutes or regulations.

Q. **Proper Operation and Maintenance**. Each permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit and with the requirements of storm water management programs. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. Proper operation and maintenance requires the operation of backup or auxiliary facilities or similar systems, installed by a permittee only when necessary to achieve compliance with the conditions of the permit.

R. **Monitoring and Records.**

1. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

2. The permittees shall retain records of all monitoring information including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of the reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application. This period may be extended by request of the Director at any time.

3. Records of monitoring information shall include:

a. The date, exact place, and time of sampling or measurements;

b. The initials or name(s) of the individual(s) who performed the sampling or measurements;

c. The date(s) analyses were performed;

d. The time(s) analyses were initiated;

e. The initials or name(s) of the individual(s) who performed the analyses;

f. References and written procedures, when available, for the analytical techniques or methods used; and

g. The results of such analyses, including the bench sheets, instrument readouts, computer disks or tapes, etc., used to determine these results.

S. Monitoring Methods. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

T. Inspection and Entry. The permittee shall allow the Director or an authorized representative of EPA, or the State, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter the permittee's premises where a regulated facility or activity is located or conducted or where records must be kept under the conditions of this permit;

2. Have access to and copy at reasonable times, any records that must be kept under the conditions of this permit; and

3. Inspect at reasonable times any facilities or equipment (including monitoring and control equipment).

U. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

V. Additional Monitoring by the Permittee(s). If the permittees monitor more frequently than required by this permit, using test procedures approved under 40 CFR Part 136 or as specified in this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report (DMR). Such increased monitoring frequency shall also be indicated on the DMR.

PART VII. PERMIT MODIFICATION

A. **Modification of the Permit:** The permit may be reopened and modified during the life of the permit to:

1. Incorporate into the permit the finalized pollutant load reduction goals agreed to by the permittees and the National Estuary Program (NEP) in the National Estuary Program Comprehensive Conservation and Management Plan for the geographical area covered by this NPDES permit;

2. Address impacts on receiving water quality caused, or contributed to, by discharges from the MS4;

3. Address changes in State or Federal statutory or regulatory requirements;

4 Include the addition of a new permittee who is the owner or operator of a portion of the Municipal Separate Storm Sewer System; or

5. Include other modifications deemed necessary by the Director to comply with the goals and requirements of the Clean Water Act.

All modification to the permit will be made in accordance with 40 CFR 122.62, 122.63, and 124.5.

B. **Termination of Coverage for a Single Permittee**

Permit coverage may be terminated, in accordance with the provisions of 40 CFR 122.64 and 124.5, for a single permittee without terminating coverage for other permittees.

C. **Modification of Storm Water Management Program(s)**

Only those portions of the Storm Water Management Programs specifically required as permit conditions shall be subject to the modification requirements of 40 CFR 124.5. Replacement of an ineffective or infeasible BMP implementing a required component of the Storm Water Management Program with an alternate BMP expected to achieve the goals of the ineffective or infeasible BMP shall be considered minor modifications to the Storm Water Management Program and not modifications to the permit. (See also Part II.G.)

D. Changes in Monitored Outfalls

This permit is issued on a system-wide basis in accordance with CWA §402(p)(3)(i) and authorizes discharges from all portions of the Municipal Separate Storm Sewer System. Since all outfalls are authorized, changes in monitoring outfalls, other than those with specific numeric effluent limitations, if any, shall be considered minor modifications to the monitoring program and not modifications to the permit. (See also Part V.B.1. and V.C.6.) Changes in monitoring outfalls with specific numeric effluent limitations shall be considered modifications to the permit and will be made in accordance with the procedures at 40 CFR 122.62.

PART VIII. DEFINITIONS

All definitions contained in Section 502 of the CWA shall apply to this permit and are incorporated herein by reference. Unless otherwise specified in this permit, additional definitions of words or phrases used in this permit are as follows:

A. "Best Management Practices" ("BMPs") means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control facility site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

B. "Bypass" means the intentional diversion of waste streams from any portion of a treatment facility, which is not a designed or established operating mode for the facility.

C. "CWA" means Clean Water Act, also referred to as "the Act" (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub.L. 92-500, as amended Pub. L. 95-217, Pub. L. 95-576, Pub. L. 6-483 and Pub. L. 97-117, 33 U.S.C. 1251 et.seq., as amended by the WQA of 1987, P.L. 100-4, the "Act."

D. "Director" means the EPA Regional Administrator or an authorized representative.

E. "Discharge" for the purpose of this permit, unless indicated otherwise, refers to discharges from the Municipal Separate Storm Sewer System (MS4).

F. "Flow-weighted composite sample" means a composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge at the time of sampling.

G. "Illicit connection" means any man-made conveyance connecting a non-storm water discharge directly to a municipal separate storm sewer system.

H. "Illicit discharge" means any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and other discharges listed in Part II. A.7.a. of this permit.

I. "Industrial Land Use" means land utilized in connection with manufacturing, processing, or raw materials storage at facilities identified under 40 CFR 122.26(b)(14).

J. "Landfill" means an area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or waste pile.

K. "Large Municipal Separate Storm Sewer System" means all municipal separate storm sewers that are either:

(i) located in an incorporated place (city) with a population of 250,000 or more as determined by the latest Decennial Census by the Bureau of Census (these cities are listed in Appendices F and G of 40 CFR Part 122); or

(ii) located in the counties with unincorporated urbanized populations of 250,000 or more, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties (these counties are listed in Appendices H and I of 40 CFR Part 122); or

(iii) owned or operated by a municipality other than those described in paragraph (i) or (ii) and that are designated by the Director as part of the large municipal separate storm sewer system.

L. "Medium Municipal Separate Storm Sewer System" means all municipal separate storm sewers that are either:

(i) located in an incorporated place (city) with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census (these cities are listed in Appendices F and G of 40 CFR Part 122); or

(ii) located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties (these counties are listed in Appendices H and I of 40 CFR Part 122); or

(iii) owned or operated by a municipality other than those described in paragraph (i) or (ii) and that are designated by the Director as part of the medium municipal separate storm sewer system.

M. "MEP" is an acronym for "Maximum Extent Practicable," the technology-based discharge standard for Municipal Separate Storm Sewer Systems established by CWA §402(p).

N. "MS4" is an acronym for "municipal separate storm sewer system" and is used to refer to either a Large or Medium Municipal Separate Storm Sewer System (e.g. "the Atlanta MS4").

O. "Municipal Separate Storm Sewer" means a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, and storm drains):

(i) owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State Law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State Law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian Tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;

(ii) designed or used for collecting or conveying storm water;

(iii) which is not a combined sewer; and

(iv) which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

P. "Permittee" means each individual co-applicant for an NPDES permit who is only responsible for permit conditions relating to the discharge that they own or operate. (Also, See 40 CFR 122.2)

Q. "Point Source" means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

R. "Severe property damage" means substantial physical damage to property, damage to the treatment facility which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

S. "State Storm Water Quality Standards", is defined at Section 403.0891 of the Florida Statutes, and State Water Policy, Chapter 62-40, Florida Administrative Code.

T. "Storm Sewer", unless otherwise indicated, refers to a municipal separate storm sewer.

U. "Storm Water" means storm water runoff, snow melt runoff, surface runoff and drainage.

V. "Storm Water Discharge Associated with Industrial Activity" is defined at 40 CFR 122.26(b)(14). (Also, See Fact Sheet for this Permit.)

W. "Storm Water Management Program" refers to a comprehensive program to manage the quality of storm water discharged from the municipal separate storm sewer system. For the purposes of this permit, the Storm Water Management Program is considered a single document, but may actually consist of separate programs (e.g. "chapters") for each permittee.

X. "Surface Water Ambient Monitoring Program" refers to a comprehensive program implemented by the Florida Department of Environmental Protection, Bureau of Surface Water Management, which is designed to accomplish the following goals:

1. Identify and document the existing condition of the surface waters of the State,

2. Document potential problem areas,

3. Establish stream ecoregion reference sites for comparison purposes,

4. Collect biological data at ecoregion reference sites to establish preliminary biological integrity measurements techniques, and

5. Establish a Statewide ambient monitoring network which will eliminate duplication, share data, increase efficiency, and improve assessment and management capabilities.

To date, the monitoring strategies included within the State of Florida's Surface Water Ambient Monitoring Program have been based on:

- Ecoregion Subregionalization and the associated stream Community Bioassessment Protocols (CBA) developed for the nonpoint source program,

- Chemistry Trend Network to fulfill the need to evaluate the State's water quality over time,

- Chemistry Status Network with emphasis on water bodies with fair or poor water quality or areas which have not been recently sampled, and

- Lake Ecoregion and Community Bioassessment Projects.

Y. "SWMP" is an acronym for "Storm Water Management Program."

Z. "Time-weighted composite" means a composite sample consisting of a mixture of equal volume aliquots collected at a constant time interval.

AA. "Waters of the United States" is defined at 40 CFR 122.2.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

Reply To
Attn Of: WD-134

FEB 1 1995

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Janice Adair, Regional Administrator
Alaska Department of Environmental Conservation
Southcentral Regional Office
3601 C Street, Suite 1334
Anchorage, AK 99503

Re: NPDES Permit No. AKS052426
Port of Anchorage NPDES Municipal Storm Water Permit

Dear Ms. Adair:

A National Pollutant Discharge Elimination System (NPDES) permit has been issued to the referenced facility. Enclosed is a copy of the transmittal letter, permit, and list of changes made from the draft to the final permit.

There were no significant comments received during the public notice period. The permit will be effective 30 days after the issuance unless a request for evidentiary hearing is received.

Sincerely,

Charles E. Findley
Director, Water Division

Enclosures

cc: Office of Management and Budget, Anchorage

Printed on Recycled Paper

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, Washington 98101

FEB 1 1995

Reply To
Attn Of: WD-134

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Don Dietz, Director
Port of Anchorage
2000 Anchorage Port Road
Anchorage, Alaska 99501

Re: NPDES Permit No. AKS052426
Port of Anchorage NPDES Municipal Storm Water Permit

Dear Mr. Dietz:

We are issuing the above referenced National Pollutant Discharge Elimination System (NPDES) permit. The enclosed document is your official copy of the permit and demonstrates that the referenced facility is authorized to discharge to waters of the United States subject to certain specified requirements. Stipulations of the state's water quality certification and Coastal Management Program consistency determination have been incorporated into the permit. More specifically, the stipulations revising the monitoring conditions are in Part IV of the permit.

There were no significant comments received during the public notice period. This permit will become effective 30 days after the issuance date unless a request for an evidentiary hearing which meets the requirements of 40 CFR 124.74 is received. A copy of these requirements is enclosed for your information.

Sincerely,

Charles E. Findley
Director, Water Division

Enclosures

cc: State Regional Office, Anchorage
State District Office, Anchorage
Office of Management and Budget, Anchorage

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R0012885

CHANGES TO DRAFT PERMIT

The following changes to the draft permit have been made for this final permit:

1) The Port of Anchorage commented that the outfall previously labelled 001, Transit Area A, was discovered by its consulting engineers to no longer exist, and asked that it be deleted from the application.

   EPA has deleted this outfall and re-numbered the remaining three outfalls as 001, 002, and 003 (see Table V.A.1.b).

2) Special requirements stipulated as part of the State of Alaska water quality certification are contained in Part IV of the permit. These special requirements include changes in monitoring, analytical test methods, and reporting requirements. Specifically:

   - The monitoring parameter "Total Aqueous Hydrocarbons" has been substituted for the parameter "Oil and Grease" found in Part II.B.9.b.

   - The analytical test methods EPA 602 and EPA 610 will be used to determine the presence of "Total Aqueous Hydrocarbons".

   - Copies of all documents, reports, and requests, required in the permit will be sent to the state offices as stipulated.

   In addition, the following changes to the permit have been made pursuant to the water quality stipulations and comments from the State:

   - Part II.A.1 has been expanded to include a statement on emphasizing source reduction techniques as a means to reduce the discharge of pollutants.

   - In Part II.B.4 the permittee is now directed to operate and maintain parking and cargo storage/staging areas in a manner to reduce, to the Maximum Extent Practicable, discharge of pollutants.

   - In Part II.B.11 the following was added as paragraph (d): a program to promote, publicize and facilitate implementation of technologies and techniques to prevent pollution through source reduction and recycling.

   - In Part II.B.7.b the items numbered 8, 12, and 13 now specify that the water be uncontaminated as found in #6.

   - The term "co-permittees" in Part II.C has been deleted.

- In Part II.C.1 the term "port vehicles" has been clarified to mean those vehicles owned or operated by The Port.

- The citation in Part H.1 has been changed to correctly read Part II.I.

- The phrase "at the permittees option" in Part V.A.4.b has been deleted.

- The reference in Part V.B.1 has been changed to correctly read Part III.A.

COVER PAGE

Permit No.: AK8052426

United States Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, Washington 98101

AUTHORIZATION TO DISCHARGE UNDER THE

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Clean Water Act, 33 U.S.C. §1251 et seq., as amended by the Water Quality Act of 1987, P.L. 100-4, the "Act",

Port of Anchorage

is authorized to discharge from a **Municipal Separate Storm Sewer System** located at **Port of Anchorage, 2000 Anchorage Port Road, Anchorage, Alaska,**

to receiving waters named **Cook Inlet,**

in accordance with discharge point(s), an approved storm water management plan, monitoring requirements, and other conditions set forth herein.

This permit shall become effective March 3, 1995.

This permit and the authorization to discharge shall expire at midnight, March 3, 2000.

Signed this 1st day of February, 1995.

Director, Water Division, Region 10
U.S. Environmental Protection Agency

R0012888

NPDES PERMIT
MUNICIPAL SEPARATE STORM SEWER SYSTEM
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PART I. DISCHARGES AUTHORIZED UNDER THIS PERMIT

A. Permit Area

This permit covers all areas within the jurisdictional boundary of the Port of Anchorage within the Municipality of Anchorage, Alaska, served by, or otherwise contributing to discharges from, municipal separate storm sewers (MS4s) owned or operated by the permittee listed in Part I.C.

B. Authorized Discharges

This permit authorizes all existing or new storm water point source discharges to waters of the United States from the MS4. This permit also authorizes the discharge of storm water commingled with flows contributed by process wastewater, non-process wastewater, or storm water associated with industrial activity provided such discharges are authorized under separate NPDES permits. This permit will consider any and all activities conducted by lessees of the Port of Anchorage while within the jurisdictional boundaries of the Port, and which activity leads to a discharge either to or from the MS4s for which this permit is written, to be the activity of the Port and subject to the conditions of this permit.

C. Limitations on Coverage

The following discharges are not authorized by this permit:

1. *Non-storm Water:* storm water discharges that are mixed with non-storm water or storm water associated with industrial activity except where such discharges are:

   a. in compliance with a separate NPDES permit; or

   b. identified by and in compliance with Part II.B.7 of this permit.

2. *Endangered Species Protection:* storm water discharges whose direct, indirect, interrelated, interconnected, or interdependent impacts would jeopardize a listed endangered or threatened species or adversely modify designated critical habitat.

3. *Historic Preservation:* storm water discharges, or the permittee construction activities or implementation of storm water management controls, which adversely effect properties listed or eligible for listing in the National Register of Historic Places, unless the permittee is in compliance with requirements of the National Historic Preservation Act and has coordinated any necessary activities to avoid or minimize impacts with the appropriate State Historic Preservation Officer; and

4. *Coastal Zone Management:* storm water discharges not in compliance with any applicable requirements of a State's Coastal Zone Management Plan.

PART II. STORM WATER POLLUTION PREVENTION & MANAGEMENT PROGRAMS

The permittee is required to develop and implement a storm water pollution prevention and management program designed to limit, to the maximum extent practicable, the discharge of pollutants from the MS4. Either collectively, or separately, the permittee's storm water pollution prevention and management program shall satisfy the requirements of paragraphs A through I, below for all portions of the MS4 authorized to discharge under this permit.

A. **POLLUTION PREVENTION REQUIREMENTS**

The permittee shall develop and implement the following pollution prevention measures:

1. The permittee shall include requirements to consider water quality impacts of new and significant re-development in its comprehensive master planning process. The goal of such requirements shall be limiting, to the maximum extent practicable, the discharge of pollutants to pre-development levels.

2. The permittee shall ensure the establishment or availability of a program to collect used motor vehicle fluids (including oil and antifreeze) and batteries for recycle or reuse. Such program shall be readily available to all lessees. This program shall be publicized and promoted on a regular basis, but at least anually.

3. The permittee shall ensure the establishment or availability of a program to collect commonly-used hazardous materials (including paint, pesticides, herbicides, cleaners, solvents, and similar hazardous materials) for recycle, reuse, or safe disposal. The program shall be readily available to all lessees and include information on locations accepting such materials on a continuous basis. This program shall be publicized and promoted on a regular basis, but at least anually.

4. The permittee shall ensure the establishment of a program, including structural controls where necessary, to reduce the discharge of floatables (including solid wastes) to the maximum extent practicable.

B. **SWMP SYSTEM-WIDE REQUIREMENTS**

The permittee shall operate a Storm Water Management Program (SWMP) in accordance with Section 402(p)(3)(B) of the Clean Water Act, the storm water regulations (40 CFR Part 122.26) and the approved SWMP plan to be submitted to EPA by the permittee. SWMP controls and activities identified in the SWMP plan shall clearly identify areas of applicability on a system-wide basis, jurisdiction-wide basis, or specific-area basis. The SWMP, and all approved updates, are hereby incorporated into this permit by reference and shall be implemented in a manner consistent with the following requirements:

1. *Statutory Requirements*: SWMPs shall include controls necessary to reduce the discharge of pollutants from the MS4 to the Maximum Extent Practicable (MEP). Controls may consist of a combination of best management practices, control techniques, system design and engineering methods, and such other provisions as the permittee, Administrator or the State determines appropriate. The various components of the SWMP, taken as a whole (rather than individually), shall be sufficient to meet the statutory MEP standard. The SWMP shall be updated as necessary to ensure conformance with the statutory requirements of Clean Water Act §402(p)(3)(B)(ii) and (iii).

2. *Structural Controls:* The permittee shall operate and maintain any storm water structural controls over which it has jurisdiction, in a manner so as to reduce the discharge of pollutants (including floatables) to the MEP.

3. *Areas of New Development:* The Port of Anchorage shall utilize a comprehensive master planning process to develop, implement, and enforce controls to reduce, to the MEP, the discharge of pollutants from areas of new development and significant redevelopment after construction is completed.

4. *Roadways:* The permittee shall operate and maintain public streets, roads, highways, parking areas, and cargo storage/staging areas under its jurisdiction in a manner so as to reduce, to the MEP, discharge of pollutants (including those related to deicing or sanding activities).

5. *Flood Control Projects:* The permittee shall ensure any flood control project it undertakes assesses and minimize to the MEP the impacts on water quality of the receiving waters. The permittee shall also evaluate the feasibility of retro-fitting existing structural flood control devices to provide additional pollutant removal from storm water. If retro-fitting is found to be feasible, the permittee shall implement the retro-fitting of existing structural devices within 3 years of such determination of feasibility.

6. *Pesticide, Herbicide, and Fertilizer Application:* The permittee shall implement controls to reduce, to the MEP, the discharge of pollutants related to application of pesticides, herbicides, and fertilizers applied by Port employees, contractors, or lessees to public right of ways, parks, and all port lands and facilities.

7. *Illicit Discharges and Improper Disposal*: The permittee shall implement an ongoing program to detect and eliminate illicit discharges and improper disposal into the storm sewer. The permittee may chose to require the discharger to the MS4 to eliminate the illicit discharges or obtain a separate NPDES permit for such discharges.

a. The permittee shall effectively prohibit non-storm water discharges to the MS4.

b. Unless identified by either the permittee, the Administrator, or the State as significant sources of pollutants to waters of the United States, the following non-storm water discharges need not be prohibited from entering the MS4, provided the necessity of such discharge(s) and appropriate control measures (if needed) to minimize the impacts of such sources, are developed under the SWMP:

(1) water line flushing;
(2) landscape irrigation;
(3) diverted stream flows;
(4) rising ground waters;
(5) uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20)) to separate storm sewers;
(6) uncontaminated pumped ground water;
(7) discharges from potable water sources;
(8) uncontaminated foundation drains;
(9) air conditioning condensate;
(10) irrigation water;
(11) springs;
(12) uncontaminated water from crawl space pumps;
(13) uncontaminated footing drains;
(14) lawn watering;
(15) individual residential car washing;
(16) flows from riparian habitats and wetlands;
(17) dechlorinated swimming pool discharges;
(18) street wash waters;
(19) NPDES permitted non-contact cooling waters and remediated ground waters, provided appropriate management practices are implemented and the discharges are in accordance with the Municipality's storm water management program; and,
(20) discharges or flows from emergency fire fighting activities.

c. The permittee shall prevent discharges of dry and wet weather overflows from sanitary sewers into the MS4. The permittee shall limit, to the maximum extent practicable, the infiltration of seepage from sanitary sewers into the MS4.

d. The permittee shall prohibit the discharge or disposal of all motor vehicle fluids and chemical wastes into separate storm sewers.

e. The permittee shall require the elimination of illicit connections as expeditiously as possible and the immediate cessation of improper disposal practices upon identification of responsible parties. Where elimination of an illicit connection within seven (7) days is not possible, the Port of Anchorage shall require an expeditious

schedule for elimination of the discharge. In the interim, the Port of Anchorage shall require the operator of the illicit connection to take all reasonable and prudent measures to minimize the discharge of pollutants to the MS4. Elimination schedules should not exceed ninety (90) days, except for capital intensive projects which shall not exceed 455 days (one year ninety days).

8. *Spill Prevention and Response:* The permittee shall implement a program to prevent, contain, and respond to spills that may discharge into the MS4. The spill response program may include a combination of spill response actions by the permittee and its lessees.

9. *Industrial & High Risk Runoff:* The permittee shall implement a program to identify, monitor, and control pollutants in storm water discharges to the MS4 from: hazardous waste treatment, storage and disposal facilities that are subject to EPCRA Title III, Section 313; bulk storage facilities; **and, any other industrial or commercial discharges the permittee determines are contributing a substantial pollutant loading to the MS4.** The program shall include:

   a. **priorities and procedures for inspections** and **establishing and implementing control measures for such discharges;**

   b. a monitoring (or self-monitoring) program for facilities identified under this section, including the collection of quantitative data on the following constituents:

      (1) any pollutants limited in an existing NPDES permit for an identified facility;
      (2) oil and grease;
      (3) chemical oxygen demand (COD);
      (4) pH;
      (5) biochemical oxygen demand, five-day (BOD_5);
      (6) total suspended solids (TSS);
      (7) total phosphorous;
      (8) total Kjeldahl nitrogen (TKN);
      (9) nitrate plus nitrite nitrogen; and
      (10) any of the metals cadmium, copper, lead, and zinc which can be reasonably expected in storm water runoff from such industrial site; and,
      (11) any information on discharges required under 40 CFR 122.21(g)(7)(iii) and (iv).

10. *Construction Site Runoff:* The permittee shall implement a program to reduce, to the MEP, the discharge of pollutants from constructions sites, including:

   a. requirements for the use and maintenance of appropriate structural and nonstructural best management practices to reduce pollutants

discharged to the MS4 upon commencement of, and during, the construction activities;

b. procedures for site planning which incorporate considerations for potential short and long term water quality impacts and minimizes, to the MEP, these impacts;

c. prioritized inspection of construction sites and enforcement of SWMP-required control measures;

d. appropriate education and training measures for construction site operators; and,

e. notification of all construction permit applicants of their potential responsibilities under the NPDES permitting program for construction site runoff.

11. *Public Education:* The permittee shall implement a public education program including:

a. a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or improper disposal of materials into the MS4;

b. a program to promote, publicize, and facilitate the proper management and disposal of used oil and commonly-used hazardous materials.

c. a program to promote, publicize, and facilitate the proper use, application, and disposal of pesticides, herbicides, and fertilizers by commercial and private applicators and distributors conducting such business within the Port of Anchorage jusrisdictional area.

C. **AREA-SPECIFIC STORM WATER MANAGEMENT PROGRAM REQUIREMENTS**
The following SWMP requirements apply only to the areas or discharges specified below. Management practices must also be developed in the SWMP for the following:

1. The Port of Anchorage (The Port) will provide an area for the washing of Port vehicles (that is, vehicles owned or operated by The Port) that will not result in the discharge of wash waters. The Port will encourage the use of detergent-free methods of vehicle washing and will require regular maintenance of the area to ensure wash waters, and resulting contaminants, will not be transported by storm water to waters of the U.S. This area is not required to be within Port jurisdictional boundaries, and does not have to be operated by the Port or Port personnel.

2. The Port may provide this area to its tenants solely for the purpose of vehicle washing. In such case, The Port accepts the responsibilty of proper operation and

maintenance of this area, and will ensure proper management practices are adhered to at all times.

3. All vehicle and equipment maintenance areas will be managed so as to control discharges from these areas to the maximum extent practicable. All hydrocarbon compounds used in these areas will be handled in a manner that will eliminate or minimize potential discharges to waters of the U.S.

D. DEADLINES FOR PROGRAM COMPLIANCE

1. Except as provided in PART III, compliance with the storm water management program shall be required within 120 days of the effective date of this permit.

2. Proposed modifications and updates to the SWMP, along with proposed schedules for implementation, shall be submitted with the Annual Report required under Part II.G. to EPA.

E. ROLES AND RESPONSIBILITIES OF PERMITTEE AND LESSEES

The SWMP plan shall clearly identify the roles and responsibilities of the permittee. Activities required of the lessees by the permittee must also be clearly identified.

F. LEGAL AUTHORITY

The permittee shall ensure legal authority exists to control discharges to and from those portions of the MS4 over which it has jurisdiction. This legal authority may be a combination of statute, ordinance, permit, contract, order or inter-jurisdictional agreements with entities having existing legal authority to:

1. Control the contribution of pollutants to the MS4 by storm water discharges associated with industrial activity and the quality of storm water discharged from sites of industrial activity;

2. Prohibit illicit discharges to the municipal separate storm sewer;

3. Control the discharge of spills and the dumping or disposal of materials other than storm water into the MS4;

4. Control through interagency agreements among co-permittees the contribution of pollutants from one portion of the MS4 to another;

5. Require compliance with conditions in ordinances, permits, contracts or orders; and,

6. Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance with permit conditions.

G. **SWMP RESOURCES**

The permittee shall provide adequate finances, staff, equipment, and support capabilities to fully implement the storm water management program.

H. **SWMP REVIEW AND MODIFICATION**

1. *Program Review:* The permittee shall conduct an annual review of the current SWMP in conjunction with preparation of the annual system-wide report required under Part II.I. This annual review shall include:

   a. A review of the status of program implementation and compliance (or non-compliance) with all schedules of compliance contained in this permit;

   b. An assessment of the effectiveness of controls established ~~by the SWMP~~;

   c. A review of monitoring data and any trends in estimated cumulative annual pollutant loadings; and,

   d. An assessment of any SWMP modifications needed to comply with the CWA §402(p)(3)(B)(iii) requirement to reduce the discharge of pollutants to the MEP.

2. *Program Modification:* The approved SWMP, and its plan, shall not be modified by the permittee without the prior approval of the EPA, unless in accordance with items a. through c. below:

   a. Modifications adding (but not subtracting or replacing) components, controls, or requirements to the approved SWMP may be made by the permittee at any time upon written notification to the permitting authority.

   b. Modifications replacing a failing Best Management Practice (BMP) identified in the SWMP with an alternate BMP may be requested in conjunction with the annual system-wide report required by Part II.I. below. Such requests must: 1) be made in writing; 2) provide an analysis of why the BMP is failing or ineffective (including cost prohibitive); 3) discuss the expectations of the effectiveness of the replacement BMP; and, 4) explain why the replacement BMP is expected to provide at least the same level of performance as originally expected of the BMP to be replaced.

   c. Modifications made under this paragraph shall not become enforceable permit conditions until such time as the modifications are approved by EPA.

   Modification requests and/or notifications shall be signed in accordance with Part VI.H.

3. *Modifications Required by the Permitting Authority:* The EPA may require the permittee to modify the SWMP as needed to:

   a. Address contributions by the MS4 discharges to impacts on receiving water quality;

   b. Include more stringent requirements necessary to comply with new State or Federal statutory or regulatory requirements; or,

   c. Include such other conditions deemed necessary by the Administrator to comply with the goals and requirements of the Clean Water Act.

   Modifications requested by the Administrator shall be made in writing, set forth the time schedule for the permittee to develop the modification(s), and offer the permittee the opportunity to propose alternative program modifications to meet the objective of the requested modification.

I. SYSTEM-WIDE REPORT

The permittee shall prepare and submit a system-wide report no later than one year after the anniversary of the effective date of this permit (**March 3, 1995**), and continue to submit an updated system-wide report every year thereafter. The report shall include the following separate sections and an overview for the entire MS4:

1. The status of implementing the components of the SWMPs that are established as permit conditions (status of compliance with any schedules established under this permit shall be included in this section);

2. Proposed changes to the SWMPs that are established as permit conditions, including an update on areas added to the MS4 due to annexation or other legal means;

3. Revisions, if necessary, to the assessments of controls and management practices;

4. A summary of the data, including monitoring data, that is accumulated throughout the last reporting year;

5. Annual expenditures for the reporting period (i.e., the last year), and projected budget for the one year period comprising the next system-wide report;

6. A summary describing the number and nature of compliance actions, inspections, and public education programs; and,

7. Identification of water quality improvements or degradation, with a discussion of those management practices implemented or proposed for implementation to address identified water quality degradation.

PART III. SCHEDULES FOR COMPLIANCE

A. IMPLEMENTATION OF POLLUTION PREVENTION MEASURES

POLLUTION PREVENTION MEASURE	ACTIVITY DESCRIPTION	DATE DUE
Part II.A.1 - New Development & Re-Development	Implement construction-phase storm water runoff control program.	March 4, 1996
	Modify land use planning process within Port to require controls for storm water quality.	March 3, 1998
	Implement requirements for post-construction storm water quality controls for new and significant re-development.	July 30, 1998
Part II.A.2 - Vehicle Fluids	Implement public education program.	July 30, 1995
	Develop collection/recycling/safe disposal program.	March 4, 1996
	Implement collection/recycling/safe disposal program.	March 3, 1997
Part II.A.3 - Common Hazardous Waste	Implement public education program.	July 30, 1995
	Develop collection/recycling/safe disposal program.	March 4, 1996
	Implement collection/recycling/safe disposal program.	March 3, 1997
Part II.A.4 - Floatables	Implement public education program.	July 30, 1995
	Implement litter control program.	July 30, 1995
	Install floatables monitoring location (See Part V.A.2)	July 30, 1995
	Complete study for targeting of structural controls.	July 30, 1996
	Complete installation of structural controls on 100% of targeted storm sewer.	July 30, 1997

B. IMPLEMENTATION OF STORM WATER MANAGEMENT PLANS

SWMP ACTIVITY	ACTIVITY DESCRIPTION	DATE DUE
PART II.B - Storm Water Management Program (SWMP) plan development	Complete development of SWMP plan	June 5, 1995
Part II.B.7 - Illicit Discharges and Improper Disposal	Implement public education program.	July 30, 1995
	Complete screening of the MS4.	July 30, 1996
	Complete follow up investigations based on screening results.	July 30, 1999
Part II.I - System-wide Report	Episodic system and implementation status report	Annually: March 3

PART IV. SPECIAL PERMIT REQUIREMENTS

The following requirements are included in this permit as stipulations of water quality certification from the Alaska Department of Environmental Conservation (ADEC).

A. **MONITORING**

1. In Part II.B.9.b the parameter "Total Aqueous Hydrocarbons" will be substituted for the parameter "Oil and Grease" on the list of parameters to be monitored.

   The parameter "Total Aqueous Hydrocarbons" (TAqH) means those collective dissolved and water-accomodated monoaromatic and polynuclear aromatic petroleum hydrocarbons that are persistent in the water column; TAqH does not include floating surface oils and greases. TAqH is calculated by summing the values of the parameters Total Aromatic Hydrocarbons (TAH) and Total Polynuclear Hydrocarbons (PAH). The parameters TAqH, TAH, and PAH are all defined in the Adopted Draft Water Quality Standards, 18 AAC 70.020(b) Note #8, dated 9/13/94. The test methods to be used to determine the presence of these parameters are the EPA 602 method for TAH and the EPA 610 method for PAH. Equivalent methods may be substituted for EPA 610 that meet the performance standards, Minimum Detection Limits (MDLs), precision, and standard recoveries specified in method 610. The applicable criteria are contained in Note #8 (cited above).

2. Table V.A.1.a (Monitoring Frequency) shall be modified as follows:

   a) The monitoring frequency and the parameters listed for monitoring in years 2 and 3 shall be identical to that listed for year 4, such that the full list of parameters will be sampled in years 2, 3, and 4 at the frequency listed under YEAR 4.

   b) The parameter "Total Aqueous Hydrocarbons" will be substituted in the table for the parameter "Oil and Grease" (as discussed above).

   c) Delete "Other Water Quality Parameters" from the table.

B. **MISCELLANEOUS**

1. Copies of all reports required in the permit will be sent to the following ADEC offices:

   Alaska Department of Environmental Conservation
   Southcentral Regional Office
   3601 C Street, Suite 1334
   Anchorage, AK 99503
   (907) 563-6529

   Alaska Department of Environmental Conservation
   Anchorage Western District Office
   800 E. Dimond Blvd. #3-470
   Anchorage, Alaska 99515
   (907) 349-7755

2. In Part II.A.1., add the following statement: The permittee shall emphasize source reduction techniques as a means to reduce the discharge of pollutants. The permittee shall inform the lessees of the availability, through ADEC, of pollution prevention resources, technical assistance programs and other non-regulatory initiatives that will support the overall objective of eliminating the discharge of pollutants.

3. In Part II.B.11., add the following as paragraph (d): a program to promote, publicize and facilitate implementation of technologies and techniques to prevent pollution through source reduction and recycling.

PART V. MONITORING AND REPORTING REQUIREMENTS

A. Storm Event Monitoring

The permittee shall implement a wet-weather monitoring program for the MS4 to provide data necessary to: 1) assess the effectiveness and adequacy of control measures implemented under the SWMP; 2) estimate annual cumulative pollutant loadings from the MS4; 3) estimate event mean concentrations and seasonal pollutants in discharges from major outfalls; 4) identify and prioritize portions of the MS4 requiring additional controls; and, 5) identify water quality improvements or degradation.

1. *Representative Monitoring:*
   The permittee shall monitor representative outfalls and/or instream monitoring locations to characterize the quality of storm water discharges from the MS4.

   a. Monitoring Requirements: (See Table V.A.1.a).

   b. Outfall Descriptions: (See Table V.A.1.b)

2. *Wet Weather Screening Program:*
   The permittee shall implement a program to screen all areas contibuting storm water to the MS4 for the presence of excessive pollutants in discharges from the MS4. The wet weather screening program:

   a. Shall screen the entire MS4 at least once during the permit term.

   b. Shall specify the sampling and non-sampling techniques, parameters, collection techniques, and analytical methods to be used for initial screening purposes. For screening samples only, sample collection and analysis need not conform to the requirements of 40 CFR Part 136 and are not subject to the requirements of Paragraphs 3, 4, and 5 below.

Table V.A.1.a. - Monitoring Requirements for Outfalls 001, 002, and 003[1]

PARAMETER	MONITORING FREQUENCY				
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Biochemical Oxygen Demand (BOD_5) (mg/l)	Once/year	Once/year	Once/year	Once/year	Once/year
Chemical Oxygen Demand (COD) (mg/l)	Once/year	Once/year	Once/year	Once/year	Once/year
Total Suspended Solids (TSS) (mg/l)	Once/year	Once/year	Once/year	Once/year	Once/year
Total Dissolved Solids (TDS) (mg/l)	Once/year	Once/year	Once/year	Once/year	Once/year
Total Nitrogen (mg/l)	Once/year	Once/year	Once/year	Once/year	Once/year
Total Kjeldahl Nitrogen (TKN) (mg/l)	Once/year	Once/year	Once/year	Once/year	Once/year
Total Phosphorus (mg/l)	---------	---------	---------	Once/year	---------
Dissolved Phosphorus (mg/l)	---------	---------	---------	Once/year	---------
Oil & Grease (mg/l)	Twice/year	Twice/year	Twice/year	Twice/year	Twice/year
Total Cadmium (ug/l)	---------	---------	---------	Once/year	---------
Total Copper (ug/l)	---------	Once/year	---------	Once/year	---------
Total Lead (ug/l)	---------	---------	---------	Once/year	---------
Total Zinc (ug/l)	---------	Once/year	---------	Once/year	---------
Ph (S.U.)	Twice/year	Twice/year	Twice/year	Twice/year	Twice/year
Hardness (as $CaCO_3$) (mg/l)	---------	---------	---------	Once/year	---------
Temperature (°C)	Twice/year	Twice/year	Twice/year	Twice/year	Twice/year

[1] This table represents the baseline monitoring requirements for the discharges and outfalls described in this permit. Some specific parameters and monitoring frequencies have have been modified pursuant to the special requirements as discussed in Part IV of this permit.

R0012904

Table V.A.1.b - Representative Monitoring Outfall Descriptions

OUTFALL	LOCATION	DESCRIPTION
001	Transit Area B	Storm water drain for Transit Area B. This area is 52.0 total acres with 16.2 acres of impervious surface.
002	Transit Area D and Transit Area A	Storm water drain for Transit Area D and a portion of Transit Area A. Transit Area D is 43.4 total acres and has 7.8 acres of impervious surface. This portion of Transit Area A has 55 total acres with 15 acres covered by impervious surface. The total acreage of impervious surface draining to outfall 002 is 22.8 acres.
003	Transit Area 12-B	Storm water drain for Transit Area 12-B. Area 12-B is 36.7 total acres with 16.8 acres of impervious surface.

c. Shall establish three monitoring locations for removal of floatable material in discharges from the MS4. The amount of material collected shall be estimated in cubic yards. Floatable material shall be measured periodically as necessary for maintenance of the removal device.

d. Shall submit, along with the system-wide report required by Part II.I, the following information:

(1) An estimate of the amount of floatable material collected (cubic yards);

(2) A summary of results and actions taken or proposed based on the results of the wet weather screening program.

e. Any monitoring location that collects an annual average of less than 3 cubic yards of floatables over any consecutive 3 calendar-year period during the permit term will no longer be considered a mandatory monitoring location. The Port must maintain at least one monitoring location for floatables regardless of the amount of floatables collected.

3. *Storm Event Data:*
Quantitative data shall be collected to estimate pollutant loadings and event mean concentrations for each parameter sampled. In addition to the parameters listed above, The Port shall maintain records on site of the date and duration (in hours) of the storm event(s) sampled; rainfall measurements or estimates (in inches) of the storm event which generated the sampled runoff; the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event; and an estimate of the total volume (in gallons) of the discharge sampled.

4. *Sample Type, Collection, and Analysis:*
a. For discharges from storm water holding ponds or other storm water impoundments with a retention period greater than 24 hours, (estimated by dividing the volume of the detention pond by the estimated volume of water discharged during the 24 hours previous to the time that the sample is collected) a minimum of one grab sample may be taken.

b. Grab samples taken during the first two hours of discharge shall be used for the analysis (if required) of pH, temperature, cyanide, oil & grease, fecal coliform, fecal streptococcus, total phenols, residual chlorine, and volatile organics. For all other parameters, data shall be reported

for flow weighted composite samples of the entire event or, at a minimum, the first three hours of discharge.

c. All such samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Composite samples may be taken with a continuous sampler or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire discharge or for the first three hours of the discharge, with each aliquot being separated by a minimum period of fifteen minutes.

d. Analysis and collection of samples shall be done in accordance the methods specified at 40 CFR Part 136. Where an approved Part 136 method does not exist, any available method may be used.

5. *Sampling Waiver:*
When a discharger is unable to collect samples due to adverse climatic conditions, the discharger must submit in lieu of sampling data a description of why samples could not be collected, including available documentation of the event. Adverse climatic conditions which may prohibit the collection of samples includes weather conditions that create dangerous conditions for personnel (such as local flooding, high winds, hurricane, tornadoes, electrical storms, etc.) or otherwise make the collection of a sample impracticable (drought, extended frozen conditions, etc.). Dischargers are precluded from exercising this waiver more than once during a two year period.

B. **Dry Weather Monitoring**

1. *Dry Weather Screening Program:*
The permittee shall continue ongoing efforts to detect the presence of illicit connections and improper discharges to the MS4. All portions (but not necessarily all outfalls) of the MS4 must be screened at least once during the permit term, in accordance with the schedule set forth in PART III.A.

2. *Screening Procedures:*
Screening methodology may be developed and/or modified based on experience gained during actual field screening activities and need not conform to the protocol at 40 CFR 122.26(d)(1)(iv)(D).

3. *Follow-up on Dry Weather Screening Results:*
The permittee shall implement a program to locate and

eliminate suspected sources of illicit connections and improper disposal identified during dry weather screening activities. Follow-up activities may be prioritized on the basis of:

a. magnitude and nature of the suspected discharge;

b. sensitivity of the receiving water; and

c. other relevant factors.

C. **Certification and Signature of Reports**

1. All reports required by the permit and other information requested by the Director shall be signed and certified in accordance with Parts VII.H. & VII.I. of the permit.

D. **Reporting: Where to Submit**

1. Monitoring results obtained during each anual reporting period shall be submitted on Discharge Monitoring Report Form(s) and included with the annual system-wide reprt. A separate Discharge Monitoring Report Form is required for each event monitored. The first report may include less than twelve months of information.

2. Signed copies of discharge monitoring reports required under Part V., the System-Wide Report required by Part II.G., SWMP modifications and modification requests, requests for changes in monitoring outfalls and all other reports required herein, shall be submitted to:

U.S. EPA, Region 10
Wastewater Management and Enforcement Branch
Municipal Storm Water Permits (WD-135)
1200 Sixth Avenue
Seattle, Washington 98101

E. **Additional Notification**

1. Copies of the discharge monitoring reports required under Part V., the System-Wide Report required by Part II.G., and other reports requested by the State shall be submitted to:

Alaska Department of Environmental Conservation
Southcentral Regional Office
3601 C Street, Suite 1334
Anchorage, AK 99503
(907) 563-6529

Alaska Department of Environmental Conservation
Anchorage Western District Office
800 E. Dimond Blvd. #3-470
Anchorage, Alaska 99515
(907) 349-7755

F. **Retention of Records**

1. The permittee shall retain at The Port the latest approved version of the storm water management program developed in accordance with Part II of this permit until at least three years after coverage under this permit terminates. The permittee shall retain at The Port all records of all monitoring information, copies of all reports required by this permit, and records of all other data required by or used to demonstrate compliance with this permit, until at least three years after coverage under this permit terminates. This period may be explicitly modified by alternative provisions of this permit or extended by request of the Director at any time.

PART VI. STANDARD PERMIT CONDITIONS

A. Duty to Comply

1. The permittee must comply with all conditions of this permit insofar as those conditions are applicable to each permittee, either individually or jointly. Any permit noncompliance constitutes a violation of CWA and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

B. Penalties for Violations of Permit Conditions

1. Criminal

   a. Negligent Violations The CWA provides that any person who negligently violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than 1 year, or both.

   b. Knowing Violations The CWA provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or both.

   c. Knowing Endangerment The CWA provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act and who knows at that time that he is placing another person in imminent danger of death or serious bodily injury is subject to a fine of not more than $250,000, or by imprisonment for not more than 15 year, or both.

   d. False Statement The CWA provides that any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed or required to be maintained under the Act or who knowingly falsifies, tampers with, or renders inaccurate, any monitoring device or method required to be maintained under the Act, shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 2 years, or by both. If a conviction is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4

years, or by both. (See Section 309(c)(4) of the Clean Water Act).

2. Civil Penalties - The CWA provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a civil penalty not to exceed $25,000 per day for each violation.

3. Administrative Penalties - The CWA provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to an administrative penalty, as follows:

   a. Class I penalty Not to exceed $10,000 per violation nor shall the maximum amount exceed $25,000.

   b. Class II penalty Not to exceed $10,000 per day for each day during which the violation continues nor shall the maximum amount exceed $125,000.

C. **Duty to Reapply**
If the permittee wishes to continue an activity regulated by this permit after the permit expiration date, the permittee(s) must apply for and obtain a new permit. The application shall be submitted at least 180 days prior to expiration of this permit. The Administrator may grant permission to submit an application less than 180 days in advance but no later than the permit expiration date. Continuation of expiring permits shall be governed by regulations promulgated at 40 CFR 122.6 and any subsequent amendments.

D. **Need to halt or reduce activity not a defense**
It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

E. **Duty to Mitigate**
The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

F. **Duty to Provide Information**
The permittee shall furnish to the Administrator, within a time specified by the Director, any information which the

Administrator may request to determine compliance with this permit. The permittee shall also furnish to the Administrator upon request copies of records required to be kept by this permit.

G. **Other Information**
When the permittee becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in any report to the Director, he or she shall promptly submit such facts or information.

H. **Signatory Requirements**
All Discharge Monitoring Reports, storm water pollution prevention plans, reports, certifications or information either submitted to the Administrator or that this permit requires be maintained by the permittee, shall be signed by:

1. either a principal executive officer or ranking elected official.

2. a duly authorized representative of that person. A person is a duly authorized representative only if:

   a. The authorization is made in writing by a person described above and submitted to the Director.

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of manager, operator, superintendent, or position of equivalent responsibility or an individual or position having overall responsibility for environmental matters for the company. (A duly authorized representative may thus be either a named individual or any individual occupying a named position).

   c. If an authorization is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new notice of intent satisfying the requirements of this paragraph must be submitted to the Director prior to or together with any reports, information, or applications to be signed by an authorized representative.

I. **Certification**
Any person signing documents under this section shall make the following certification:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

J. **Penalties for Falsification of Reports**
Section 309(c)(4) of the Clean Water Act provides that any person who knowingly makes any false material statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including reports of compliance or noncompliance shall, upon conviction, be punished by a fine of not more than $10,000, or by imprisonment for not more than 2 years, or by both.

K. **Penalties for Falsification of Monitoring Systems**
The CWA provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by fines and imprisonment described in Section 309 of the CWA.

L. **Oil and Hazardous Substance Liability**
Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under section 311 of the CWA or section 106 of CERCLA.

M. **Property Rights**
The issuance of this permit does not convey any property rights of any sort, nor any exclusive privileges, nor does it authorize any injury to private property nor any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

N. **Severability**
The provisions of this permit are severable, and if any provision of this permit, or the application of any provision

of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

O. **Requiring an individual permit**

1. The Administrator may require the permittee authorized by this permit to obtain an individual NPDES permit. Any interested person may petition the Administrator to take action under this paragraph. The Director may require any owner or operator authorized to discharge under this permit to apply for an individual NPDES permit only if the owner or operator has been notified in writing that a permit application is required. This notice shall include a brief statement of the reasons for this decision, an application form (as necessary), a statement setting a deadline for the owner or operator to file the application, and a statement that on the effective date of the individual NPDES permit, coverage under this permit shall automatically terminate. Individual permit applications shall be submitted to the address of the appropriate Regional Office shown in Part V.D. of this permit. The Administrator may grant additional time to submit the application upon request of the applicant. If an owner or operator fails to submit in a timely manner an individual NPDES permit application as required by the Administrator, then the applicability of this permit to the individual NPDES permittee is automatically terminated at the end of the day specified for application submittal.

2. Any owner or operator authorized by this permit may request to be excluded from the coverage of this permit by applying for an individual permit. The owner or operator shall submit an individual application as specified by 40 CFR 122.26(d) with reasons supporting the request to the Administrator. Individual permit applications shall be submitted to the address of the appropriate Regional Office shown in Part V.D. of this permit. The request may be granted by the issuance of a individual permit if the reasons cited by the owner or operator are adequate to support the request.

P. **State/Environmental Laws**

1. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by section 510 of the Act.

2. No condition of this permit shall release the permittee from any responsibility or requirements under other environmental statutes or regulations.

Q. **Proper Operation and Maintenance**

The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit and with the requirements of storm water pollution prevention plans. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. Proper operation and maintenance requires the operation of backup or auxiliary facilities or similar systems, installed by a permittee only when necessary to achieve compliance with the conditions of the permit.

R. **Monitoring and records**

1. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

2. The permittee shall retain records of all monitoring information including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of the reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application. This period may be extended by request of the Administrator at any time.

3. Records of monitoring information shall include:

   a. The date, exact place, and time of sampling or measurements;

   b. The initials or name(s) of the individual(s) who performed the sampling or measurements;

   c. The date(s) analyses were performed;

   d. The time(s) analyses were initiated;

   e. The initials or name(s) of the individual(s) who performed the analyses;

   f. References and written procedures, when available, for the analytical techniques or methods used; and

g. The results of such analyses, including the bench sheets, instrument readouts, computer disks or tapes, etc., used to determine these results.

S. **Monitoring Methods**
Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

T. **Inspection and Entry**
The permittee shall allow the Administrator or an authorized representative of EPA, or the State, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter upon the permittee's premises where a regulated facility or activity is located or conducted or where records must be kept under the conditions of this permit;

2. Have access to and copy at reasonable times, any records that must be kept under the conditions of this permit; and,

3. Inspect at reasonable times any facilities or equipment (including monitoring and control equipment).

U. **Permit Actions**
This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

PART VII. PERMIT MODIFICATION

A. **Modification of the Permit**

The permit may be reopened and modified during the life of the permit to address:

1. changes in the State's Water Quality Management Plan, including Water Quality Standards;

2. changes in State or Federal statutes or regulations;

3. add a co-permittee who is the owner or operator of a portion of the MS4;

4. changes in portions of the storm water management program that are considered permit conditions; or

5. other modifications deemed necessary by the Administrator to meet the requirements of the Clean Water Act.

All modification to the permit will be made in accordance with 40 CFR 122.62, 122.63, and 124.5.

B. **Termination of Coverage for a Single Co-permittee**

Permit coverage may be terminated, in accordance with the provisions of 40 CFR 122.64 and 124.5, for a single co-permittee without terminating coverage for other co-permittees.

C. **Modification of Storm Water Management Program(s)**

Only those portions of the SWMPs specifically required as permit conditions shall be subject to the modification requirements of 40 CFR 124.5. Replacement of a failing BMP implementing a required component of the SWMP with an alternate BMP expected to provide at least the same level of performance initially expected of the failing BMP, shall be considered minor modifications to the permit and will be made in accordance with the procedures at 40 CFR 122.63.

D. **Changes in Monitoring Outfalls**

This permit is issued on a system-wide basis in accordance with CWA § 402(p)(3)(i) and authorizes discharges from all portions of the MS4. Since all outfalls are authorized, changes in monitoring outfalls, other than those with specific numeric effluent limitations, shall be considered minor modifications to the permit and will be made in accordance with the procedures at 40 CFR 122.63.

PART VIII. DEFINITIONS

"Administrator" means the Regional Administrator.

"Best Management Practices" ("BMPs") means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control facility site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

"CWA" means Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub.L. 92-500, as amended Pub. L. 95-217, Pub. L. 95-576, Pub. L. (6-483 and Pub. L. 97-117, 33 U.S.C. 1251 et.seq.

"Co-permittee" means a permittee to a NPDES permit that is only responsible for permit conditions relating to the discharge for which it is operator.

"Director" means the Regional Administrator or an authorized representative.

"Discharge" for the purpose of this permit, unless indicated otherwise, refers to discharges from the Municipal Separate Storm Sewer System (MS4).

"Flow-weighted composite sample" means a composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

"Illicit connection" means any man-made conveyance connecting an illicit discharge directly to a municipal separate storm sewer.

"Illicit discharge" means any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to a NPDES permit (other than the NPDES permit for discharges from the municipal separate storm sewer) and discharges resulting from fire fighting activities.

"Landfill" means an area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or waste pile.

"Land application unit" means an area where wastes are applied onto or incorporated into the soil surface (excluding manure spreading operations) for treatment or disposal.

"MS4" is an acronym for "municipal separate storm sewer system" and is used to refer to either a Large or Medium Municipal Separate Storm Sewer System.

"Large or Medium municipal separate storm sewer system" means all municipal separate storm sewers that are either:

(i) located in an incorporated place (city) with a population of 100,000 or more as determined by the latest Decennial Census by the Bureau of Census (these cities are listed in Appendices F and G of 40 CFR Part 122); or

(ii) located in the counties with unincorporated urbanized populations of 100,000 or more, except municipal separate storm sewers that are located in the incorporated places, townships or towns within such counties (these counties are listed in Appendices H and I of 40 CFR Part 122); or

(iii) owned or operated by a municipality other than those described in paragraph (i) or (ii) and that are designated by the Director as part of the large or medium municipal separate storm sewer system.

"Municipal Separate Storm Sewer" means a conveyance, or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains): (i) owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State Law) having jurisdiction over disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State Law such as a sewer district, flood control district or drainage district, or similar entity, or an Indian Tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States; (ii) designed or used for collecting or conveying storm water; (iii) which is not a combined sewer; and (iv) which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

"Point Source" means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharges. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

"Storm sewer", unless otherwise indicated, refers to a municipal separate storm sewer.

"Storm Water" means storm water runoff, snow melt runoff, and surface runoff and drainage.

"SWMP" is an acronym for "Storm Water Management Program."

"Time-weighted composite" means a composite sample consisting of a mixture of equal volume aliquots collected at a constant time interval.

"Waste pile" means any noncontainerized accumulation of solid, nonflowing waste that is used for treatment or storage.

"Waters of the United States" means:

(a) All waters which are currently used, were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide;
(b) All interstate waters, including interstate "wetlands";
(c) All other waters such as interstate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds the use, degradation, or destruction of which would affect or could affect interstate or foreign commerce including any such waters:
(1) Which are or could be used by interstate or foreign travelers for recreational or other purposes;
(2) From which fish or shellfish are or could be taken and sold in interstate or foreign commerce; or
(3) Which are used or could be used for industrial purposes by industries in interstate commerce;
(d) All impoundments of waters otherwise defined as waters of the United States under this definition;
(e) Tributaries of waters identified in paragraphs (a) through (d) of this definition;
(f) The territorial sea; and
(g) Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in paragraphs (a) through (f) of this definition.

Waste treatment systems, including treatment ponds or lagoons designed to meet the requirements of CWA are not waters of the United States. This exclusion applies only to manmade bodies of water which neither were originally created in waters of the United States (such as disposal areas in wetlands) nor resulted from the impoundment of waters of the United States.

NPDES Permit No. OKS000201

AUTHORIZATION TO DISCHARGE UNDER THE
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Clean Water Act, 33 U.S.C. 1251 *et seq.*, as amended by the Water Quality Act of 1987, P.L. 100-4, the "Act",

City of Tulsa
Department of Public Works
200 Civic Center
Tulsa, Oklahoma 74103

is(are) authorized to discharge, in accordance with the Storm Water Management Program(s), effluent limitations, monitoring requirements, and other provisions set forth in Parts I, II, III, IV, V, VI, VII, and VIII herein,

from all portions of the City of Tulsa Municipal Separate Storm Sewer System (MS4) owned or operated by any permittee listed above, to waters of the United States.

This permit will become effective October 1, 1994

This permit and the authorization to discharge under the National Pollutant Discharge Elimination System shall expire at midnight, on September 30, 1999

Signed this 26 day of August, 1994

Monica L. Burrell
Environmental Engineer
Municipal Section (6W-PM)

Myron O. Knudson, P.E.
Director
Water Management Division (6W)

R0012921

PART I. DISCHARGES AUTHORIZED UNDER THIS PERMIT.

A. **Permit Area.** This permit covers all areas located within the corporate boundary of the City of Tulsa that are served by municipal separate storm sewers owned or operated by the permittee(s).

B. **Authorized Discharges.**

1. Except for discharges prohibited under Part I.B.2, this permit authorizes all existing or new storm water point source discharges to waters of the United States from those portions of the Municipal Separate Storm Sewer System owned or operated by the permittee(s).

2. The following discharges, whether discharged separately or commingled with municipal storm water, are not authorized by this permit:

a. *Non-storm Water and Industrial Storm Water:* discharges of non-storm water; any Storm Water Discharge Associated with Industrial Activity; or other storm water discharges required to obtain an NPDES permit, except where such discharges are:

(1) regulated by a separate NPDES permit (or the discharger has applied for such permit); or

(2) identified by and in compliance with Part II.A.6.a.

b. *Spills:* discharges of material resulting from a spill. Where discharge of material resulting from a spill is necessary to prevent loss of life, personal injury, or severe property damage, the permittee(s) shall take, or insure the responsible party for the spill takes, all reasonable steps to minimize or prevent any adverse effects on human health or the environment. (See also Part II.A.7 and Part VI.E.) This permit does not transfer liability for a spill itself from the party(ies) responsible for the spill to the permittee(s) nor relieve the party(ies) responsible for a spill from the reporting requirements of 40 CFR Part 117 and 40 CFR Part 302.

C. **Permittee Responsibilities.**

1. Each permittee is responsible for:

a. Compliance with permit conditions relating to discharges from portions of the Municipal Separate Storm Sewer System where the permittee is the operator;

b. Storm Water Management Program implementation on portions of the Municipal Separate Storm Sewer System where the permittee is the operator;

c. Compliance with annual reporting requirements as specified in Part V.C.;

d. Collection of representative wet weather monitoring data required by Part V.A., according to such agreements as may be established between permittees; and

e. A plan of action to assume responsibility for implementation of storm water management and monitoring programs on their portions of the Municipal Separate Storm Sewer System should interjurisdictional agreements allocating responsibility between permittees be dissolved or in default.

2. Permittees are jointly responsible for permit compliance on portions of the Municipal Separate Storm Sewer System where operational or Storm Water Management Program implementation authority over portions of the Municipal Separate Storm Sewer System is shared or has been transferred from one permittee to another in accordance with legally binding agreements.

D. **Discharge Goals.**

The following goals are established for discharges from the Municipal Separate Storm Sewer System:

1. No discharge of toxics in toxic amounts.

2. No discharge of pollutants in quantities that would cause a violation of State Water Quality Standards.

3. No discharge of floatable debris, oils, scum, foam, or grease in other than trace amounts.

4. No discharge of non-storm water from the municipal separate storm sewer system (except as provided in Part I.B.2.).

5. No degradation or loss of State-designated beneficial uses of receiving waters as a result of storm water discharges from the municipal separate storm sewer (unless authorized by the State in accordance with the State's Antidegradation Policy).

PART II. STORM WATER POLLUTION PREVENTION & MANAGEMENT PROGRAM(S).

Each permittee shall contribute to the development, revision and implementation of a comprehensive Storm Water Management Program including pollution prevention measures, treatment or removal techniques, storm water monitoring, use of legal authority, and other appropriate means to control the quality of storm water discharged from the Municipal Separate Storm Sewer System. The Storm Water Management Program shall be implemented in accordance with Section 402(p)(3)(B) of the Act, and the Storm Water Regulations (40 CFR Part 122.26).

Controls and activities in the Storm Water Management Program shall identify areas of permittee responsibility on a jurisdiction, applicability, or specific area basis. The Storm Water Management Program shall include controls necessary to effectively prohibit the discharge of non-storm water into municipal separate storm sewers and reduce the discharge of pollutants from the Municipal Separate Storm Sewer System to the Maximum Extent Practicable (MEP).

The Storm Water Management Program shall cover the term of this permit and shall be updated as necessary, or as required by the Director, to ensure compliance with the statutory requirements of Section 402(p)(3)(B) of the Act. Modifications to the Storm Water Management Program shall be made in accordance with Parts II.G., and III. Compliance with the Storm Water Management Program and any schedules in Part III. shall be deemed compliance with Parts II.A, and II.B. The Storm Water Management Program, and all updates made in accordance with Part II.G., are hereby incorporated by reference.

Implementation of the Storm Water Management Program may be achieved through participation with other permittees, public agencies, or private entities in cooperative efforts to satisfy the requirements of Part II. in lieu of creating duplicate program elements for each individual permittee. The Storm Water Management Program, taken as a whole, shall achieve the "effective prohibition on the discharge of non-storm water" and "MEP" standards from Section 402(p)(3)(B) of the Act.

A. <u>Storm Water Management Program Requirements.</u>

1. *Structural Controls and Storm Water Collection System Operation:* The Municipal Separate Storm Sewer System and any storm water structural controls shall be operated in manner to reduce the discharge of pollutants to the Maximum Extent Practicable.

2. *Areas of New Development and Significant Redevelopment:* A comprehensive master planning process (or equivalent) to develop, implement, and enforce controls to minimize the discharge of pollutants from areas of new development and significant re-development after construction is completed shall be implemented. The goals of such controls shall be:

   a. New development - limiting increases in the discharge of pollutants in storm water as a result of development, and

   b. Re-development - reducing the discharge of pollutants in storm water.

3. *Roadways:* Public streets, roads, and highways shall be operated and maintained in a manner to minimize discharge of pollutants, including those pollutants related to deicing or sanding activities.

4. *Flood Control Projects:* Impacts on receiving water quality shall be assessed for all flood management projects. The feasibility of retro-fitting existing structural flood control devices to provide additional pollutant removal from storm water shall be evaluated.

5. *Pesticide, Herbicide, and Fertilizer Application:* Each permittee shall implement controls to reduce the discharge of pollutants related to the permittee's storage and application of pesticides, herbicides, and fertilizers. Permittees with jurisdiction over lands not directly owned by that entity (e.g. incorporated city with authority over activities occurring anywhere within their city limits) shall also implement programs to reduce the discharge of pollutants related to commercial application and distribution of pesticides, herbicides, and fertilizers.

6. *Illicit Discharges and Improper Disposal:* Non-storm water discharges to the municipal separate storm sewer system shall be effectively prohibited.

   a. In accordance with 40 CFR 122.26(d)(2)(iv)(B)(1), certain non-storm water discharges to the municipal separate storm sewer system need not be addressed as illicit discharges or improper disposal. The Storm Water Management Program shall identify any non-storm water discharges that the permittee(s) does not prohibit, along with any conditions placed on such non-storm water discharges to the municipal separate storm sewer system. The permittee(s) shall prohibit, on a case-by-case basis, any individual non-storm water discharge (or class of non-storm water discharges) otherwise allowed under this paragraph that is determined to be contributing significant amounts of pollutants to the municipal separate storm sewer system.

   b. Each permittee shall prevent (or require the operator of the sanitary sewer to eliminate) unpermitted discharges of dry and wet weather overflows from sanitary sewers into the Municipal Separate Storm Sewer System. Each permittee shall limit the infiltration of seepage from sanitary sewers into the Municipal Separate Storm Sewer System.

   c. The permittee(s) shall ensure the implementation of a program to reduce the discharge of floatables (e.g. litter and other human-generated solid refuse). The floatables control program shall include source controls and, where necessary, structural controls.

   d. The discharge or disposal of used motor vehicle fluids, household hazardous wastes, grass clippings, leaf litter, and animal wastes into separate storm sewers shall be prohibited. The permittee(s) shall ensure the implementation of programs to collect used motor vehicle fluids (at a minimum, oil and antifreeze) for recycle, reuse, or proper disposal and to collect household hazardous waste materials (including paint, solvents, pesticides, herbicides, and other hazardous materials) for recycle, reuse, or proper disposal. Such programs shall be readily available to all private residents and shall be publicized and promoted on a regular basis.

   e. A program to locate and eliminate illicit discharges and improper disposal into the Municipal Separate Storm Sewer System shall be implemented. This program shall include dry

weather screening activities to locate portions of the Municipal Separate Storm Sewer System with suspected illicit discharges and improper disposal. Follow-up activities to eliminate illicit discharges and improper disposal may be prioritized on the basis of magnitude and nature of the suspected discharge; sensitivity of the receiving water; and/or other relevant factors. This program shall establish priorities and schedules for screening the entire Municipal Separate Storm Sewer System at least once per five years. The permittee(s) shall utilize a consistent method (e.g. by land area, by outfall, etc.) for determining the percentage of the municipal separate storm sewer system that has been screened. Facility inspections may be carried out in conjunction with other municipal programs (e.g. pretreatment inspections of industrial users, health inspections, fire inspections, etc.), but must include random inspections for facilities not normally visited by the municipality.

f. Each permittee shall require the elimination of illicit discharges and improper disposal practices as expeditiously as reasonably possible. Where elimination of an illicit discharge within thirty (30) days is not possible, the permittee shall require an expeditious schedule for removal of the discharge. In the interim, the permittee shall require the operator of the illicit discharge to take all reasonable and prudent measures to minimize the discharge of pollutants to the Municipal Separate Storm Sewer System.

g. The permittee(s) shall maintain, and update as necessary, a list of discharges to municipal separate storm sewers that has been issued a NPDES permit. The list shall include the name, location and NPDES permit number of the discharger.

7. *Spill Prevention and Response:* A program to prevent, contain, and respond to spills that may discharge into the Municipal Separate Storm Sewer System shall be implemented. The spill response program may include a combination of spill response actions by the permittee(s) (and/or another public or private entity), and legal requirements for private entities within the permittee's municipal jurisdiction.

8. *Industrial & High Risk Runoff:* A program to identify and control pollutants in storm water discharges to the Municipal Separate Storm Sewer System from municipal landfills; other treatment, storage, or disposal facilities for municipal waste (e.g. transfer stations, incinerators, etc.); hazardous waste treatment, storage, disposal and recovery facilities; facilities that are subject to EPCRA Title III, Section 313; and any other industrial or commercial discharge the permittee(s) determines are contributing a substantial pollutant loading to the Municipal Separate Storm Sewer System shall be implemented. The program shall include:

a. priorities and procedures for inspections and establishing and implementing control measures for such discharges;

b. a monitoring program (Part II.A.11.c.); and

c. a list of industrial storm water sources discharging to the Municipal Separate Storm Sewer System shall be maintained and update as necessary.

9. *Construction Site Runoff:* A program to reduce the discharge of pollutants from constructions sites shall be implemented. This program shall include:

   a. requirements for the use and maintenance of appropriate structural and nonstructural best management practices to reduce pollutants discharged to the Municipal Separate Storm Sewer System during the time construction is underway;

   b. inspection of construction sites and enforcement of control measures (in accordance with priorities and procedures established in the Storm Water Management Program);

   c. appropriate education and training measures for construction site operators; and

   d. notification of appropriate building permit applicants of their potential responsibilities under the NPDES permitting program for construction site runoff.

10. *Public Education:* A public education program with the following elements shall be implemented:

   a. a program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or improper disposal of materials, including floatables, into the Municipal Separate Storm Sewer System;

   b. a program to promote, publicize, and facilitate the proper management and disposal of used motor vehicle fluids and household hazardous wastes.

   c. a program to promote, publicize, and facilitate the proper use, application, and disposal of pesticides, herbicides, and fertilizers by the public and commercial and private applicators and distributors.

11. *Monitoring Programs:* The following monitoring programs shall be implemented in addition to the monitoring required by Part V.:

   a. The *Dry Weather Screening Program* shall continue ongoing efforts to detect the presence of illicit connections and improper discharges to the Municipal Separate Storm Sewer System. All areas of the Municipal Separate Storm Sewer System must be screened at least once during the permit term. Screening methodology may be modified based on experience gained during actual field screening activities and need not conform to the protocol at 40 CFR 122.26(d)(1)(iv)(D). Sample collection and analysis need not conform to the requirements of 40 CFR Part 136. However, samples taken to <u>confirm</u> (e.g. in support of possible legal action) a particular illicit connection or improper disposal practice should conform to the requirements of 40 CFR Part 136.

b. *Wet Weather Screening Program:* The permittee(s) shall identify, investigate, and address areas within their jurisdiction that may be contributing excessive levels of pollutants to the Municipal Separate Storm Sewer System. The wet weather screening program:

(1) shall screen the Municipal Separate Storm Sewer System, in accordance with the procedures specified in the Storm Water Management Program.

(2) shall specify the sampling and non-sampling techniques to be used for initial screening and follow-up purposes. Sample collection and analysis need not conform to the requirements of 40 CFR Part 136. However, samples taken to confirm (e.g. in support of possible legal action) a particular discharger is a source of significant quantities of pollutants should conform to the requirements of 40 CFR Part 136.

c. The *Industrial and High Risk Runoff Monitoring Program* shall include monitoring for pollutants in storm water discharges to the Municipal Separate Storm Sewer System from municipal landfills; other treatment, storage, or disposal facilities for municipal waste (e.g. transfer stations, incinerators, etc.); hazardous waste treatment, storage, disposal and recovery facilities; facilities that are subject to EPCRA Title III, Section 313; and any other industrial or commercial discharge the permittee(s) determines are contributing a substantial pollutant loading to the Municipal Separate Storm Sewer System.

(1) Except as provided in (2) below, the monitoring program shall including the collection of quantitative data on the following constituents:

(a) any pollutants limited in an existing NPDES permit for a subject facility;
(b) oil and grease;
(c) chemical oxygen demand (COD);
(d) pH;
(e) biochemical oxygen demand, five-day (BOD_5);
(f) total suspended solids (TSS);
(g) total phosphorous;
(h) total Kjeldahl nitrogen (TKN);
(i) nitrate plus nitrite nitrogen; and
(j) any information on discharges required under 40 CFR 122.21(g)(7)(iii) and (iv).

Data collected by the industrial facility to satisfy the monitoring requirements of an NPDES or State discharge permit may be used to satisfy this requirement. Permittee(s) may require the industrial facility to conduct self-monitoring to satisfy this requirement.

(2) **Alternative Certification:** In lieu of monitoring, the permittee may accept a certification from a facility that raw and waste materials, final and intermediate products, by-products, material handling equipment or activities, industrial machinery or operations, or significant materials from past industrial activity are not presently exposed to storm water and are not expected to be exposed to storm water for the certification period. Where the permittee(s)

accept a "no exposure" certification, the permittee(s) shall conduct at least one site inspection of the facility every five years to verify the "no exposure" exemption.

B. Area-specific Storm Water Management Program Requirements. Reserved.

C. Deadlines for Program Implementation. Except as provided in Part III., full implementation of the Storm Water Management Program shall begin within 90 days from the effective date of the permit.

D. Roles and Responsibilities of Permittee(s). The Storm Water Management Program, together with any attached interagency agreements, shall clearly identify the roles and responsibilities of each permittee.

E. Legal Authority. Each permittee shall ensure legal authority to control discharges to and from those portions the Municipal Separate Storm Sewer System over which it has jurisdiction. This legal authority may be a combination of statute, ordinance, permit, contract, order or inter-jurisdictional agreements with permittees with existing legal authority to:

1. Control the contribution of pollutants to the Municipal Separate Storm Sewer System by Storm Water Discharges Associated with Industrial Activity and the quality of storm water discharged from sites of industrial activity;

2. Prohibit illicit discharges to the Municipal Separate Storm Sewer System;

3. Control the discharge of spills and the dumping or disposal of materials other than storm water (e.g. industrial and commercial wastes, trash, used motor vehicle fluids, leaf litter, grass clippings, animal wastes, etc.) into the Municipal Separate Storm Sewer System;

4. Control through interagency or interjurisdictional agreements among permittees the contribution of pollutants from one portion of the Municipal Separate Storm Sewer System to another;

5. Require compliance with conditions in ordinances, permits, contracts or orders; and

6. Carry out all inspection, surveillance and monitoring procedures necessary to determine compliance with permit conditions.

F. Storm Water Management Program Resources. Each permittee shall provide adequate finances, staff, equipment, and support capabilities to implement their activities under the Storm Water Management Program.

G. Storm Water Management Program Review and Update.

1. *Storm Water Management Program Review:* Each permittee shall participate in an annual review of the current Storm Water Management Program in conjunction with preparation of the annual report required under Part V.C.

2. *Storm Water Management Program Update:* The permittee(s) may change the Storm Water Management Program during the life of the permit in accordance with the following procedures:

   a. The approved Storm Water Management Program shall not be changed by the permittee(s) without the approval of the Director, unless in accordance with Parts II.G.2.b. and 2.c.

b. Changes adding (but not subtracting or replacing) components, controls, or requirements to the Storm Water Management Program may be made by the permittee(s) at any time upon written notification to the Director.

c. Changes replacing an ineffective or unfeasible BMP specifically identified in the Storm Water Management Program with an alternate BMP may be requested at any time. Unless denied by the Director, changes proposed in accordance with the criteria below shall be deemed approved and may be implemented by the permittee(s) 60 days from submittal of the request. Such requests shall include the following:

(1) an analysis of why the BMP is ineffective or infeasible (including cost prohibitive),

(2) expectations on the effectiveness of the replacement BMP, and

(3) an analysis of why the replacement BMP is expected to achieve the goals of the BMP to be replaced.

d. Changes resulting from schedules contained in Part III. may be requested following completion of an interim task or final deadline. Unless denied by the Director, proposed changes meeting the criteria contained in the applicable Part III schedule shall be deemed approved and may be implemented by the permittee(s) 60 days from submittal date.

e. Change requests and/or notifications shall be made in writing, signed in accordance with Part VI.H. by all directly affected permittees, and include a certification that all permittees were given an opportunity to comment on proposed changes.

3. *Updates Required by the Permitting Authority:* The permitting authority may require changes to the Storm Water Management Program as needed to:

a. address impacts on receiving water quality caused, or contributed to, by discharges from the Municipal Separate Storm Sewer System;

b. include more stringent requirements necessary to comply with new State or Federal statutory or regulatory requirements; or

c. include such other conditions deemed necessary by the Director to comply with the goals and requirements of the Act.

Changes requested by the Director shall be made in writing, set forth the time schedule for the permittee(s) to develop the changes, and offer the permittee(s) the opportunity to propose alternative program changes to meet the objective of the requested modification. All changes required by the Director shall be made in accordance with 40 CFR 124.5, 40 CFR 122.62, or as appropriate 40 CFR 122.63.

4. *Transfer of Ownership, Operational Authority, or Responsibility for Storm Water Management Program Implementation:* The permittee(s) shall implement the Storm Water Management Program on all new areas added to their portion of the municipal separate storm sewer system (or for which they become responsible for implementation of storm water quality controls) as expeditiously as practicable, but not later than three years from addition of the new areas. Implementation may be accomplished in a phased manner to allow additional time for controls that cannot be implemented immediately.

   Prior to land annexation, the permittee(s) shall include a schedule for extending the Storm Water Management Program to the annexed areas in the Storm Water Management Program. At least 30 days prior to transfer of operational authority or responsibility for Storm Water Management Program implementation, all parties shall prepare a schedule for transfer of responsibility for Storm Water Management Program implementation on the affected portions of the Municipal Separate Storm Sewer System.

H. **Retention of Storm Water Management Program Records.** The permittee shall retain the Storm Water Management Program developed in accordance with Parts II. and III. for at least 3 years after coverage under this permit terminates.

PART III. SCHEDULES FOR IMPLEMENTATION AND COMPLIANCE

The Permittee(s) shall comply with the following schedules for Storm Water Management Program implementation and augmentation, and permit compliance.

A. Implementation and Augmentation of Storm Water Management Program(s)

STORM WATER MANAGEMENT PROGRAM COMPONENT	ACTIVITY	DATE DUE/FREQUENCY
1. New & Re-Development	a. Adoption of the Storm water Management Criteria Manual or another construction storm water runoff control program.	January 1, 1995
	b. Implementation of the Stormwater Management Criteria or another construction storm water runoff control program.	February 1, 1995
2. Household Hazardous Waste	a. Provide summary of evaluation and assessment of results from various collection/recycling/safe disposal program options, including those currently underway, to determine the most applicable program for long term use which meets criteria specified in b. below.	July 1, 1996
	b. Develop collection/recycling/safe disposal program which includes periodic collection events and should ensure a publicly available drop off location(s) that provides for occasional long weekday hours, or weekend operations.	August 1, 1996
	c. Implement collection/recycling/safe disposal program.	August 1, 1997

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STORM WATER MANAGEMENT PROGRAM COMPONENT	ACTIVITY	DATE DUE/FREQUENCY
3. Floatables	a. Implement public education program.	January 1, 1995
	b. Install two floatables monitoring locations.	May 1, 1995
	c. Complete study for targeting of structural controls and develop schedule for implementation.	May 1, 1996
4. Illicit Discharges and Improper Disposal	a. Implement public education program.	January 1, 1995
	b. Complete dry weather screening of 20% of MS4.	June 1, 1995
	c. Complete dry weather screening of 40% (cumulative) of MS4	June 1, 1996
	d. Complete dry weather screening of 60% (cumulative) of MS4	June 1, 1997
	e. Complete dry weather screening of 80% (cumulative) of MS4	June 1, 1998
	f. Complete dry weather screening of 100% (cumulative) of MS4	June 1, 1999
5. Legal Authority	a. Adopt comprehensive Storm Water Ordinance	July 1, 1996
6. Wet Weather Screening Program	a. Update SWMP to include wet weather screening program.	July 1, 1995
	b. Complete wet weather screening of 50% of MS4.	July 1, 1997
	c. Complete wet weather screening of 100% (cumulative) of MS4.	July 1, 1999

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STORM WATER MANAGEMENT PROGRAM COMPONENT	ACTIVITY	DATE DUE/FREQUENCY
7. Flood Control Projects	a. Complete evaluation of existing flood control structures for feasible water quality retrofit projects.	October 1, 1998
	b. Complete schedule for proposed water quality retrofits to existing flood control structures.	November 1, 1998
8. Industrial and High Risk	a. Develop program to identify, monitor, and control pollutants from targeted facilities	July 1, 1995
	b. Implement program	July 1, 1996
9. Pesticide, Herbicide, and Fertilizer Application	a. Implement annual training/education on pesticide and fertilizer management techniques.	January 1, 1995
	b. Establish requirement for commercial pesticide applicators to be licensed under the Oklahoma Pesticide Applicators Law.	April 1, 1995

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B. **Compliance with effluent limitations.** Reserved.

C. **Reporting compliance with schedules.** No later than 14 days following a date for a specific action (interim milestone or final deadline) identified in the above schedule(s), the permittee(s) shall submit a written notice of compliance or noncompliance to the Director in accordance with Parts V.E.

D. **Updating Storm Water Management Program.** The permittee(s) shall update the Storm Water Management Program(s), as appropriate, in response to changes required by Part III.A. Such updates shall be made in accordance with Part II.G.2.

PART IV. DISCHARGE LIMITATIONS.

...RESERVED...

PART V. MONITORING AND REPORTING REQUIREMENTS.

A. Storm Event Discharges.

1. *Representative Monitoring:* Monitoring shall be conducted on representative outfalls, internal sampling stations, and/or instream monitoring locations to characterize the quality of storm water discharges from the Municipal Separate Storm Sewer System.

   a. Monitoring Requirements: Refer to Table(s) V.A.1.a(1).

   b. Outfall Descriptions: Refer to Table V.A.1.b.

   c. Alternate representative monitoring locations may be substituted for just cause during the term of the permit. Requests for approval of alternate monitoring locations shall be made to the Director in writing and include the rationale for the requested monitoring station relocation. Unless disapproved by the Director, use of an alternate monitoring location (except for outfalls with numeric effluent limitations) may commence 30 days from the date of the request. For outfalls where numeric effluent limitations have been established, the permit must be modified prior to substitution of alternate monitoring locations. Six samples shall be collected during the first year of monitoring at substitute outfalls.

Table V.A.1.a.(1) - Representative Monitoring Requirements: Outfalls 001, 002, 003, 003, 004, & 005

PARAMETERS	REPORT FOR EACH MONITORING PERIOD (each sample type)			SAMPLE TYPE(S)		MONITORING FREQUENCY[1]
	Minimum	Average	Maximum	Grab	Composite	
Biochemical Oxygen Demand (BOD_5) (mg/l)		Yes	Yes		Yes	1/season[2]
Chemical Oxygen Demand (COD) (mg/l)		Yes	Yes		Yes	1/season
Oil and Grease (mg/l)		Yes	Yes	Yes		1/season
Total Suspended Solids (TSS) (mg/l)		Yes	Yes		Yes	1/season
Total Dissolved Solids (TDS) (mg/l)		Yes	Yes		Yes	1/season
Total Nitrogen (mg/l)		Yes	Yes		Yes	1/season
Total Kjeldahl Nitrogen (TKN) (mg/l)		Yes	Yes		Yes	1/season
Total Phosphorus (mg/l)		Yes	Yes		Yes	1/season
Dissolved Phosphorus (mg/l)		Yes	Yes		Yes	1/season
Total Cadmium (ug/l)		Yes	Yes		Yes	1/season
Total Copper (ug/l)		Yes	Yes		Yes	1/season
Total Lead (ug/l)		Yes	Yes		Yes	1/season
Total Zinc (ug/l)		Yes	Yes		Yes	1/season
Fecal Coliform (colonies/100 ml)		Yes	Yes	Yes		1/season
pH (S.U.)	Yes		Yes	Yes		1/season
Hardness (as $CaCO_3$) (mg/l)	Yes	Yes	Yes	Yes		1/season
Temperature (°C)	Yes	Yes	Yes	Yes		1/season

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PARAMETERS	REPORT FOR EACH MONITORING PERIOD (each sample type)			SAMPLE TYPE(S)		MONITORING FREQUENCY[1]
	Minimum	Average	Maximum	Grab	Composite	
Diazinon (ug/l)		Yes	Yes	Yes	Yes	1/season
Total Phenol (mg/l)[3]		Yes	Yes	Yes		1/season

[1] Monitoring frequency for each year unless monitoring under Alternative Bioassessment Option (See Part V.A.2.)
[2] Seasonal monitoring periods are: **July - October, November - February, and March - June.**
[3] Total Phenol shall be monitored only at outfall 002.

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Table V.A.1.b - Representative Monitoring Outfall Descriptions

OUTFALL	LOCATION	DESCRIPTION	RESPONSIBLE PERMITTEE
001	2400 26th Street East, 200 feet west of Lewis Avenue and 5 ft south of 26th Street	100% old residential, drains 39.3 acres	City of Tulsa
002	11th Street (Southwest Blvd.), on the east bank of the Arkansas River, 50 ft north of the old 11th St. Bridge	Old commercial area, drains approximately 14.7 acres	City of Tulsa
003	71st Street East @ Joe Creek, 50 ft. south of 71st Street on the west bank of Joe Creek	100% New Commercial, drains 15.1 acres	City of Tulsa
004	54th Street East @ Mingo Creek, on the west bank of Mingo Creek at the end of 54th Street	100% Industrial, drains 25.0 acres	City of Tulsa
005	9717 58th Street East, directly north of 9717 E. 58th Street on the south bank of Mingo Creek	100% Industrial, drains 23.0 acres	City of Tulsa

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2. *Representative Monitoring - Rapid Bioassessment Option:* The permittee(s) has the option of developing and implementing a rapid bioassessment monitoring program.

   a. The permittee(s) shall obtain all necessary aquatic wildlife collection permits from appropriate State and/or Federal agencies (e.g. State Fish and Game Commission).

   b. Permittee(s) utilizing the rapid bioassessment monitoring option shall conduct monitoring of the separate storm sewer system as described in Part V.A.1., except the monitoring for years 2, 3, and 5 are no longer required. All other requirements of Part V.A.1., A.3., and A.4. (e.g.: samples types, parameters,...) remain unchanged.

   c. If the permittee(s) elects to develop and implement a rapid bioassessment monitoring program, the permittee(s) shall submit an approvable monitoring program to EPA no later than one year from the effective date of this permit. An approvable program must include:

      (1) monitoring of at least two waterbodies receiving storm water discharges from the municipal separate storm sewer system plus a reference site located within the same ecological region as the municipal separate storm sewer system;

      (2) monitoring of each station at least twice per year, with monitoring conducted at essentially the same time periods each year; and

      (3) concurrent (e.g. within a day or two) monitoring of the reference site each time a station located in the receiving waters of the municipal separate storm sewer system is monitored.

      Unless disapproved by the Director within 60 days, a proposed rapid bioassessment monitoring plan meeting the criteria herein shall be deemed approved and the permittee(s) may implement the alternate rapid bioassessment program.

   d. The permittee(s) shall notify the Director and State (addresses provided in Part V.E.), in writing, at least 14 days prior to commencing an alternate rapid bioassessment monitoring program.

3. *Storm Event Data:* For Part V.A.1. and any additional sampling conducted for Part V.A.6., quantitative data shall be collected to estimate pollutant loadings and event mean concentrations for each parameter sampled. Records shall be maintained of all analytical results, the date and duration (in hours) of the storm event(s) sampled; rainfall measurements or estimates (in inches) of the storm event which generated the sampled runoff; the duration (in hours) between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event; and an estimate of the total volume (in gallons) of the discharge sampled.

4. *Sample Type, Collection, and Analysis:* The following requirements apply only to samples collected for Part V.A.1 and any additional sampling conducted for Part V.A.6.

a. For discharges from holding ponds or other impoundments with a retention period greater than 24 hours, (estimated by dividing the volume of the detention pond by the estimated volume of water discharged during the 24 hours previous to the time that the sample is collected) a minimum of one grab sample may be taken.

b. Grab samples taken within the first two hours of discharge shall be used for the analysis (if required) of pH, temperature, cyanide, oil & grease, fecal coliform, fecal streptococcus, total phenols,residual chlorine, and (at the permittee's option) volatile organics. For all other parameters, data shall be reported for flow weighted composite samples of the entire event or, at a minimum, the first three hours of discharge.

c. Samples shall be collected from the discharge resulting from a representative storm event that is greater than 0.1 inches in magnitude and that occurs at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Composite samples may be taken with a continuous sampler or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire discharge or for the first three hours of the discharge, with each aliquot being separated by a minimum period of fifteen minutes.

The required 72 hour storm event interval is waived where the preceding measurable storm event did not result in a measurable discharge. The required 72 hour storm event interval may also be waived where the permittee(s) documents that less than a 72 hour interval is representative for local storm events during the season when sampling is being conducted.

d. Analysis and collection of samples shall be done in accordance the methods specified at 40 CFR Part 136. Where an approved Part 136 method does not exist, any available method may be used unless a particular method or criteria for method selection (such as sensitivity) has been specified in the permit.

5. *Seasonal Loadings and Event Mean Concentrations.* All necessary sampling data shall be collected to provide estimates for each major outfall of seasonal pollutant loadings and event mean concentrations for a representative storm event for the parameters listed in Table V.A.1.a.(1) - Representative Monitoring Requirements. This information may be estimated from the representative monitoring locations and shall take into consideration land uses and drainage areas for the outfall. The estimates of seasonal loadings and event mean concentrations shall be included in the Annual Report for year four of the permit.

B. Floatables Monitoring.

Shall establish two monitoring locations for removal of floatable material in discharges to or from the Municipal Separate Storm Sewer System. Floatable material shall be collected at the frequency necessary for maintenance of the removal devices, but not less that twice per year. The amount of material collected shall be estimated in cubic yards.

C. **Annual Report.** Each permittee shall contribute to the preparation of an annual system-wide report to be submitted by no later than October 15, 1995, and annually thereafter by October 15th in accordance with this permit. The report shall cover the previous year from July 1 to June 30 (with first annual report period beginning on the effective date of the permit) and include the following separate sections, with an overview for the entire Municipal Separate Storm Sewer System and subsections for each permittee:

1. The status of implementing the storm water management program(s) (status of compliance with any schedules established under this permit shall be included in this section);

2. Proposed changes to the storm water management program(s) ;

3. Revisions, if necessary, to the assessments of controls and the fiscal analysis reported in the permit application under 40 CFR 122.26(d)(2)(iv) and (d)(2)(v);

4. A summary of the data, including monitoring data, that is accumulated throughout the reporting year;

5. Annual expenditures for the reporting period, with a breakdown for the major elements of the storm water management program, and the budget for the year following each annual report;

6. A summary describing the number and nature of enforcement actions, inspections, and public education programs; and

7. Identification of water quality improvements or degradation.

Preparation and submittal of a system-wide annual report shall be coordinated by the city of Tulsa. The report shall indicate which, if any, permittees have failed to provide required information on the portions of the Municipal Separate Storm Sewer System for which they are responsible to the core municipality by 45 days prior to the report due date. Joint responsibility for report submission shall be limited to participation in preparation of the overview for the entire system and inclusion of the identity of any permittee who failed to provide input to the annual report. Each individual permittee shall be individually responsible for content of the report relating to the portions of the Municipal Separate Storm Sewer System for which they are responsible and for failure to provide information for the system-wide annual report in a timely manner. Each permittee shall sign and certify the annual report in accordance with Part VI.H. and include a statement or resolution that the permittee's governing body or agency (or delegated representative) has reviewed or been appraised of the content of the Annual Report.

D. **Certification and Signature of Reports.** All reports required by the permit and other information requested by the Director shall be signed and certified in accordance with Part VI.H.

E. **Reporting: Where and When to Submit.**

1. Representative monitoring results (Part V.A.1) obtained during the reporting period running from July 1 to June 30 shall be submitted on Discharge Monitoring Report Form(s) no later than the due date for the annual report required by Part V.C.. The Discharge Monitoring Reports should be submitted along with the Annual Report. A separate Discharge Monitoring Report Form is required for each monitoring period (e.g. season) specified in Part V.A.1.

2. Signed copies of discharge monitoring reports required under Part V., the Annual Report required by Part V.C., and all other reports required herein, shall be submitted to:

U.S. EPA, Region 6
Water Management Division
Enforcement Branch (6W-EA)
1445 Ross Avenue
Dallas, Texas 75202-2733

3. Requests for Storm Water Management Program updates, changes in monitoring locations, or application for an individual permit shall be submitted to:

U.S. EPA, Region 6
Water Management Division (6W-PM)
1445 Ross Avenue
Dallas, Texas 75202-2733

4. Additional Notification. In addition, the permittee(s) shall provide copies of discharge monitoring reports, annual reports, requests for Storm Water Management Program updates or changes in monitoring locations, and all other reports required herein, to:

Program Manager
Oklahoma Department of Environmental Quality
Water Quality Program
1000 N.E. 10th Street, WQS 0207
Oklahoma City, OK 73117-1212

PART VI. STANDARD PERMIT CONDITIONS.

A. **Duty to Comply.** The permittee(s) must comply with all conditions of this permit insofar as those conditions are applicable to each permittee, either individually or jointly. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action; for permit termination, revocation and reissuance, or modification; or for denial of a permit renewal application.

B. **Penalties for Violations of Permit Conditions.**

1. *Criminal Penalties.*

a. Negligent Violations: The Act provides that any person who negligently violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $2,500 nor more than $25,000 per day of violation, or by imprisonment for not more than 1 year, or both.

b. Knowing Violations: The Act provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a fine of not less than $5,000 nor more than $50,000 per day of violation, or by imprisonment for not more than 3 years, or both.

c. Knowing Endangerment: The Act provides that any person who knowingly violates permit conditions implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act and who knows at that time that he is placing another person in imminent danger of death or serious bodily injury is subject to a fine of not more than $250,000, or by imprisonment for not more than 15 years, or both.

d. False Statement: The Act provides that any person who knowingly makes any false material statement, representation, or certification in any application, record, report, plan, or other document filed or required to be maintained under the Act or who knowingly falsifies, tampers with, or renders inaccurate, any monitoring device or method required to be maintained under the Act, shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 2 years, or by both. If a conviction is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or by both. (See Section 309(c)(4) of the Act).

2. *Civil Penalties.* The Act provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to a civil penalty not to exceed $25,000 per day for each violation.

3. *Administrative Penalties.* The Act provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Act is subject to an administrative penalty, as follows:

a. Class I penalty: Not to exceed $10,000 per violation nor shall the maximum amount exceed $25,000.

b. Class II penalty: Not to exceed $10,000 per day for each day during which the violation continues nor shall the maximum amount exceed $125,000.

C. **Duty to Reapply.** If the permittee wishes to continue an activity regulated by this permit after the permit expiration date, the permittee must apply for and obtain a new permit. The application shall be submitted at least 180 days prior to expiration of this permit. The Director may grant permission to submit an application less than 180 days in advance but no later than the permit expiration date. Continuation of expiring permits shall be governed by regulations promulgated at 40 CFR 122.6 and any subsequent amendments.

D. **Need to Halt or Reduce Activity Not a Defense.** It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

E. **Duty to Mitigate.** The permittee(s) shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

F. **Duty to Provide Information.** The permittee(s) shall furnish to the Director, within a time specified by the Director, any information which the Director may request to determine compliance with this permit. The permittee(s) shall also furnish to the Director upon request copies of records required to be kept by this permit.

G. **Other Information.** When the permittee becomes aware that he or she failed to submit any relevant facts or submitted incorrect information in any report to the Director, he or she shall promptly submit such facts or information.

H. **Signatory Requirements.** All Discharge Monitoring Reports, storm water management programs, reports, certifications or information either submitted to the Director or that this permit requires be maintained by the permittee(s), shall be signed by:

1. for a municipality, State, or other public agency: by either a principal executive officer or ranking elected official; or

2. a duly authorized representative of that person. A person is a duly authorized representative only if:

   a. The authorization is made in writing by a person described above and submitted to the Director.

   b. The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity, such as the position of manager, operator, superintendent, or position of equivalent responsibility or an individual or position having overall responsibility for environmental matters for the company. A duly authorized representative may thus be either a named individual or any individual occupying a named position.

   c. If an authorization is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new written authorization satisfying the requirements of this paragraph must be submitted to the Director prior to or together with

any reports, information, or applications to be signed by an authorized representative.

3. Certification: Any person signing documents under this section shall make the following certification: "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

I. Penalties for Falsification of Monitoring Systems. The Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by fines and imprisonment described in Section 309 of the Act.

J. Oil and Hazardous Substance Liability. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under section 311 of the Act or section 106 of CERCLA.

K. Property Rights. The issuance of this permit does not convey any property rights of any sort, nor any exclusive privileges, nor does it authorize any injury to private property nor any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

L. Severability. The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

M. Requiring a Separate Permit.

1. The Director may require any co-permittee authorized by this permit to obtain a separate NPDES permit. Any interested person may petition the Director to take action under this paragraph. The Director may require any co-permittee authorized to discharge under this permit to apply for a separate NPDES permit only if the co-permittee has been notified in writing that a permit application is required. This notice shall include a brief statement of the reasons for this decision, an application form (as necessary), a statement setting a deadline for the co-permittee to file the application, and a statement that on the effective date of the separate NPDES permit, coverage under this permit shall automatically terminate. Separate permit applications shall be submitted to the address shown in Part V.E. The Director may grant additional time to submit the application upon request of the applicant. If an owner or operator fails to submit in a timely manner a separate NPDES permit application as required by the Director, then the applicability of this permit to the co-permittee is automatically terminated at the end of the day specified for application submittal.

2. Any co-permittee authorized by this permit may request to be excluded from the coverage of this permit by applying for an separate permit. The co-permittee shall submit a separate application as specified by 40 CFR 122.26(d) with reasons supporting the request to the Director. Separate permit applications shall be submitted to the address shown in Part V.E. The request may be granted by the issuance of a separate permit if the reasons cited by the co-permittee are adequate to support the request.

N. State/Environmental Laws.

1. Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable State law or regulation under authority preserved by section 510 of the Act.

2. No condition of this permit shall release the permittee from any responsibility or requirements under other environmental statutes or regulations.

O. Proper Operation and Maintenance. The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit and with the requirements of storm water management programs. Proper operation and maintenance also includes adequate laboratory controls and appropriate quality assurance procedures. Proper operation and maintenance requires the operation of backup or auxiliary facilities or similar systems, installed by a permittee only when necessary to achieve compliance with the conditions of the permit.

P. Monitoring and Records.

1. Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.

2. The permittee shall retain records of all monitoring information including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation, copies of the reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of the sample, measurement, report or application. This period may be extended by request of the Director at any time.

3. Records of monitoring information shall include:

a. The date, exact place, and time of sampling or measurements;

b. The initials or name(s) of the individual(s) who performed the sampling or measurements;

c. The date(s) analyses were performed;

d. The time(s) analyses were initiated;

e. The initials or name(s) of the individual(s) who performed the analyses;

f. References and written procedures, when available, for the

analytical techniques or methods used; and

g. The results of such analyses, including the bench sheets, instrument readouts, computer disks or tapes, etc., used to determine these results.

Q. Monitoring Methods. Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit.

R. Inspection and Entry. The permittee shall allow the Director or an authorized representative of EPA, or the State, upon the presentation of credentials and other documents as may be required by law, to:

1. Enter the permittee's premises where a regulated facility or activity is located or conducted or where records must be kept under the conditions of this permit;

2. Have access to and copy at reasonable times, any records that must be kept under the conditions of this permit;

3. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

4. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Act, any substance or parameters at any location.

S. Permit Actions. This permit may be modified, revoked and reissued, or terminated for cause. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance does not stay any permit condition.

T. Additional Monitoring by the permittee. If the permittee monitor more frequently than required by this permit, using test procedures approved under 40 CFR Part 136 or as specified in this permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the Discharge Monitoring Report (DMR). Such increased monitoring frequency shall also be indicated on the DMR.

PART VII. PERMIT MODIFICATION.

A. **Modification of the Permit.** The permit may be reopened and modified during the life of the permit to address:

1. changes in the State's Water Quality Management Plan, including Water Quality Standards;

2. changes in State or Federal statutes or regulations;

3. add a new permittee who is the owner or operator of a portion of the Municipal Separate Storm Sewer System;

4. changes in portions of the Storm Water Management Program that are considered permit conditions; or

5. other modifications deemed necessary by the Director to meet the requirements of the Clean Water Act.

All modification to the permit will be made in accordance with 40 CFR 122.62, 122.63, and 124.5.

B. **Termination of Coverage for a Single Permittee.** Permit coverage may be terminated, in accordance with the provisions of 40 CFR 122.64 and 124.5, for a single permittee without terminating coverage for other permittees.

C. **Modification of Storm Water Management Program(s).** Only those portions of the Storm Water Management Programs specifically required as permit conditions shall be subject to the modification requirements of 40 CFR 124.5. Replacement of an ineffective or infeasible BMP implementing a required component of the Storm Water Management Program with an alternate BMP expected to achieve the goals of the original BMP shall be considered minor changes to the Storm Water Management Program (as described in Part II.G.2.b. and 2.c.) and not modifications to the permit.

D. **Changes in Monitoring Outfalls.** Changes in monitoring outfalls, other than those with specific numeric effluent limitations (as described in Part V.A.1.c.), shall be considered minor modifications to the permit and will be made in accordance with the procedures at 40 CFR 122.63.

PART VIII. DEFINITIONS.

All definition contained in Section 502 of the Act shall apply to this permit and are incorporated herein by reference. Unless otherwise specified, additional definitions of words or phrases used in this permit are as follows:

A. "Best Management Practices" ("BMPs") means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the United States. BMPs also include treatment requirements, operating procedures, and practices to control facility site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

B. "CWA" or "The Act" means Clean Water Act (formerly referred to as the Federal Water Pollution Control Act or Federal Water Pollution Control Act Amendments of 1972) Pub.L. 92-500, as amended Pub. L. 95-217, Pub. L. 95-576, Pub. L. 96-483 and Pub. L. 97-117, 33 U.S.C. 1251 et.seq.

C. "Co-permittee" is defined at 40 CFR 122.26(b)(1).

D. "Core Municipality" means, for the purpose of this permit, the municipality whose corporate boundary (unincorporated area for counties and parishes) defines the municipal separate storm sewer system. (ex. City of Dallas for the Dallas Municipal Separate Storm Sewer System, Harris County for unincorporated Harris County).

E. "Director" means the Regional Administrator or an authorized representative.

F. "Discharge" for the purpose of this permit, unless indicated otherwise, refers to discharges from the Municipal Separate Storm Sewer System (Municipal Separate Storm Sewer System).

G. "Flow-weighted composite sample" means a composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

H. "Illicit connection" means any man-made conveyance connecting an illicit discharge directly to a municipal separate storm sewer.

I. "Illicit discharge" is defined at 40 CFR 122.26(b)(2).

J. "Individual Residence" refers, for the purposes of this permit, to single or multi-family residences. (e.g. single family homes and duplexes, townhomes, apartments, etc.)

K. "Landfill" means an area of land or an excavation in which wastes are placed for permanent disposal, and which is not a land application unit, surface impoundment, injection well, or waste pile.

L. "Land application unit" means an area where wastes are applied onto or incorporated into the soil surface (excluding manure spreading operations) for treatment or disposal.

M. "Large or medium municipal separate storm sewer system" is defined at 40 CFR 122.26(b)(4) & (7).

N. "MEP" is an acronym for "Maximum Extent Practicable," the technology-based discharge standard for Municipal Separate Storm Sewer Systems established by CWA §402(p).

O. "MS4" is an acronym for "Municipal Separate Storm Sewer System" and is

used to refer to either a Large or Medium Municipal Separate Storm Sewer System (e.g. "the Dallas MS4").

P. "Municipal Separate Storm Sewer" is defined at 40 CFR 122.26(b)(8).

Q. "Part '#'" refers, unless otherwise indicated, to Part "#" of this permit (e.g. Part V.E.2.).

R. "Permittee" refers to any "person," as defined at 40 CFR 122.2, authorized by this NPDES permit to discharge to Waters of the United States.

S. "Point Source" means any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharges. This term does not include return flows from irrigated agriculture or agricultural storm water runoff.

T. "Storm sewer", unless otherwise indicated, refers to a municipal separate storm sewer.

U. "Storm Water" means storm water runoff, snow melt runoff, and surface runoff and drainage.

V. "Storm Water Discharge Associated with Industrial Activity" is defined at 40 CFR 122.26(b)(14).

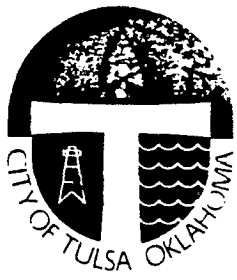
W. "Storm Water Management Program" refers to a comprehensive program to manage the quality of storm water discharged from the municipal separate storm sewer system. For the purposes of this permit, the Storm Water Management Program is considered a single document, but may actually consist of separate programs (e.g. "chapters") for each permittee.

X. "SWMP" is an acronym for "Storm Water Management Program."

Y. "Time-weighted composite" means a composite sample consisting of a mixture of equal volume aliquots collected at a constant time interval.

Z. "Waters of the United States" is defined at 40 CFR 122.2.

ENVIRONMENTAL OPERATIONS
596-9501 (Suite 401)
•
WASTE SYSTEMS
596-9641 (Suite 505)
•
WATER SUPPLY SYSTEMS
596-9648 (Suite 501)
•
WATER DISTRIBUTION SYSTEMS
596-9484
•
UNDERGROUND
COLLECTION SYSTEMS
669-6100
•
QUALITY ASSURANCE
591-4375



DEPARTMENT OF PUBLIC WORKS

707 SOUTH HOUSTON • TULSA, OKLAHOMA •

October 30, 1997

Los Angeles Regional Water Quality Control Board
101 Center Plaza Drive
Monterey Park, CA 91754

Attention: Dan Radulescu

RE: Information of City of Tulsa storm water quality programs

Dear Mr. Radulescu:

Here is the information regarding the City of Tulsa's storm water quality programs. I am providing you this information freely with the condition that you provide me with information targeting municipal storm water quality programs in your region. I am always interested in comparing Tulsa's programs to those from other regions . This information may be used to make improvements to existing programs.

If you have any questions or comments please feel free to contact me at (918) 591-4379.

Sincerely,

Scott D. VanLoo
Environmental Compliance Specialist

SV/alm

cc: M. Slaughter
D. Wilson

R0012953

ANNUAL REPORT

Municipal Storm Water Discharge Permit #OKS000201

for the period of
July 1, 1996 - June 30, 1997

City of Tulsa, OK
Oklahoma Department of Transportation
Oklahoma Turnpike Authority

prepared by:
City of Tulsa, Environmental Services

R0012954

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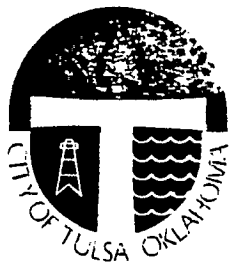
ENVIRONMENTAL OPERATIONS
596-9501 (Suite 401)
•
WASTE SYSTEMS
596-9841 (Suite 505)
•
WATER SUPPLY SYSTEMS
596-9848 (Suite 501)
•
WATER DISTRIBUTION SYSTEMS
596-9484
•
UNDERGROUND
COLLECTION SYSTEMS
669-6100
•
QUALITY ASSURANCE
591-4375



DEPARTMENT OF PUBLIC WORKS

707 SOUTH HOUSTON • TULSA OKLAHOMA • 74127

October 13, 1997

Oklahoma Department of Environmental Quality
Dave Farrington
Water Quality Division
1000 N.E. 10th Street
Oklahoma City, OK 73117-1212

Dear Mr. Farrington:

Enclosed is the Annual Report for the NPDES Municipal Storm Water Discharge Permit #OKS000201 for the period of July 1, 1996, through June 30, 1997. Further, "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

If you have any questions regarding this submittal, please contact me at (918)591-4378.

Sincerely,

Douglas E. Wilson
Environmental Monitoring Manager

DEW:alm

Attachments

cc: Charles Hardt
Marsha Slaughter

R0012956

OKLAHOMA DEPARTMENT OF TRANSPORTATION
200 N. E. 21st Street
Oklahoma City, OK 73105-3204

September 24, 1997

Oklahoma Department of Environmental Quality
Dave Farrington
Water Quality Division
1000 NE 10th Street
Oklahoma City, OK 73117-1212

Dear Mr. Farrington:

Enclosed is the City of Tulsa's Annual Report for the NPDES Municipal Storm Water Discharge Permit #OKS000201 for the period of July 1, 1996 through June 30, 1997. Further, "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

If you have any questions regarding this submittal, please contact Ms Dawn Sullivan at (405)521-2515.

Sincerely,

Bruce E. Taylor, P.E.
Chief Engineer

BT:TGM:DRS

AN EQUAL OPPORTUNITY EMPLOYER

OKLAHOMA TURNPIKE AUTHORITY

3500 Martin Luther King Avenue ◦ P.O. Box 11357 ◦ Oklahoma City, Oklahoma 73136-0357 ◦ (405) 425-3600
Fax (405) 427-8246

October 13, 1997

Oklahoma Department of Environmental Quality
Dave Farrington
Water Quality Division
1000 NE 10th Street
Oklahoma City, OK 73117-1212

Dear Mr. Farrington:

Enclosed is the Annual Report for the NPDES Municipal Storm Water Discharge Permit #OKS000201 for the period of July 1, 1996 through June 30, 1997. Further, "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who managed the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

If you have any questions regarding this submittal, please contact Mr. Gary R. Broyles at (405) 425-3600.

Very truly yours,

Gary R. Broyles

Gary R. Broyles, P.E.
Division Engineer

copy: OTA Engineering Files

Governor Frank Keating, Member Ex-Officio • Fred J. Hall, Chairman • Francis Rooney, Vice Chairman
Steve LaForge, Secretary & Treasurer • Judy Curtis, Member • Robert M. Kane, Member
Albert C. Kelly, Jr., Member • Neal A. McCaleb, Director

1. ***The status of implementing the storm water management program(s) (status of compliance with any schedules established under this permit shall be included in this Section).***

The storm water management program (Part II) of the City of Tulsa's municipal storm water discharge permit consists of eleven separate programs. In order to effectively address the status of each program, each program will be addressed individually.

Part II(A)(1) Structural Controls and Storm Water Collection System Operation

The City of Tulsa's storm water management program includes provisions for the maintenance of both above and below ground structural storm water controls including detention ponds, inlets, conduits and channels. The purpose of this program is to assure proper operation of these structural controls for better control of storm water runoff and improved water quality. The following table is an inventory of the work performed on those structures during this reporting period.

Maintenance of Storm Water Structural Controls

Channels/Streams/ Detention Ponds	1,116 acres	mowing	12 x/year of mowable property
Channels/Streams/ Detention Ponds	1,452 acres	weed control (herbicide)	All parcels 1x/year for broad leaf weed control, and 336 acres 4x/year for growth control
Channels/Streams/ Detention Ponds	1,800 acres	cleaning	3,255 cubic yards/period
		siltation removal (roadside ditching)	195,237 linear feet/period
		siltation removal (ponds/streams)	36,549 linear feet/period
Storm Sewer Pipes	1,200 miles	inspect flush/clean repair or replace	1.66 miles/period 1.82 miles/period 141 units/period
Catch Basin/Inlets	47,000 units	inspect & clean repair	5,360 units/period 318 units/period
Pump Stations	6 units	clean interior, inspect. & maintain	1,663 maintenance activities/period

R0012959

Part II(A)(2) Areas of New Development and Significant Redevelopment

The Stormwater Management Criteria Manual (adopted in 1994) is a comprehensive manual designed to assist engineers, designers and construction operators in all aspects of storm water runoff control before, during and after construction activities are complete. This includes both water quality and quantity. This manual is utilized by Projects Administration of the Public Works Department as well as site development engineers during the design and review phases of all new developments and significant redevelopment projects that occur within the City of Tulsa. Additionally, the Watershed Development Regulations (Title 11-A, Ordinance #16959) list the current practices regarding regulation of new development and significant redevelopment for the control of storm water runoff rates and quality.

During this reporting period, anyone planning to develop or redevelop areas of Tulsa followed an extensive planning, designing and review process with the City of Tulsa. This insured the area targeted for development met all city requirements, including reducing the discharges of pollutants during and after construction was completed. This process involved Project Administration, Development Services, Field Engineering and Design Engineering of the City of Tulsa and focused attention on storm water quality.

Part II(A)(3) Roadways

The Street Maintenance Section of the Public Works Department, through the utilization of private contractors, swept arterial streets 8 times removing 5,049 cubic yards of debris from a total of 3,948 miles during this reporting period. Emphasis was placed on sweeping after deicing material was no longer required as a result of a snow or ice event. Residential streets were swept 4 times removing 14,378 cubic yards of debris from a total 6,700 miles during this reporting period. Site Specific Hourly Sweeping involved 433 hours. Expressway sweeping for the Oklahoma Department of Transportation (ODOT) totaled 191 miles removing 1,427 cubic yards of material.

Also, the removal of trash was performed on all city street right-of-ways prior to mowing. The specifics of this task is discussed in Part II(A)(6)(c) Floatables.

Part II(A)(4) Flood Control Projects

The Projects Administration group of Tulsa's Public Works Department performed project design review of 19 major flood management projects designed during this reporting period. This included a determination of whether all criteria established by the city's Stormwater Management Criteria Manual had been met or exceeded including consideration of existing water quality. Where possible, water quality treatment principles were incorporated into the design of these flood control projects.

R0012960

Part II(A)(5) Pesticide, Herbicide and Fertilizer Application

The application of pesticides, herbicides and fertilizers was performed by the City of Tulsa's Public Works Department and the Park and Recreation Department. The City of Tulsa required all city employed pesticide applicators as well as all contract applicators to be licensed and subject to all of the regulations under the Oklahoma Pesticide Applicators Law. Surface Drainage & Vegetation Maintenance personnel of the Public Works Department that applied pesticides, herbicides and fertilizers received in-house training during this reporting period. Parks and Recreation Department employees that applied pesticides, herbicides and fertilizers received annual training. In addition, workshops and conferences were held on the proper application and disposal.

The City of Tulsa Community Affairs Section began work on a brochure which addresses the proper application and disposal of pesticides, herbicides and fertilizers during this period. This brochure's target audience is the public and is expected to be finalized during the reporting period of 97/98.

Through the continuation of two City of Tulsa sponsored household pollutant collection events held during this reporting period 11,801 lbs. pesticides/poisons were collected from the public and disposed of in an environmentally friendly manner.

ODOT has 16 certified applicators that apply pesticides, herbicides and fertilizers in the Tulsa area. Each applicator attended annual training that instructed them on the proper use, application and disposal of pesticides, herbicides and fertilizers.

Part II(A)(6) Illicit Discharge and Improper Disposal

a.) Non-storm water discharges

The Quality Assurance Section of the city's Public Works Department performed 208 investigations that involved possible illicit discharges to the storm and sanitary sewer during this reporting period. Ordinance #18588 was adopted during the 94/95 reporting period and continues to be utilized for the removal of non-storm water discharges through enforcement actions (see Section 6, "Summary of Enforcement Actions, Inspections, and Public Education").

Once an illicit discharge was identified, the responsible party was required to either stop the discharge, redirect the discharge to the sanitary sewer or obtain an NPDES waste water discharge permit from the Oklahoma Department of Environmental Quality/U.S. EPA. The reporting of illicit discharges and improper disposal to the storm sewer system was reported to the Quality Assurance Section by concerned citizens (via the Mayors Action Center or directly from a citizen), other city departments and government agencies.

R0012961

b.) Sanitary sewer overflows

In a continuing effort to eliminate sanitary sewer overflows during this reporting period the city's Engineering Services Section contracted with consulting engineers to conduct sanitary sewer evaluation surveys in several drainage areas and have let several construction contracts for rehabilitation of manholes, sanitary sewer lines and construction of sanitary sewer relief lines. In addition, Engineering Services is currently evaluating the construction of two flow equalization basins in the Flatrock and Coal creek drainage basins.

As addressed earlier in Part II(A)(1), Tulsa's Underground Collection Section continues to utilize aggressive inspection, repair and cleaning programs for the sanitary sewer system in order to eliminate sanitary overflows. The following items were performed under the supervision of Underground Collections during this reporting period:

- Five homes with sanitary sewer discharges to the storm sewer were identified. Per city direction, these home owners are now in the process of repairing defective plumbing and connecting to the sanitary sewer.
- At the intersection of 8th & Cheyenne a city sanitary sewer line cross connection to the storm sewer was located and corrected.
- A city contractor identified and corrected 95 cross connections between the storm and sanitary sewers while performing a sanitary sewer evaluation survey in the Coal creek drainage basin.

c.) Floatables

Tulsa has taken a very aggressive approach toward floatable control. Utilization of existing programs has had an impact on reducing litter. The "Pride in Tulsa" organization is instrumental in a series of programs which target litter control, such as:

- Operation Cleansweep, April 20-27, 1997 (20,000 people remove litter at various sites in Tulsa),
- Environmental Summit (educational program for middle and high school aged children),
- Pride Partners (area businesses who take pride in Tulsa through donations, clean-ups and recycling), and
- Free dump days at the landfill.

The Metropolitan Environmental Trust (M.e.t.) was also responsible for many of these activities planned around Earth Day, through their planning and performance. The M.e.t. created and maintains a web page for recycling at address WWW.WEBTEK.COM/METRECYCLE. The M.e.t also operates 12 recycling depots giving citizens accessible locations for the collection of materials for recycling. These items include plastics, paper products, glass, aluminum, batteries, oil and antifreeze. They are also used for the distribution of environmental educational information. See "Collection of Used Motor Vehicle Fluids and Household Hazardous Wastes" for data concerning this program.

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The city's Community Affairs Section utilized utility bill stuffers and pamphlets to educate the public regarding their responsibility to reduce floatable pollution in storm water runoff. Data was obtained by Surface Drainage & Vegetative Management during this reporting period regarding floatable make-up and quantity through the use of two floatable monitoring locations (see Section 4-Monitoring Data).

Through assistance from the Oklahoma Turnpike Authority, Oklahoma Department of Environmental Quality and Oklahoma Tourism and Recreation Department, Oklahoma Department of Transportation (ODOT) reinstated the "Don't Lay that Trash on Oklahoma" anti-litter campaign at a state wide cost of $350,000. The ODOT, at a cost of 1.1 million dollars, began the development of a heavily publicized anti-litter campaign called "Oklahoma, Keep Our Land Grand"during this reporting period. This program is scheduled to begin during the summer of 1997 and will utilize TV, radio, highway signs and other advertisements. Additionally, ODOT held the ninth annual "Trash Off" Day in Tulsa on April 12. Other clean-up efforts which were utilized included the "Adopt a Highway" which included 20 groups in the permit area and inmate litter removal.

The City of Tulsa's Park and Recreation Department emptied approximately 450 trash containers placed at 120 parks and 25 storm water detention sites 2 to 3 times per week. The pickup frequency was reduced slightly during the off season. Fifty two dumpster type containers at 38 park sites were also emptied weekly by the City's Waste Systems Section. Trash containers were placed in parks to serve special events and scheduled activities. In addition, Park and Recreation Department maintenance crews picked up loose trash from parks as needed.

The Street Maintenance Section of the City of Tulsa continued to utilize litter crews which removed approximately 107,000 bags of litter from expressways and streets during this reporting period. These crews consisted of inmate work crews and city private contractors.

d.) Collection of used motor vehicle fluids and household hazardous wastes

The city continues to support the M.e.t.'s recycling depots which accept oil, antifreeze and batteries, as well as other recyclable materials. All depots are accessible to the public 24 hours per day, 7 days per week and are located in areas that are easily accessible to the public. The amount of material received by these depots for the last fiscal year of July 1, 1996 through June 30, 1997 can be found on the following table:

oil	46,015 gals.
antifreeze	3,757 gals.
plastics	293,857 lbs.
aluminum	135,020 lbs.
glass	1,158,458 lbs.
batteries	58,709 lbs.
newspaper	6,161,378 lbs.
magizines	718,879 lbs.

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The city sponsored two household pollutant collection events during this reporting period. They were both held on a weekend. The event dates were October 26 & 27, 1996 and April 5 & 6, 1997. Both events were a success with 6,575 gallons of oil, 505 gallons of antifreeze, 33,827 cans of paint and 17,530 pounds of flammable liquid collected from 4,180 participants. Thousands of pounds of other household hazardous wastes were brought to the events and thereby removed from the waste stream. These programs were also used to distribute educational material to the public regarding locations of the recycling depots, and environmentally friendly alternatives for chemicals used in the household.

These programs were so successful that two events are planned for the reporting year of 97-98.

In a continued effort to develop and implement the most effective household hazardous waste collection program given limited resources, the City of Tulsa, through the M.e.t., held a permanent location household hazardous waste pilot program from March 15 through May 31, 1997. This pilot program had varying hours of operations which included weekdays and extended weekends. This program was a success due to the fact that alot of important information was obtained including:

- The handling and disposal of household hazardous waste can be change as long as it is recled or safely disposed.
- Facility use or disposal charge is not a popular idea.;
- The scheduling for the disposal of material by each participant is not necessary.
- It is more desirable to dispose of the material at the next bi-annual household pollutant collection event rather than immediately.

As a result and given the fact that the current programs are very successful, no permanent household pollutant collection facility is planned for establishment in the near future.

e.) Locate and eliminate illicit discharges and improper disposal

The Quality Assurance Section of the Public Works Department performed dry weather field screening on over 14% (264 outfalls) of the City of Tulsa's storm sewer system during the reporting period of June 1, 1996 through May 31, 1997. This brought the total permit area screened to 63.2% (413 outfalls) since the beginning of this program in October of 1994.

The City of Tulsa is compliant with the compliance schedule for the complete dry weather field screening of the entire permit coverage area by June 1, 1999.

The Underground Collections Section (UCS) of the city's Public Works Department continued efforts to locate sanitary and storm sewer cross connections during this reporting period. This was accomplished through the use of TV inspection and smoke testing techniques. Additional work completed during the fiscal year of 96-97 included:

352,757 feet of sanitary sewer TV inspected
8,765 feet of storm sewer TV inspected
123 storm and sanitary manholes raised to grade

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141 main line storm sewer repairs
325 main line sanitary sewer repairs

In most cases, these repairs result in the elimination of storm water infiltrating into the sanitary sewer which helps to reduce overflows or illicit discharges to the storm sewer from the sanitary sewer. In either case, the repairs resulted in the improvement of storm water quality.

Rehabilitation projects supplemented UCS efforts by correcting known storm sewer problem areas that were primarily structurally related (see b. Sanitary Sewer Overflows).

As previously mentioned, the investigation/complaint procedures used by the city's Quality Assurance Section have been very effective in locating illicit discharges and improper disposal practices during this reporting period/season (see "Public Education - Public reporting of illicit discharges and improper disposal").

f.) Removal of illicit discharges

Once illicit discharges are located by Quality Assurance, the responsible party is required to halt the discharge, redirect the discharge to the sanitary sewer or obtain an NPDES wastewater discharge permit from the U.S. EPA. The responsible party is given 30 days to comply. If compliance could not be attained by the party within 30 days, enforcement action in the form of an expeditious schedule of compliance was taken. With the adoption of the Ordinance #18588, the Quality Assurance Section placed nine parties on compliance schedules. The result was full compliance for all nine parties.

g.) Maintain a list of NPDES permit holders within the City of Tulsa

The Quality Assurance Section maintains a list of NPDES industrial storm water and wastewater permit holders which operate within the city limits. This list includes the name, location, and NPDES permit number, as well as contact person, SIC codes, and other pertinent information for each NPDES permit holder. This information is obtained during inspections and is updated regularly. The Customer Services Division of the City of Tulsa maintains a list of NPDES construction storm water permit holders. Building permits are not issued for construction sites larger than 5 acres until an NPDES storm water discharge permit has been obtained and a pollution prevention plan is in place.

Part II(A)(7) Spill Prevention and Response

This requirement was met through the coordination of the Tulsa Fire Department (TFD) and their Hazardous Materials unit, along with Tulsa City-County Health Department and the City's Quality Assurance Section. All agencies and city sections responding to spills are required to follow the newly adopted storm water quality ordinance. This ordinance requires the removal of the pollutant rather than flushing of this pollutant into the storm sewer unless there is an immediate threat to life and health.

For this reporting period the Tulsa Fire Department responded to a total of 561 incidents involving spills and/or releases that could potentially threaten the separate storm sewer system. The reported spill incidents from the previous fiscal year 95/96 totaled only 97 spill incidents. This increase is attributed largely to how the TFD has changed the way

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they respond to spills. The Fire Dept. is employing the use of satellite haz-mat companies strategically located within the city's five district response areas. These personnel are trained and equipped to either emulsify or absorb spills if possible. Emulsification is an allowable provision in the storm water quality ordinance if there is an immediate danger to public health and safety. The 95/96 fiscal year figure of 97 spills reflected only those that required a response from the Haz-Mat unit(s) and went beyond the capability of the satellite companies.

Additionally, spill prevention was discussed during each of the 600 sanitary and storm sewer inspections performed by the city's Quality Assurance Section during this reporting period.

Part II(A)(8) Industrial & High Risk Runoff

A program to identify, monitor and control pollutants from municipal landfills; treatment storage and disposal facilities for municipal waste; facilities subject to EPCRA Title III, Section 313 reporting requirements; and any other industrial and commercial discharge the City determines contributes substantial pollutant loading to the City's storm sewer system was implemented during this reporting period. This program contains procedures and priorities for inspections and monitoring, and establishes implementation of control measures for such discharges. A data base of industrial storm water sources discharging to the City's storm sewer was maintained. Six hundred storm water runoff inspections were performed during this reporting period. As a result, nine enforcement actions were taken in order to eliminate illegal or illicit discharges.

This program also allows inspectors to educate owners and operators of industry on the storm water quality regulations and requirements as per Ordinance #18588 and the city's NPDES Municipal Storm Water Discharge Permit.

Part II(A)(9) Construction Site Runoff

This requirement was met by the Customer Services Section (Building Inspections and Development Services) and the Engineering Services Divisions of the city's Public Works Department.

a.) The use and maintenance of structural and nonstructural best management practices (BMPs) to reduce pollutants discharged to the city's storm sewer from construction sites has been achieved through the enforcement of Title 11-A Chapter 3 (Watershed Development Regulations) and the PFPI and building permit. The Development Services Section issued 18 "Earth Change" permits (permits required by developer for any earth change activity within the city that is greater than 1 acre) during this reporting period. These permits require the operator to have adequate erosion control measures in place and maintained throughout the life of the project. Prior to receiving an earth change permit, applicants were required to submit an executable NOI and acceptable storm water pollution prevention plan for all sites disturbing at least 5 acres.

b.) The Public Works Department inspected 21,505 construction sites during this reporting period. Of those, Customer Services performed 21,424 (14,028 commercial and 7,396 residential) and Engineering Services performed 81. Appropriate structural

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and nonstructural erosion control measures (BMPs) were inspected during these aforementioned site inspections. If the existing erosion control methods were inadequate, additional structural or nonstructural BMPs were required. Approximately five percent of the inspections performed by Customer Services resulted in some type of enforcement action during this reporting period, while approximately 20 notices of violations were issued by Engineering Services. All violation notices issued by Engineering Services consisted of a statement of the violation along with a time period for correction.

Inspections were performed by both the Customer Services and Engineering Services Divisions of the Public Works Department as a result of both scheduling and citizen complaints.

c.) On April 7, 1997 the Blue Thumb Project sponsored a meeting at the Tulsa Metropolitan Home Builders Association which involved builders and contractors from the Tulsa area. Guest speakers included EPA officials, Bob Reeves and Thea Lomax. Current NPDES storm water regulations that pertain to construction sites were discussed.

On April 19, 1997, representatives from the city's Public Works Department gave presentations to area builders, developers and contractors. The meeting focused on the recently announced changes in the EPA erosion control regulations and how they would apply to developing and building in the City of Tulsa.

An ODOT committee drafted a manual called "ODOT Storm Water Management Guidelines for Design and Construction Activities" during this reporting period. This manual focuses on upgrading erosion control practices both as how they are specified on the construction plans and how these practices are applied in the field. Distribution and implementation is scheduled for the Fall of 1997.

ODOT sponsored a two day long course on erosion and sediment control. This training targeted the project level inspectors, project engineers, designers, contractors, foreman, superintendents and other project personnel. The content of the course included storm water runoff, sediment and erosion control, construction site stabilization, pollution prevention plans and related subjects as they apply to highway and bridge construction. This course was first held in October and was attended by approximately 100 people.

d.) The City of Tulsa's Engineering Services constructed 24 storm water pollution prevention plans for city operated construction sites, such as capital improvements, during this reporting period.

Additionally, the notification of the building permit applicants of their responsibility under the NPDES permitting program was also accomplished during the building permit application review process by the Development Services Section. Through the platting process and the privately financed public improvements, Development Services screened proposed developments to determine the appropriate compliance requirements and notified the applicants of those requirements, including NPDES erosion and sediment control requirements, prior to issuing building permits.

Development Services provided both the summary guidance and the full manual of EPA published guidance books Storm Water Management for Construction Activities - Developing Pollution Prevention Plans and Best Management Practices to assist developers and design engineers in the preparation of a storm water pollution prevention plans. Anyone required to obtain an NPDES storm water discharge permit submitted a

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storm water pollution prevention plan along with an executed NOI to Development Services for review prior to receiving a watershed development permit. During the review process of the storm water pollution prevention plan, Development Services utilized the EPA Construction General Permit Requirements Preconstruction Checklist. The Homerville example, found in the EPA's Storm Water Management For Construction Activities guidance manual, was used as guidance for construction storm water pollution prevention plans.

Part II(A)(10) Public Education

Educating the public on the prevention of pollution at the source as well as what is required by the city's municipal storm water discharge permit has been the focus of several of our efforts. This required the involvement of Community Affairs and Quality Assurance Sections as well as the Metropolitan Environmental Trust and the Blue Thumb Project during this reporting period. Public education was accomplished through the distribution of educational material, public speaking and sponsoring of city wide environmental awareness events on numerous topics which relate to the city's storm water permit.

The Blue Thumb Program continues to be an important part of Tulsa's public education for non-point source pollution. This EPA funded program is coordinated by the OSU Cooperative Extension and Tulsa County Conservation District. The program's goal is to make the citizens of Tulsa aware of non-point source pollution and to encourage the adoption of practices that protect Tulsa's urban watersheds. This program has greatly contributed to the education of the public through the organization and training of citizen watershed monitoring groups, monthly newsletters called "Blue Thumb Prints" and "Data Dip Net", organization and sponsorship of an annual resource management conference and local creek clean-up, supervision of an aggressive storm sewer stenciling program and numerous non-point source demonstrations at area schools.

The M.e.t. created numerous pamphlets and other material which focused on the proper management and disposal of commonly generated household pollutants. These pamphlets are distributed to the public at various locations and events throughout the Tulsa metropolitan area.

a.) Public reporting of illicit discharges and improper disposal

Several publications created by the Community Affairs Section of the City of Tulsa, asked citizens to be observant and immediately report illegal or illicit discharges to the Mayors Action Center. These publications included numerous utility bill stuffers (City Life), pamphlets ("1996 Regulatory Floodplain Guide" and "1997 Official Notices of Flood Hazard") and City News articles. Additionally, during numerous public speaking engagements by City of Tulsa personnel, invitations were extended for citizens to call the Mayors Action Center to report any unusual or illegal discharges to the city's storm sewer.

Other assistance came from the Blue Thumb Program which developed brochures stating "Report any illegal dumping to the city of Tulsa Public Works Department" and includes telephone numbers to report 24 hour a day. These brochures were placed in areas

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regularly accessible to the public such as all thirteen recycling depots, the household pollutant collection events, City Hall and various locations.

Increased public education on the reporting of illicit discharges and improper disposal has resulted in Quality Assurance performing an average of 247 investigations each of the last two reporting periods versus 147 during the first year of the permit. This has resulted in an average increase of 160% in the number of investigations in the last two reporting periods

While performing inspections, Quality Assurance personnel informed citizens to report any unusual discharge into the city's storm sewer to the Quality Assurance Section or the Mayors Action Center immediately.

On October 12, 1996, the city's Underground Collections Section had a booth at Safe Kids Fall Fire and Safety Extravaganza Day. During both activities educational material was distributed regarding not only the unsafe practice of playing in the sewer system but also illegal dumping into the storm sewer.

b.) Proper management and disposal of used motor vehicle fluids

Public education in the area of the proper management and disposal of used motor vehicle fluids was accomplished through the creation of utility bill stuffers in conjunction with the city's household pollutant collection events by the Community Affairs Section.

Also, the Blue Thumb Program's stenciling of approximately 643 storm sewer inlets during this reporting period is important because storm sewer inlets appear to be the main discharge point of used motor vehicle fluids into the storm sewer.

The M.e.t. created and distributed numerous pamphlets on the proper management and recycling of many household pollutants including automobile fluids such as oil and antifreeze. These pamphlets are readily available to the public at City Hall, the M.e.t. office, INCOG offices, all thirteen recycling depots and the household pollutant collection events.

c.) Proper use, application, and disposal of pesticides, herbicides and fertilizers

Public education in the proper use, application and disposal of pesticides, herbicides and fertilizers was accomplished during this reporting period through the distribution of pamphlets created by the M.e.t. as well as the numerous notices placed in City Life (utility bill stuffer) by Community Affairs. Community Affairs also created and made available pamphlets which contain information on this educational topic. These pamphlets include the 1996 Guide to Regulatory Floodplains, the 1997 Official Notice Flood Hazard Information mailer and the 1997 Official Notice Repetitive Loss mailer.

Public education about the proper application of pesticides, herbicides and fertilizers was performed during this reporting period by the Oklahoma State University (OSU) Extension Service through their Master Gardeners Program. This program contacted approximately 30,000 residents of Tulsa County. The OSU Extension Service also operated a telephone hotline staffed by trained personnel to answer questions regarding various horticultural issues including the proper application and disposal of pesticides, herbicides and fertilizers. This service is offered five days a week, from 9 a.m. to 4 p.m., and is backed with numerous brochures available to the public. Oklahoma Educational Television Association (OETA) broadcasts the OSU production "Oklahoma Gardening"

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to local residents twice a week. Host, Brenda Simons, consistently emphasizes proper handling, use and disposal of these products to a viewing audience of approximately 60,000 each week. OSU Extension Service will continue these successful programs in to the next reporting period.

Part II(A)(11) Monitoring Programs

All monitoring requirements were met through the continuation of the dry weather field screening program, and the implementation of the wet weather field screening and industrial & high risk runoff programs during this reporting period.

a.) Dry Weather Field Screening

This program has been implemented by the Quality Assurance Section. This program was previously mentioned in this report in Part II(A)(6)(e).

b.) Wet Weather Field Screening

A total of 34 monitoring sites were chosen which represent the watersheds that make up the city's storm sewer system. This program will be used to identify watersheds within the City of Tulsa that may have reduced storm water runoff quality during storm events. A secondary benefit of this program is to gauge the effectiveness of other storm water management programs and implemented best management practices. During this reporting period, 20 of the 34 wet weather field screening sites were monitored. All the analyses were completed in accordance with 40 CFR Part 136 and will be reviewed during the next reporting period.

Baseline monitoring of all 34 monitoring sites has begun. This will give the City of Tulsa a baseline for water quality during normal flow conditions.

c.) Industrial & High Risk Runoff

The Industrial & High Risk Runoff monitoring began during this reporting period. This monitoring took the form of both the collection of self monitoring storm water runoff sample results from eight industries and the sampling of one industry by the Quality Assurance Section. Additional monitoring will take place during the reporting period of 97\98.

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2. *Proposed changes to the storm water management program(s)*

During this reporting period it was determined that minor changes were required to one program in order to improve its effectiveness. This program is Part II(A)(11)(b) the Wet Weather Screening Program. Wet weather field screening procedures were changed to include a QA/QC Section and correct the address of one monitoring location. No other changes were made to any of the storm water management programs during this reporting period. A copy of the revised Wet Weather Field Screening Program can be found as Attachment A.

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3. Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application under 40 CFR 122.26(d)(2)(v)and (d)(2)(vi)

No revisions to the "Assessment of Controls" or "Fiscal Analysis" were needed during this reporting period.

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4. A summary of the data, including monitoring data, that is accumulated throughout the reporting year.

Data was obtained from three monitoring programs during this reporting period. Each of the sources are explained in the following paragraphs with associated data.

Storm Event Monitoring Data

The first source of data was the storm event monitoring. Storm event samples were collected during the three monitoring periods which make up this reporting period, as required. The five required monitoring locations were sampled plus a sixth. Analysis was performed using methods found in 40 CFR Part 136. The following is a summary of the data from each monitoring period:

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July 1 through October 31, 1996 Storm Event Monitoring Data

OUTFALL NUMBER	001	002	003	004	005	006
LOCATION	2400 E. 26th	11th @ SWBlvd	71ST @ JOE Cr.	54th & MINGO Cr.	9717 E. 58th	106th & SHERIDAN
Land Use Type	residential	commercial	commercial	industrial	industrial	residential
Drainage Area (acres)	39.3	14.7	15.1	25.0	23.0	12.3
Monitoring Period (season)	juloct96	juloct96	juloct96	juloct96	juloct96	juloct96
Date	19-Sept-96	14-Sept-96	14-Sept-96	14-Sept-96	14-Sept-96	14-Sept-96
Duration (hr.)	2.2	4.75	4.75	4.75	4.75	4.75
Duration since last event (hr.)	85.9	455	455	455	455	455
Sample No.	6091914	6091613	6091614	6091615	6091616	6091617
Precipitation (in)	0.22	0.15	0.12	0.24	0.22	0.14
Sample Volume(L)	5	14.5	20	20	5	20
Storm Volume(gal)	5984	11130	14960	22627	4376	42815
pH	7.3	7.3	7.7	7.7	7.9	6.8
Cd (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cu (mg/l)	<0.016	<0.016	<0.016	<0.016	0.033	<0.016
Pb (mg/l)	0.0127	0.019	0.016	0.008	0.004	0.004
Zn (mg/l)	0.033	0.022	0.112	0.076	0.066	0.024
BOD (mg/l)	9.6	9.9	6.2	11	8.7	11
COD (mg/l)	64	65	70	160	80	52
O&G (mg/l)	<5	5.7	0<5	6.4	5.9	<5
Phos (total) (mg/l)	0.243	0.373	0.136	0.112	0.095	0.114
Phos (diss.) (mg/l)	0.227	0.367	0.146	0.186	0.107	0.123
Phenol (mg/l)	*	<0.04	*	*	*	*
TSS (mg/l)	32	48	21	104	6	67
TDS (mg/l)	2544	226	67	118	225	164
TKN (mg/l)	0.648	1.165	1.659	1.071	1.699	1.012
Hardness (mg/l)	24.2	98.2	26.5	56.7	84.9	100.8
Temperature (C°)	19.5	22	22	24	24	22
Fecal Coliform (col/100ml)	45000	6546	14685	22000	11307	17118
Diazinon (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrogen (mg/l)	0.834	2.397	0.494	0.594	2.594	2.043

* Analysis of this parameter not required for this sampling location.

November 1, 1996 through February 28, 1997 Storm Event Monitoring Data

OUTFALL NUMBER	001	002	003	004	005	006
LOCATION	2400 E. 26th	11TH @ SWBlvd	71ST @ JOE Cr.	54th & MINGO Cr.	9717 E. 58th	106th & SHERIDAN
Land Use Type	residential	commercial	commercial	industrial	industrial	residential
Drainage Area (acres)	39.3	14.7	15.1	25.0	23.0	12.3
Monitoring Period (season)	novfeb97	novfeb97	novfeb97	novfeb97	novfeb97	novfeb97
Date	16-Nov-96	16-Nov-96	16-Nov-96	16-Nov-96	16-Nov-96	16-Nov-96
Duration (hr.)	5.98	5.98	5.98	5.98	5.98	5.98
Duration since last event (hr.)	236.25	236.25	236.25	236.25	236.25	236.25
Sample No.	6111814	6111813	6111817	6111815	6111816	6111820
Precipitation (in)	1.73	1.71	1.73	1.77	1.78	1.38
Sample Volume(L)	22.5	19	25	39	22.5	16
Storm Volume(gal)	109282	77044	253871	564740	286484	38298
pH	7.2	7.2	6.8	8.5	7.3	6.7
Cd (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cu (mg/l)	0.018	0.0210	<0.016	0.0270	0.039	0.016
Pb (mg/l)	0.0164	0.048	0.0034	0.038	0.0083	0.0077
Zn (mg/l)	0.051	0.072	0.036	0.252	0.103	0.045
BOD (mg/l)	6.5	3	2	4	4	7
COD (mg/l)	30	18	5.4	10	27	15
O&G (mg/l)	13	34.2	<5	22.6	15.9	<5
Phos (total) (mg/l)	0.507	0.299	<0.07	0.235	0.089	0.216
Phos (diss.) (mg/l)	0.304	0.152	<0.07	0.262	0.088	0.335
Phenol (mg/l)	*	<0.05	*	*	*	*
TSS (mg/l)	64	228	40	374	122	96
TDS (mg/l)	47	57	37	68	83	131
TKN (mg/l)	0.34	<0.28	0.61	0.5	0.96	1.9
Hardness (mg/l)	39.4	39.5	10.8	20.6	16.1	21.1
Temperature (C°)	14	14	14	14.1	14.5	14.5
Fecal Coliform (col/100ml)	2206	1909	1545	11818	28000	1288
Diazinon(mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrogen(mg/l)	0.27	0.22	0.125	0.226	0.236	0.768

* Analysis of this parameter not required for this sampling location.

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March 1, 1997 through June 30, 1997 Storm Event Monitoring Data

OUTFALL NUMBER	001	002	003	004	005	006
/LOCATION	2400 E. 26th	11TH @ SWBlvd	71ST @ JOE Cr.	54th & MINGO Cr.	9717 E. 58th	106th & SHERIDAN
Land Use Type	residential	commercial	commercial	industrial	industrial	residential
Drainage Area (acres)	39.3	14.7	15.1	25.0	23.0	12.3
Monitoring Period (season)	marjun97	marjun97	marjun97	marjun97	marjun97	marjun97
Date	25-Mar-97	25-Mar-97	25-Mar-97	4-Apr-97	25-Mar-97	25-Mar-97
Duration (hr.)	3.316	3.316	3.316	7.33	3.316	3.316
Duration since last event (hr.)	635.33	635.33	635.33	142.7	635.33	635.33
Sample No.	36511	36510	36514	37872	36512	36513
Precipitation (in)	0.87	0.79	0.9	0.46	0.77	0.75
Sample Volume(L)	7	16	20	28	9	17
Storm Volume(gal)	26554	12790.8	99858	109283	42553.72	21841.6
pH	7.5	8	7.4	7.6	6.5	5.85
Cd (mg/l)	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Cu (mg/l)	<0.016	<0.016	<0.016	0.024	<0.016	<0.016
Pb (mg/l)	<0.0005	<0.0005	<0.0005	0.0082	<0.0005	<0.0005
Zn (mg/l)	<0.020	<0.020	<0.020	0.12	<0.020	<0.020
BOD (mg/l)	19	12	8.7	17	6.6	9
COD (mg/l)	84	69	34	86	44	34
O&G (mg/l)	<5	<5	<5	<5	<5	<5
Phos (total) (mg/l)	0.862	0.493	0.128	0.215	0.238	0.090
Phos (diss.) (mg/l)	0.493	0.467	0.16	<0.07	0.207	0.084
Phenol (mg/l)	*	0.04	*	*	*	*
TSS (mg/l)	208	340	55	60	27	28
TDS (mg/l)	292	111	50	111	205	151
NO2 (mg/l)	0.56	0.26	0.44	0.13	0.33	0.31
NO3 (mg/l)	1	0.667	0.51	0.462	1.65	0.88
TKN (mg/l)	2.08	0.883	0.684	1.77	1.4	1.07
Hardness (mg/l)	30.1	30.1	14.5	31.6	34.7	28.5
Temperature (C°)	13.7	14	13.3	14	13.3	13.4
Fecal Coliform (col/100ml)	2100	460	18	21000	470	919
Diazinon (mg/l)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrogen (mg/l)	1	0.68	0.51	0.47	1.66	0.88

* Analysis of this parameter not required for this sampling location.

R0012976

Wet Weather Screening Data

The second program in which monitoring data was obtained was the wet weather field screening program. There are 34 individual watersheds in the jurisdiction of the City of Tulsa, each with a monitoring location. Twenty of those watersheds were monitored during this reporting period. All samples were grab samples, as defined by the Standard Operating Procedures for Wet Weather Field Screening. Data consists of both field and laboratory analysis. All laboratory analysis was performed using methods found in 40 CFR Part 136. The following is summary of that data:

OUTFALL #	1	2	4	5	6	13	14
DATE	2/26/97	2/26/97	2/20/97	2/20/97	2/20/97	2/26/97	2/26/97
FLOW (Cu.Ft/sec)	99	83.52	75	33	14.2	10.8	13.2
Temperature (C°)	9	8	13.5	12.8	13.5	9.7	9.5
pH (std. units)	8	7.5	8.3	8.2	8.2	7.4	7.38
Hardness (mg/l)	164.3	63.2	85.6	196	248.2	94.3	100.7
NH3 (mg/l)	0.397	0.568	0.142	<0.10	<0.10	0.435	0.496
BOD (mg/l)	4.3	6.8	7	4	3	10	2.2
Cd (mg/l)	<4	<4	<4	<4	<4	<4	<4
COD (mg/l)	14	83	18	42	11	117	14
Cu (ug/l)	<4	10	<20	24	56	17	6.6
Fecal Coliform (col/100ml)	451	2000	3154	2343	181	4500	181
N(tot) (mg/l)	0.5	0.55	0.57	0.25	<0.2	<0.2	0.3
O&G (mg/l)	<5	<5	8.6	<5	<5	<5	<5
Pb (ug/l)	<50	<50	7.6	<1	<1	<50	<50
Phenol (mg/l)	<0.04	0.123	<0.04	<0.04	<0.04	<0.04	<0.04
PO4(dis) (mg/l)	0.114	0.605	0.285	0.217	<0.07	0.78	0.106
PO4(tot) (mg/l)	0.7	0.766	0.246	0.255	<0.07	0.78	0.144
TDS (mg/l)	357	132	108	544	396	242	221
TKN (mg/l)	0.722	0.476	0.26	0.45	0.54	<0.3	<0.3
TSS (mg/l)	45	412	172	126	36	356	31
Zn (ug/l)	25	130	100	51	14	81	49
time (hr.) since last rainfall	115	115	317.47	317.47	317.47	115	115
Rainfall Duration (hours)	7.6	7.6	12.03	12.03	12.03	7.6	7.6
Rainfall amt. (inches)	0.99	0.99	1.94	1.94	1.94	0.99	0.99

R0012977

Wet Weather Screening Data (cont.)

OUTFALL	15	16	17	18	19	20	21
DATE	2/26/97	9/19/96	9/19/96	2/20/97	2/20/97	2/20/97	2/20/97
FLOW (cu.Ft/sec)	60	30	49.08	185.1	8	43.2	18.9
Temperature (C°)	9.6	19.8	20.5	14	14.5	14	14
pH (std. units)	7.95	7.6	7.8	7.5	7	7.8	7.7
Hardness (mg/l)	41.2	51.3	44.4	58.5	167.5	189.6	149
NH3 (mg/l)	0.334	No Rlts	No Rlts	0.305	<0.1	<0.1	0.145
BOD (mg/l)	4.9	5.5	8.4	8	6	4	18
Cd (ug/l)	<4	<2	<2	<4	<4	<4	<4
COD (mg/l)	81	38	66	30	64	37	18
Cu (ug/l)	9.9	<16	<16	<20	<16	<16	<16
Fecal Col. (col/100ml)	2600	43000	73637	15766	2343	860	1262
N(tot) (mg/l)	0.36	0.938	0.857	0.6	0.22	0.3	1.31
O&G (mg/l)	60.1	16.3	10	<5	<5	<5	<5
Pb (ug/l)	<50	21.6	21.2	9.2	<1	<1	<1
Phenol (mg/l)	<0.04	<0.04	<0.04	<0.04	<0.04	0.042	<0.04
PO4(dis) (mg/l)	0.235	0.15	0.173	0.211	0.136	0.21	0.316
PO4(tot) (mg/l)	0.59	0.149	0.196	0.237	0.18	0.21	0.276
TDS(mg/l)	136	2409	1738	130	234	140	384
TKN (mg/l)	0.450	<0.30	0.307	0.64	0.77	0.45	1.2
TSS (mg/l)	480	37	58	76	98	90	614
Zn (ug/l)	140	55	75	78	35	61	46
time (hrs.) since last rainfall	115	88	88	317.47	317.47	317.47	317.47
Rainfall Duration (hours)	7.6	2	2	12.03	12.03	12.03	12.03
Rainfall amt. (inches)	0.99	0.18	0.18	1.94	1.94	1.94	1.94

R0012978

Wet Weather Screening Data (cont.)

OUTFALL #	22	23	29	30	31	34
DATE	2/20/97	2/20/97	2/26/97	2/26/97	2/26/97	2/26/97
FLOW (cu.Ft/sec)	49.8	62.9	8	13	4.5	205.5
Temperature (C°)	12	11	10	9.1	9.1	7
pH (std. units)	7.2	7.5	7.6	7.4	7.4	8.4
Hardness (mg/l)	146.1	302.6	44.5	164.1	117.3	91.6
NH3 (mg/l)	<0.10	<0.1	0.242	0.204	0.134	<0.10
BOD (mg/l)	62	5	6.4	<2	3.2	6.1
Cd (ug/l)	<4	<4	<4	<4	<4	<4
COD (mg/l)	107	37	33	24	29	69
Cu (ug/l)	36	<20	7.9	<4	<4	5.7
Fecal Col. (col/100ml)	6217	631	2150	721	541	2300
N(tot) (mg/l)	0.56	<0.2	0.54	0.27	0.25	0.67
O&G (mg/l)	<5	<5	21.1	19.9	<5	<5
Pb (ug/l)	44	<1	<50	<50	<50	<50
Phenol (mg/l)	<0.04	<0.04	<0.04	0.08	<0.04	<0.04
PO4(dis) (mg/l)	0.379	0.315	0.2	<0.07	0.149	0.263
PO4(tot) (mg/l)	0.309	0.323	0.252	<0.07	0.173	0.509
TDS(mg/l)	308	426	79	325	282	171
TKN (mg/l)	1.2	0.31	<0.3	0.739	0.675	0.881
TSS (mg/l)	1756	90	56	60	54	412
Zn (ug/l)	380	68	150	18	<10	50
time (hrs.) since last rainfall	317.47	317.47	115	115	115	115
Rainfall Duration (hours)	12.03	12.03	7.6	7.6	7.6	7.6
Rainfall amt. (inches)	1.94	1.94	0.99	0.99	0.99	0.99

R0012979

Floatable Monitoring Summary

Data was obtained from two floatable monitoring locations. Inspections were performed after various rainfall events during this reporting period. If floatables were present during an inspection, they were collected and data was gathered regarding the quantity in cubic yards and make-up in percent organic and inorganic. A summary of the data is as follows:

Station: Osage 1101 W. Pine Street

Drainage area: 722 acres or 1.21 square miles

Date	Inspection	Collection (yds.3)	% Organic	% Inorganic
07/09/96	yes			
07/23/96	yes			
08/14/96	yes			
08/28/96	yes			
08/30/96	yes	2	90	10
09/17/96	yes			
09/26/96	yes			
09/27/96	yes	2.5	98	2
10/25/96	yes	1	98	2
11/01/96	yes	2	98	2
11/05/96	yes			
11/07/96	yes	5	98	2
11/17/96	yes			
12/03/96	yes	1	98	2
02/19/97	yes			
02/21/97	yes	0.75	98	2
02/28/97	yes	1	98	2
03/25/97	yes	0.2	99	1
04/11/97	yes			
04/16/97	yes	0.5	97	3

R0012980

Floatable Monitoring Summary (cont.)

Station: Osage 1101 W. Pine Street (cont.)

Date	Inspection	Collection (yds.)3	% Organic	% Inorganic
05/08/97	yes	0.33	98	2
05/29/97	yes			
06/19/97	yes			
06/26/97	yes	0.5	95	5
07/02/97	yes	5	98	2

Total cubic yards collected.....21.78
Average floatable make up (%).....98.....2

Station: Sheridan 10400 South 67 East Avenue

Drainage area: 74 acres or 0.116 square miles

Date	Inspection	Collection (yds.)3	% Organic	% Inorganic
07/09/96	yes			
07/23/96	yes			
08/14/96	yes			
08/28/96	yes			
08/28/96	yes			
08/30/96	yes	3	98	2
09/17/96	yes			
09/18/96	yes	0.5	98	2
09/26/96	yes			
09/27/96	yes	0.5	98	2
10/25/96	yes	2	98	2
11/01/96	yes	2.0	98	2
11/05/96	yes	3	99	1

R0012981

Floatable Monitoring Summary (cont.)

Station: Sheridan 10400 South 67 East Avenue (cont.)

Date	Inspection	Collection (yds.)3	% Organic	% Inorganic
11/07/96	yes	2	99	1
11/17/96	yes			
11/27/96	yes			
12/03/96	yes	1	99	1
02/19/97	yes	0.75	99	1
02/21/97	yes	0.5	98	2
02/28/97	yes	0.5	99	1
03/25/97	yes	1	98	2
04/11/97	yes			
04/16/97	yes			
05/08/97	yes	0.25	99	1
05/29/97	yes	0.25	100	0
06/19/97	yes			
06/26/97	yes	0.5	99	1

Total cubic yards collected.....17.75
Average floatable make up (%).....98.....2

R0012982

5. Annual expenditures for the reporting period, with a breakdown for the major elements of the storm water management program and the budget for the year following each annual report.

The annual expenditures for compliance with the City's NPDES Municipal Storm Water Discharge Permit can be found in the table that follows. Cost of implementation of individual requirements, such as wet weather field screening are not subdivided because many of the permit's requirements were already being completed as part of another task performed by the City. The fiscal analysis reflects the annual budget for compliance with the permit. It is projected that the cost to complete the permit requirements would increase at least 10% if individual cost accounting would be required on every item.

Fiscal Analysis Summary - Storm Water Management Programs

PROGRAM COMPONENT	FISCAL YEAR 96/97	FISCAL YEAR 97/98
LEGAL AUTHORITY		
	$19,971	$20,370
CHARACTERIZATION DATA		
- Continued Monitoring	$0	$0
- Continued Modeling/ Database	$0	$0
RESIDENTIAL and COMMERCIAL		
-Structural Control O&M	$4,624,432	$4,716,920
-New Development	$617,765	$630,120
-Street O&M	$444,373	$453,261
-Retrofitting Evaluation	$0	$40,000
-Landfill Monitoring	$1,169	$1,192
-Special Monitoring - Zinc Lake	$21,649	$22,082
-Pesticides	$15,966	$16,285

R0012983

PROGRAM COMPONENT	FISCAL YEAR 96/97	FISCAL YEAR 97/98
ILLICIT DISCHARGES		
-Enforce Ordinance	$0	$0
-Agency Coordination and Public Education	$786,373	$802,675
-Field Screening	$0	$0
-Storm Sewer Investigation	$1,228,220	$1,252,784
-Prevent / Contain Spills	$890,492	$908,302
-Water Quality	$75,770	$77,286
-Public Reporting	$20,171	$20,575
-Education Oil / Toxics	$0	$0
-Sanitary Seepage	$37,544	$38,295
INDUSTRIAL		
-Inspection / Control Measures	$0	$0
-Monitoring Program	$0	$0
CONSTRUCTION SITES		
-Plan Review	$0	$0
-BMP Requirements (i)	$0	$0
-Site Inspection and Enforcement	$486,834	$496,570
-Site Operator Training	$0	$0
STORM WATER QUALITY PROGRAM		
OPERATION	$162,365	$165,612
TOTAL	$9,433,092	$9,662,328

(i) Included with Residential/Commercial, New Development

R0012984

6. A summary describing the number and nature of enforcement actions, inspections and public education programs during this reporting period.

Enforcement Actions

Fourteen enforcement actions were taken during this reporting period by the Quality Assurance Section of the City of Tulsa. They were:

1. Interstate Tool
   1044 North Columbia Place
   Tulsa, OK

   A storm water inspection revealed a scrap metal bin located directly above a storm sewer drop inlet and a large volume of metal punch pieces and associated oil inside the storm sewer. Interstate Tool was placed on a Consent Order to remedy this situation. This facility "plugged" the subject storm drain and is currently compliant.

2. Pyromet Group
   10325 East 58th Street
   Tulsa, OK

   This facility was placed on a consent order to remove a discharge of overflow water from a cooling tower which flowed into the storm sewer. This discharge was rerouted to the sanitary sewer and the facility is currently compliant.

3. Cartec
   2524 South Harvard Ave.
   Tulsa, OK

   Cartec was issued a notice of violation for a spill of approximately 20 gallons of oil into the storm sewer. Cartec cleaned up this spill and moved waste oils/antifreeze storage inside. Cartec is currently compliant.

4. John Zink
   11920 East Apache
   Tulsa, OK

   An inspection revealed non-contact cooling water from test furnaces which discharged to the storm sewer. As a result, the company was placed on a consent order to obtain compliance within a specified amount of time. The order required either the redirection of the discharge to the sanitary sewer, stop the discharge or obtain an NPDES wastewater discharge permit from the EPA. The company plumbed the discharge to the sanitary sewer and is currently in compliance.

R0012985

5. *Braden Manufacturing*
   5199 North Mingo Road
   Tulsa, OK

   During a facility inspection a wash basin from an equipment maintenance garage, and several drinking-water fountains which discharged to the storm sewer were discovered. The company was placed on a consent order to attain compliance. The company removed the subject wash basin as well as all but one water fountain. The remaining fountain was plumbed to the sanitary sewer. The company is currently in compliance.

6. Borden/Meadow Gold
   215 North Denver
   Tulsa, OK

   A leaking water chiller discharging into the storm sewer was located at this facility. The company was placed on a consent order to attain compliance. The company investigated, found and repaired a leak in the subject water chiller. The company is currently compliant.

7. Labels One Inc.
   5151 South 110th East Ave
   Tulsa, OK

   During a facility inspection two sink waste drains discharging to the storm sewer were identified. As a result, the company was placed on a consent order to obtain compliance within a specified amount of time. The order required either the redirection of the discharge to the sanitary sewer or cease the subject discharge. The company plumbed the discharge to the sanitary sewer and is currently in compliance.

8. Lot Maintenance Inc.
   5305 South. 24th West Ave
   Tulsa, OK

   Lot Maintenance Inc. was issued a Notice Of Violation for washing residual material from drums into the street which subsequently flowed into the storm sewer system. The operator ceased this practice as soon as they were told this was in violation of City of Tulsa Ordinance #18588. This contractor is currently in compliance.

9. John Zink Company
   11920 East Apache
   Tulsa, OK

   John Zink Company was issued a Notice Of Violation for failure to notify the City of Tulsa "in writing" as outlined in their consent order. John Zink had satisfactorily remedied the illicit discharge of "furnace testing" water prior to the violation. The facility is currently compliant.

R0012986

10. Labels One Inc.
5151 South 110th. East Ave.
Tulsa, OK

Labels One Inc. was issued a Notice Of Violation for failure to notify the City of Tulsa "in writing" as outlined in their consent order. The owners of this facility had satisfactorily remedied the illicit discharge of "waste drains" to the storm sewer.

11. Metal Services
640 West 41st. Street
Tulsa, OK

Metal Services was issued a Notice Of Violation for powerwashing sediment from forklifts, other industrial machinery/equipment and metal parts which subsequently discharged to the storm sewer. This practice has ceased. However, the operator has filed an application with ODEQ (Oklahoma Department Of Environmental Quality) for a permit to discharge process wastewater. They are currently compliant.

12. Walterbach Homes
Box 904141
Tulsa, OK

City of Tulsa personnel responded to a citizen complaint of paint being discharged to the storm sewer. The subject discharge was traced to the source which was a home building site operated by Walterbach Homes. This resulted in the issuance of a Notice Of Violation. Subsequently, the discharge was halted and the operator is currently compliant.

13. Orbit Valve Service Co. Inc.
East 46th Place, Unit D
Tulsa, OK

A storm water inspection revealed a wash basin and a hydrotesting unit which discharged to the storm sewer system. The operator was placed on a consent order to remedy these illicit discharges within seven days. The wash basin was removed from service and the hydrotest water discharge was rerouted to the sanitary sewer within the required time frame. The facility is currently compliant.

14. Buck Construction Co.
9520 East 55th Street
Tulsa, OK

A Notice Of Violation was issued to Buck Construction Co. for discharging paint to the storm sewer. The operator ceased the discharge and is currently in compliance.

R0012987

If during a construction site inspection it was demonstrated that a noncompliant situation existed, enforcement actions were taken. Enforcement action was taken against 5 percent of those construction sites inspected by the Customer Services Section. Approximately 20 notices of violation were issued by the city's Engineering Services Section.

Inspections

As stated previously in Section 1 of this report, the city's Underground Collections Section performed inspections on 66.8 miles of sanitary sewer and 1.66 miles of storm sewer during fiscal year of 96-97.

The Quality Assurance Section performed a total of 970 inspections during this reporting period. These consist of both storm water quality and industrial pretreatment inspections. The industrial pretreatment inspections focus on wastestream types and disposal techniques primarily to the sanitary sewer and secondarily, to the storm sewer from industrial and commercial facilities. The storm water quality inspections consist of both inspections and surveys focusing on sources of pollutants in storm water runoff only.

As mentioned in Section 1 of this report, Customer Services performed 21,424 (14,028 commercial and 7,396 residential) and Engineering Services performed 81 construction/erosion control inspections during this reporting period to insure compliance with the city's permit.

Public Education Programs

The public education programs utilized by the City of Tulsa have been described in Section 1 of this report. Tulsa realizes that public education plays an important role in the reduction of nonpoint source pollution. The major programs are as follows:

- Distribution of literature at recycling depots and household hazardous waste events.
- Utility bill stuffers targeting illicit discharges and improper disposal, household hazardous waste, used automobile fluids and pesticides, herbicides and fertilizer application and disposal.
- Public speaking at industrial and social organizations including Metropolitan Tulsa Builders Association, Oklahoma Pretreatment Coordinators Meeting, Oklahoma Campus Safety Association, Blue Thumb Volunteers and Blue Thumb Resource Management Conference.
- Articles in the "City News", a monthly publication with a circulation of approximately 6000, regarding recycling, the household pollutant collection events, reporting of illegal or illicit discharges, recycling of antifreeze and oil and the importance of protecting water quality.
- Earth Day activities including Operation Clean Sweep, free dump day at the landfill and free mulch give away.
- Blue Thumb Resource Conference.

R0012988

- On May 17, 1997, in conjunction with National Rivers Clean-up Week (May 10-17, 1997) the City of Tulsa and the Blue Thumb Project sponsored a volunteer clean-up of approximately 3 miles of Mooser Creek. Over 30 people removed approximately 60 trash bags of trash and brought attention to the importance of urban water quality.
- Blue Thumb Volunteers stenciled approximately 643 curbs near storm sewer inlets with the wording "DUMP NO WASTE, DRAINS TO RIVER" during this reporting period. This brings the total number of inlets stenciled since the beginning of this project to a 3,843.

Many of these programs are completed through the cooperative efforts of other groups, such as The Metropolitan Environmental Trust (The M.e.t.) and the Tulsa County Soil Conservation Service - Blue Thumb Program.

As stated earlier (Section 1 Part II.a.) the "Don't Lay That Trash On Oklahoma" campaign was resurrected by ODOT during this reporting period. This co-permitee also sponsored in-house training programs on controlling erosion at construction sites, as well as "Trash Off" day and "Adopt a Highway" anti-litter programs. The state wide "Oklahoma, Keep Our Land Grand" anti-litter program was developed and is scheduled for implementation during the next reporting period.

During the performance of investigations and inspections, City of Tulsa representatives maintain the philosophy to first educate industrial representatives and responsible parties on storm water best management practices as well as their responsibility in the area of storm water quality. Enforcement actions are taken when deemed necessary to insure permit compliance.

R0012989

7. Identification of water quality improvements or degradation.

In order to identify water quality improvements or degradation, the event mean concentration (EMC) for this reporting period was compared against the EMC calculated for the last two reporting periods as well as the permit application period and the EMC data obtained from the Nationwide Urban Runoff Program study. This has resulted in the following table.

95/96 EMC Data Comparison Table

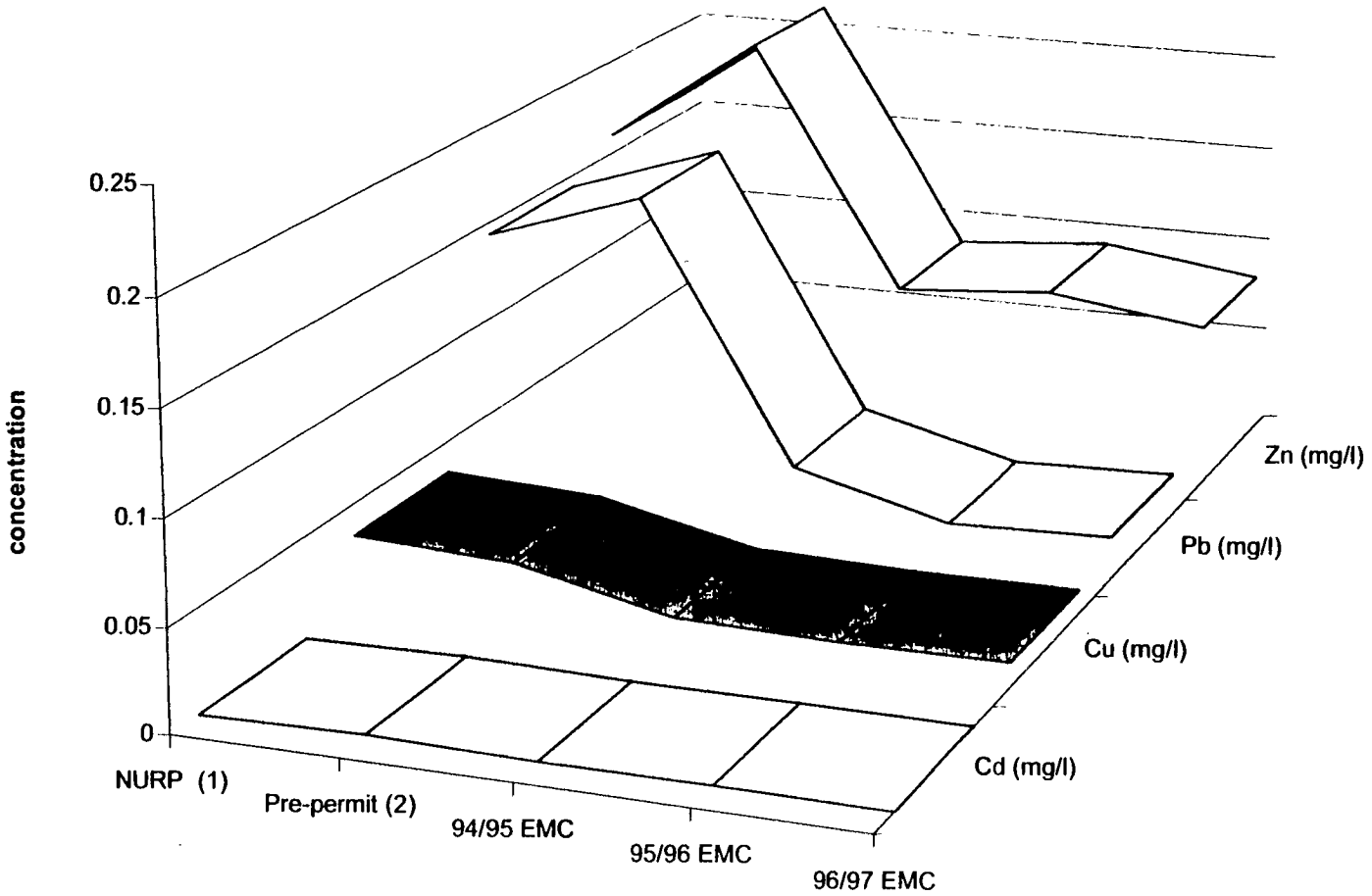
Parameter	96/97 EMC	95/96 EMC	94/95 EMC	NURP Results (1)	Pre-permit Results (2)
Cd (mg/l)	<0.010	0.0002	<0.002	no results	0.0015
Cu (mg/l)	0.0118	0.011	0.013	0.034	0.030
Pb (mg/l)	0.0215	0.019	0.039	0.144	0.170
Zn (mg/l)	0.0853	0.096	0.090	0.160	0.215
BOD (mg/l)	7.1	10	7	9	9.4
COD (mg/l)	47.2	60	52	65	70.2
O&G (mg/l)	5.8	1.5	3	no results	no results
Phosphorus (T) (mg/l)	0.2677	0.324	0.271	0.333	0325
Phosphorus (D) (mg/l)	0.2129	0.245	0.171	0.120	0.115
TSS (mg/l)	107	105	94	100	135
TDS (mg/l)	253	229	139	no results	100
TKN (mg/l)	1.453	1.774	1.013	1.500	1.66
Fecal Coliform (col/100 ml)	9190	3508	24,246	no results	no results
Diazinon (mg/l)	<0.005	<0.005	<0.005	no results	no results
Nitrogen (mg/l)	1.029	1.755	1.091	0.680	0.78

(1) Reference: U.S. EPA Results of Nationwide Urban Runoff Program, Washington, D.C. Tables 6-12 & 6-17.
(2) Reference: Part 2 Application for NPDES Municipal Storm Water Discharge Permit, submitted to U.S. EPA, Table 3-11.
* No analysis completed for this data.

The following charts give a simple graphical representation of the above table.

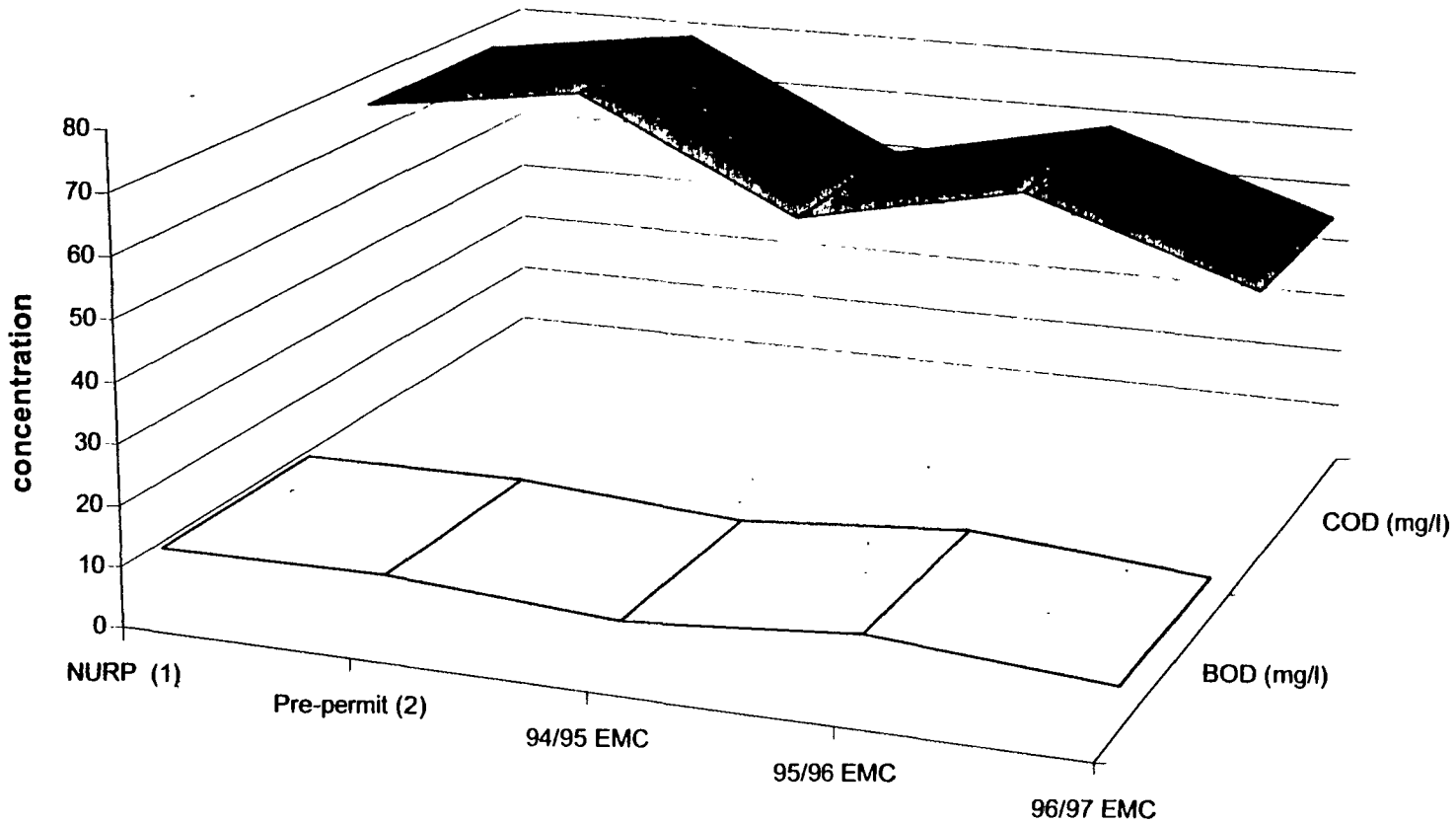
R0012990

Metals



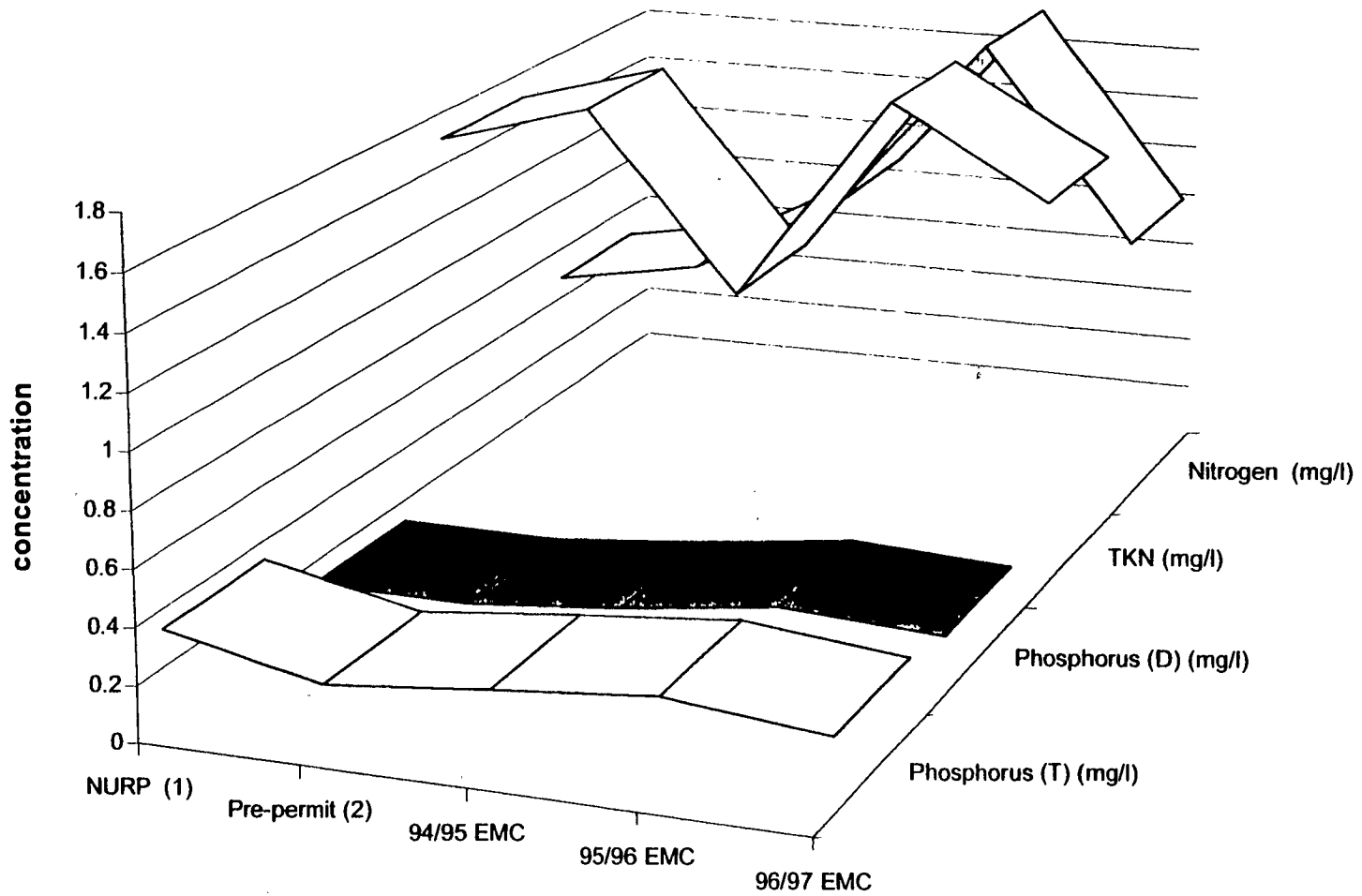
R0012991

BOD, COD



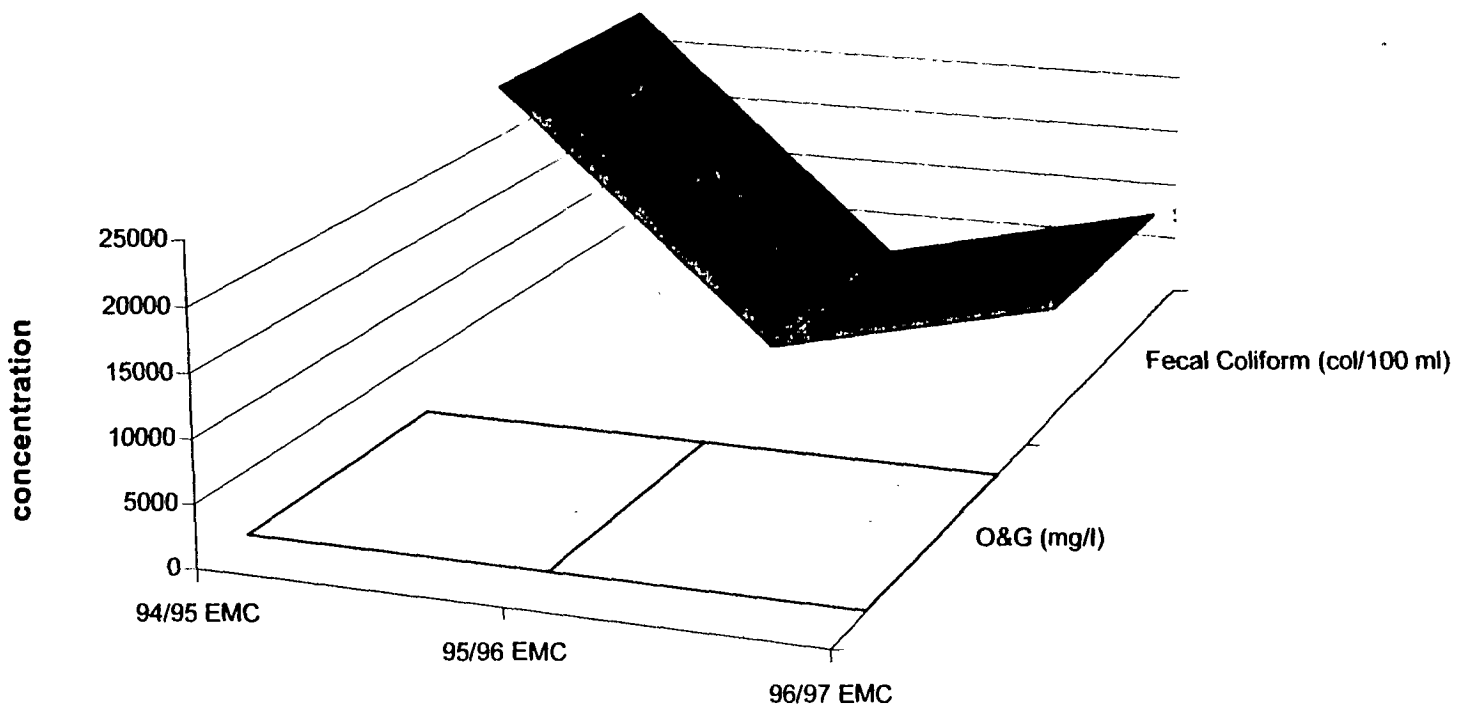
R0012992

Phosphorus (total & dissolved), TKN, Nitrogen



R0012993

Oil & Grease, Fecal Coliform



R0012994

After reviewing the charts the following conclusions were drawn.

- There was a reduction in the concentration of three of four metals analyzed with the cadmium showing no change in concentration.
- There is not enough data to determine an overall trend for fecal coliform and oil & grease.
- Long term trends show that nitrogen and total kjeldahl nitrogen(TKN) are erratic at best, but appear to have decreased in concentration during this reporting period.
- Both total and dissolved phosphorus appears to have remained at a constant level.
- Total dissolved solids (TDS) concentrations continue to increase while total suspended solids (TSS) were reduced slightly.

R0012995

ATTACHMENTS

R0012996

STANDARD OPERATING PROCEDURES
FOR
WET WEATHER FIELD SCREENINGS

CITY OF TULSA, OKLAHOMA
DEPARTMENT OF PUBLIC WORKS
ENVIRONMENTAL OPERATIONS DIVISION
QUALITY ASSURANCE SECTION

REVISION DATE : July 17, 1997

OBJECTIVE : These procedures are designed in order to insure the completion of the Wet Weather Field Screening requirement found in the City's Municipal Storm Water Discharge Permit # OKS000201. The wet weather field screening program was developed in order to identify watersheds within the City which have a poor quality discharge during storm events. Once these areas of reduced water quality are identified other storm water quality programs can be implemented.

The wet weather field screening program can also be used to gauge the effectiveness of other storm water permit programs and storm water best management practices (BMP). If results are not what were anticipated, then corrective action can be taken.

These procedures will update the Storm Water Management Program (Part II.A.) of the City's Municipal Storm water Discharge Permit. Implementation of these procedures shall commence by January 1, 1996.

WORK GROUP : These procedures will be implemented and used by personnel of the Industrial Pretreatment group of the Quality Assurance Section of the Public Works Dept.

Wet Weather Field Screening Procedures

I. Identification of Screening Location for Each Watershed

Within the corporate boundary of the City of Tulsa there are a number of individual watersheds. Each watershed will be represented by at least 1 wet weather field screening location. Thirty four screening locations have been selected. They are:

Watershed	Screening Location
1) Upper Mingo - Sugar Creek - Southpark - Ford Creek - Catfish Creek - Upper Mingo - Alsuma Creek	N/W corner of Hicks Park (bridge)

	Watershed	Screening Location
2)	Fulton Creek / Bell Creek	behind 3235 South 93rd East Ave.
3)	Audobon Creek	2500 South 92nd East Ave (South East corner of Rockwell detention pond on northside of creek)
4)	Jones Creek / Mill Creek	1120 South 89th East Ave (bridge)
5)	Tupelo Creek	5th Street & South Mingo (bridge)
6)	Cooley Creek	North of US 169 & Admiral Blvd (bridge)
7)	Lower Mingo	46th Street North @ Mingo Creek (bridge)
8)	Swan Creek	2700 South Riverside Drive (outfall)
9)	Coal Creek	5600 East Mohawk Park Drive (bridge)
10)	Flat Rock Creek	US 75 @ Flat Rock Creek (bridge)
11)	Dirty Butter Creek	36th Street North @ Dirty Butter Creek (bridge)
12)	Valley View Creek Channel	833 East 46th Street North (bridge)
13)	Harlow Creek Tributary	6216 West Edison (bridge)
14)	Harlow Creek	4701 West Edison (north bridge)
15)	Parkview Ditch	1710 West Charles Page (bridge)
16)	Civic Center (DT) / Oak Creek	East bank US 75 @ Arkansas River (E1SW)
17)	Elm Creek	2200 South Riverside Drive (B1SW)
18)	Crow Creek	Crow Creek @ Riverside Dr (Pedestrian bridge)
19)	Joe Creek	Joe Creek @ Riverside Drive (bridge)
20)	Fred Creek	81st Street @ Fred Creek (bridge)
21)	Vensel Creek	South Delaware @ Vensel Creek (bridge)
22)	Cherry Creek / Redfork Creek	4900 South Elwood Ave (bridge)
23)	Mooser Creek	5200 South Elwood Ave (bridge)
24)	Fry Ditch #2	10524 South 76th East Ave (bridge)
25)	West Branch of Haikey Creek	8000 South Garnett (bridge)
26)	Adams Creek	17625 East 51st Street (bridge)
27)	Spunky Creek (south)	3300 South 193rd East Ave (bridge)
28)	Spunky Creek (north)	1400 South 193rd East Ave (bridge)
29)	Perryman Ditch	5600 South Riverside Drive (outfall)
30)	Nickel Creek	3100 West 91st Street South (bridge)
31)	Hager Creek	702 West 91st Street South (bridge)
32)	Little Haikey Creek	10500 East 101st Street South (bridge)
33)	Flat Rock Creek Tributary	Flat Rock Creek Trib & US 75
34)	Brookhollow Creek	2900 South Mingo Road (bridge)

Each screening location has been chosen prior to the program implementation using the following criteria :

- Screening location would best represent the entire watershed
- Screening location is accessible by sampling crews,
- Screening location is safe for sampling crews during wet weather events.

The screening of these 34 watersheds will be completed as per the City's compliance schedule milestone (Part III,A,6). At least 50% of these watersheds will be screened by July

1, 1997 and 100% by July 1, 1999. Depending on the results, additional screening may be required. Baseline screening will be performed provided the resources are available.

II. Pre-storm Event Procedures

Some portions of the wet weather field screening must be performed during a storm event. This places the group responsible for the completion of these procedures at the mercy of the weather, which can be unpredictable.. Therefore, pre-storm event planning and preparation is a high priority. The following items must be completed during the pre-storm event preparation.

1. Become familiar with screening locations;
2. Monitor weather conditions;
3. Obtain and prepare equipment and bottles necessary to perform wet weather field screening;
4. Place crews on standby after normal business hours once conditions appear favorable for a storm event;
5. Target watersheds in which screening must occur;
6. Notify the laboratory

III. Storm Event Procedures

A storm event is defined as "a rainfall event with a magnitude of 0.1 inch or greater which occurs after a period of 72 hours with less than a 0.1 inch of rainfall. Rainfall information can be found in the rainfall information sheet obtained daily from Customer Services (596-1846). This sheet is located either near the Storm water Watershed Map or in the file marked NovaStar Rain Data. Once a storm event occurs the following items must be completed:

1) Obtain wet weather field screening samples at targeted watershed screening locations. All samples must be grab samples for each field screening location and must be taken during the first two hours of the storm event. Each sample must be properly labeled and immediately cooled to less than 4 degrees C.

2) Field screening analysis for each screening locations sampled must be performed. This includes:

   Visual Inspection for :
   - Odor,
   - Color,
   - Clarity, and
   - Floatables.

Parameters to be sampled and analyzed are:

Parameters	Container type	Sample Volume	Container Number
° Water Temperature	plastic	250ml	1
° pH	plastic	250ml	1
° Hardness	plastic	250ml	1
- Fecal Coliform	plastic (whirlpak)	100ml	2
- Cd (cadmium)	plastic	1000ml	3
- Zn (zinc)	plastic	1000ml	3
- Cu (copper)	plastic	1000ml	3
- Pb (lead)	plastic	1000ml	3
- TDS	plastic	1000ml	4
- TSS	plastic	1000ml	4
- Oil & Grease	glass	2000ml	5
- COD	plastic	1000ml	6
- TKN	plastic	1000ml	6
- Nitrogen (total)	plastic	1000ml	6
- Phosphorus (total)	plastic	1000ml	6
- Phosphorus (dis.)	plastic	1000ml	6
- Ammonia	plastic	1000ml	6
- BOD5	plastic	1000ml	7
- Phenol	glass (amber)	1000ml	8

° Analysis will be performed by Industrial Pretreatment using EPA Approved Methods
- Analysis will be performed by the Quality Assurance Laboratory using EPA Approved Methods
Shaded areas represent individual bottles, (i.e. . Cd, Zn, Cu, Pb would be one bottle of 1000 ml).

4) Complete "Wet Weather Field Screening" sheet (Attachment A) for each field screening location.

5) Complete a chain of custody form for each screening location

6) Transport all field screening samples along with the proper chain of custody to the Northside Laboratory, except for the fecal coliform, which is delivered to the Mohawk Laboratory.

IV. QA/QC

In order to insure the implementation of sound sampling procedures, at least one quality control/quality assurance sample must be obtained with every sampling event. The QA/QC samples will consist of field blanks and duplicate analyses. Field blanks consist of filling sample bottles with reagent grade analyte free deionized water while in the field. The field blanks will be submitted to the laboratory for analysis for the following parameters:

- Zinc (total)
- Fecal Coliform
- Cadmium (total)
- TKN
- Copper (total)
- Phosphorus (dissolved)
- Phenol
- TSS
- TDS
- Oil & Grease
- COD
- Nitrogen (total)
- Phosphorus (total)
- Lead (total)
- BOD5
- Ammonia

Each sampling crew must obtain a field blank with each set of samples they are obtaining. For example:

sampling crew X is required to obtain samples from watershed #1 and #2. They would obtain one field blank and have it analyzed for the above parameters. If there are 3 sampling crews involved with the collection of 10 samples then three field blanks would be collected and turned into the laboratory for analysis.

Duplicate analyses will also be performed for one out of every ten samples analyzed by Industrial Pretreatment for hardness.

Matrix spikes and duplicates analysis will be performed by Quality Assurance Laboratories.

V. Post Storm Event Procedures

Once the field work is completed then the completion of the necessary office work is required to finish up wet weather field screening for the targeted screening locations. The extent of the follow-up work is dictated by the results of the field screening. The following procedures must be implemented during post storm event wet weather field screening:

1) Complete the following paper work within 48 hours of the end of the rainfall event sampled; "Storm Event Check List," "Rainfall Data Information Sheet," and "Storm Event Data Sheet." (see attachments).

2) All completed "Wet Weather Field Screening" sheets and laboratory analysis reports must be reviewed by an Environmental Compliance Specialist.

3) If results reveal "unusually high pollutant concentrations" in runoff, then one or any combination of the following actions may be employed :
   a) Implementation of a storm water management program found in the Permit;
   b) Revision of storm water BMP;
   c) Implement further wet weather field screening upstream if the screening location in order to locate source(s) of pollutants.

3) "Unusually high pollutant concentrations" are defined as those pollutants found in concentration above the typical values of the same pollutants in previous storm event samples.

Once corrective action is taken in the watershed with "unusually high pollutant concentrations", re-screen the watershed to determine if runoff quality has improved. If runoff quality has not improved then continue to implement aforementioned actions until runoff quality improves.

Data from the "Wet Weather Field Screening" sheets and the laboratory results should now be entered into the WETWETH.MDB database (attachment B).

VI. Report / Data Usage

The data obtained during the wet weather field screening will be used for report generation. A report will be completed by July 1 annually. The report will include :

1) The number of locations screened from July 1st through June 30th;
2) Results of all screenings;
3) The number of screened locations with poor quality runoff;
4) Actions taken to address poor quality runoff; and
5) All follow-up screening data.

Copies of this report will be distributed for review.

VII. Note

1) Storm event monitoring must take precedence over wet weather field screening during each storm event sampling period.

2) Direct any questions regarding this SOP or dry weather field screening to Scott VanLoo.

THIRD ANNUAL REPORT

THE BROWARD COUNTY EPA NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) PERMIT (NPDES NUMBER FLS000016, EFFECTIVE DATE DECEMBER 1, 1996)

February 8, 2001

DEVELOPED BY THE CO-PERMITTEES:

UNINCORPORATED BROWARD COUNTY
CITY OF COCONUT CREEK;
CITY OF COOPER CITY;
CITY OF CORAL SPRINGS;
CITY OF DANIA;
TOWN OF DAVIE;
CITY OF DEERFIELD BEACH;
CITY OF HALLANDALE;
TOWN OF LAUDERDALE-BY-THE-SEA;
CITY OF LAUDERDALE LAKES;
CITY OF LAUDERHILL;
CITY OF LIGHTHOUSE POINT;
CITY OF MARGATE;
CITY OF MIRAMAR;
CITY OF NORTH LAUDERDALE;
CITY OF OAKLAND PARK;
CITY OF PARKLAND;
TOWN OF PEMBROKE PARK;
CITY OF PEMBROKE PINES;
CITY OF PLANTATION;
CITY OF POMPANO BEACH;
VILLAGE OF SEA RANCH LAKES;
CITY OF SUNRISE;
CITY OF TAMARAC;
CITY OF WILTON MANORS;
and
FLORIDA DEPARTMENT OF TRANSPORTATION

R0013003

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2. City of Oakland Park Adopt-a-highway Program.
- $ Pesticide Applicator Certificates from Co-permittee's.
- $ Construction Site Operator Training.
- $ Pesticides and Nutrients Occurrence at Golf Courses.
- $ 1998-1999 Dry Field Screening.
- $ Log of Violations Reported to DPEP and Enforcement Action Taken.
- $ Literature Regarding the Illicit Discharges or Improper Disposal to MS4.
- $ Brochure for Household Hazardous Waste Program.
- $ List of Sewer Spills and Letter to Water Treatment Plants.
- $ Log of Industrial Storm Water Sources Discharging to Ms4.
- $ Inspection Procedure for Construction Site Runoff.
- $ List of Construction Site Inspected by DPEP.
- $ List of Construction Sites in Broward County Subject to NPDES-MS4 Regulation.
- $ List of Major NPDES Outfalls in Broward County.
- $ Fiscal Analysis from Co-permittees.
- $ Log of Industrial High Risk Facility Inspections.
- $ FDOT Outfall Inspections.
- $ Presentation to Painting and Decorating Contractors of America.
- $ Stormwater Program in the City of Tamrac.
- $ Surfacewater Ambient Monitoring Data.
- $ Sample Results for the Investigation of Organic Pollutent.
- $ FDOT Reports.

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B. OVERALL EVALUATION OF THE SWMP

Objective of the Program

Broward County is complying with the requirements of the NPDES MS4 Permit by implementing a comprehensive Storm Water Management Program (SWMP). The intent of the SWMP is to reduce the amount of pollutants, generally to the maximum extent possible, entering waters of the United States through the MS4 of unincorporated Broward County and the other co-permittees for the Broward County MS4 permit.

Nine stormwater management programs are required to be developed and implemented within the first three years of the permit. Within these nine programs, there are 102 activities or tasks that are required to be performed.

Major Findings

The following major findings of the program include the following:

- $ Dry field screening revealed that no illicit discharges to the MS4 were evident in 50 major outfalls in Broward County.
- $ Co-permittee inspection and maintenance activities at stormwater treatment ponds and exfiltration trenches compared favorably with EPA goals.
- $ Five out of 53 Stormwater drainage complaints received resulted in warning notices.
- $ Two golf courses in Broward County were investigated for pesticide and nutrient runoff. Some pesticides and nutrients were found in small quantities near surface water bodies.

Major Accomplishments

Some of the major accomplishments of the program include the following:

- $ Completion of the 50-site dry field screening and monitoring of five wet field sites.
- $ NPDES Annual Workshop has provided a valuable resource for the co-permittees to coordinate and discuss activities for the implementation of Stormwater management programs.
- $ An Educational Workshop was given for Best Management Practices on Erosion and Sedimentation control. Twenty five people were certified by the state after passing an examination.
- $ Broward County DPEP gave a presentation to the painting and decorating contractors about potential pollution problems and solutions as part of their public outreach program.
- $ Household Hazardous Waste Collection Program collected flammable, toxic, corrosive and reactive waste from Broward County residents. Educational material associated with disposal techniques for oils, toxins, and household waste materials were distributed to public.
- $ Some of the co-permittees have started public out reach programs on how to protect surface water from getting contaminated.
- $ Forty-eight facilities were inspected for non-domestic direct discharge.
- $ Construction sites with area greater than five acres were inspected for sedimentation and erosion control measures. General contractors were informed about Notice of Intent (NOI) to EPA and Best

Management Practices for construction runoff.

- $ Enforcement action was taken against five vehicle wash facilities that were out of compliance.
- $ Best management practices for marine facilities were developed and distributed to the public.
- $ The city of Tamarac started a comprehensive street improvement program. The summary of the program has been included in attachment 20.

Strengths

Co-permittees are pro-active in public education about pollution control to the storm drains. More cities are installing pollution control baffles for control of debris, grease and oils in their catch basins.

More Co-permittees are working towards creating more accurate data base of their outfalls with new available technology like geographical information system. This will help in the future for dryfield screening and maintenance of those outfalls.

Weaknesses

Some of the work performed by DPEP are also requirements of the City of Fort Lauderdale and the City of Hollywood permits which is a duplicate work efforts.

The five year Broward County permit ends on December 2001. However, DEP is proposing to charge fee from September 1, 2000 as they receive delegation from EPA. The DEP fee will be an extra financial burden for all co-permitees that was not expected.

There is uncertainty as to how much the DEP permit fees will be. It could be a big burden for small co-permittees in the Broward County.

The City of Weston which was part of the unincorporated Broward County is now an incorporated city. To our knowledge, Weston has not been added as a co-permittee on the Broward County permit.

Future Direction of Program

The long-term future direction of the program is dependent upon the involvement of the state and federal agencies. Delegation of the NPDES MS4 Stormwater permitting program to Florida Department of Environmental Protection may institute changes which are unknown at this time. FDEP Phase II Storm Water management program may also affect the future direction of the program. Our understanding from representatives of DEP is that current co-permittees will remain co-permittees regardless of whether their population now exceeds 100,000 or weather they qualify under the Phase II regulations.

C. SUMMARY TABLE FOR STORM WATER MANAGEMENT PROGRAM ELEMENT STATUS/COMPLIANCE

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
Structural Controls	Coconut Creek	Canals Inspected	15 miles, once/ mos.	YES	10 miles, once/ mos	Copies of Inspection Report Forms Available Upon Request
		Canals Maintained	As needed	N/A	7 miles maintained	Copies of Inspection Report Forms Available Upon Request
		Inlets and Catch Basins Inspected	1400 units once/3 months	YES	1400 units once/3 mos	critical units inspection 3 mos
		Inlets and Catch Basins Maintained	As needed	N/A	283 units once/yr	Copies of Inspection Report Forms Available Upon Request
		Storm Water Treatment Ponds Inspected	2 semi-annually	YES	2 semi-annually	Copies of Inspection Report Forms Available Upon Request
		Channel Control Structures Inspected	5 units once/month	YES	5 units/mos	Out falls were inspected
	Cooper City	Stormwater Pump Station Inspected	1 unit once/mos	YES	1 unit once/mos	Records available on request
		Stormwater Treatment Ponds Inspected	1 once/mos	YES	1 once/mos	Records available on request
		Channel Control Structures Inspected	25 unit once/mos	YES	25 unit once/mos	Records available on request
	Coral Springs	Canals Inspected/ Maintained	Not applicable	N/A	Not applicable	Drainage district inspects and maintained the canal
		Lakes/detention Ponds Inspected/ Maintained	Not applicable	N/A	Not applicable	No lakes or Detention ponds owned by the city
	Dania	Inlet and Catch Basins Inspected	872 unit twice/yr	YES	899 units twice/yr	Records are available on request
		Inlets and Catch Basins Maintained	872 unit twice/yr	YES	899 units twice/yr	Records are available on request
		Canals Inspected	8 miles twice/month	YES	8 miles inspected	Records are available on request
		Canals Maintained	As needed	YES	8 miles maintained	Records are available on request
		Stormwater Pump Station Inspected	1 unit once/month	YES	1 unit twice/yr	Records are available on request
		Storm Treatment Pond-dry Retention or Detention Maintained	maintained once per month	YES	maintained once per month	Records are available on request

R0013013

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Grate Inlets Inspected	As needed	YES	Checked and cleaned after every storm	Records are available on request
	Davie	Inlets and Catch Basins inspected	2307 Unit once/year	YES	2307 Unit once/year	Records are available on request
		Lakes/detention Ponds - Acres	4 once/mos	N/A	4 once/mos	Records are available on request
	Deerfield Beach	Canals Inspected	10 miles twice/yr	YES	10 miles twice/yr	Records are available on request
		Canals Maintained	As needed	YES	10 miles twice/yr	Records are available on request
		Exfiltration Trench	15 miles twice/yr	YES	15 miles twice/yr	Records are available on request
		Stormwater Treatment Dry Ponds	2 times /yr	YES	2 times/yr	Records are available on request
		Stormwater Treatment Wet Ponds	2 times/yr	YES	2 times /yr	Records are available on request
	Hallandale	Canals Inspected	8.2 miles once/mos	YES	8.2 miles/mos	Schaffer Canal was also inspected
		Stormwater Lift Station	4 units once/mos	YES	4 units once/mos	Inspected and maintained Records are available
		Swales	N/a	N/A	N/a	Maintained by the property owner
	Lauderdale by the Sea	Catch Basins Inspected	23 units 4 times/yr	YES	23 units 4 times/yr	Records are available on request
		Infiltration Trenches	20 units 4 times/yr	YES	20 units 4 times/yr	Records are available on request
	Lauderdale Lakes	Canals Inspected	11 surface Acres/Week	YES	11 surface Acres/Week	Records are available on request
		Canals Maintained	69 Surface Acres/ 6 mos	YES	69 Surface Acres/ 6 mos	Records are available on request
		Grate Inlets Inspected	Once/ 2 weeks	YES	Once/ 2 weeks	Records are available on request
		Lakes Maintained	4 Surface Acres/ 3 mos	YES	4 Surface Acres/ 3 mos	Records are available on request
		Strom Drain Inlets Inspected	498 units,once/6 mos	YES	498 units,once/6 mos	Records are available on request
	Lauderhill	Canals Inspected	12 miles, once/mos	YES	12 miles, once/mos	this task is being performed during the schedule maintenance
		Canals Maintained	As needed	N/A	12 miles maintained	Installation of Triploid Grass Carp fish to control the aquatic vegetation
		Inlets and Catch Basins Inspected/ Maintained	457 units once/mos	N/A	457 inlets and catch basins cleaned	Records are available upon request
		Channel Control Structure Inspected	191 units once/mos	N/A	191 units once/mos	Bridge Culverts

R0013014

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Channel Control Structure Inspected	As needed	N/A	191 units/ 6 mos	Records available on request
		Storm drain inlets inspected	776 inlets once/6 mos	N/A	776 inlets once/6 mos	Records available on request
		Street sweeping / Litter control	11.5 miles once/mos	N/A	11.5 miles/mos	Records available on request
		Lakes/ Detention Ponds Maintained	7- lakes once/mos	YES	7 lakes once/mos	Cleaned and sprayed for aquatic plant
	Lighthouse Point	Canals Inspected	12 miles once/mos	YES	12 miles once/mos	Records are available upon request
		Canals Maintained	As needed	YES	12 miles maintained	Records are available upon request
		Inlets and Catch Basins	457 units once/mos	YES	457 units once/mos	Records are available upon request
		Grate Inlets Inspected	457 inlets once/yr	YES	457 inlets once/yr	Records are available upon request
	Margate	Canals Inspected	23 miles once/yr	YES	23 miles once/yr	Canals are maintained and inspected
		Canals Maintained	23 miles once/yr	YES	23 miles once/8 weeks	Litter and debris is also removed as needed and in response to citizen complaints
		Inlets and Catch Basins Inspected 1856 Units	1856 units twice/yr	YES	1856 units twice/yr	Inspection is done at time of maintenance Inlets and catch basins are also inspected prior to storm
		Drainage Control Structure	2 units once/6 mos	YES	2 units once/week	Units are pump station
		Drainage Ditches	Concrete lined once a month grass twice a month	YES	Concrete lined once a month grass twice a month	Ditches are also cleaned as needed Grass ditches are cut at least twice a month
	Miramar	Canals Inspected	55 acres once/mos	YES	55 acres once/mos	Records are available on request
		Canals Maintained	Monthly	YES	55 acres/mo	Records are available on request
		Inlets and Catch Basins Inspected	Approx. 2000 once/year	N/A	300 inspected	Records are available on request
		Inlets and Catch Basins Maintained	As needed	N/A	300 unit	Records are available on request
		Weir Inspected	1 unit / 6 mos	YES	1 unit/6mos	Records are available on request
		Stormwater Sewer Pipe Culverts	As needed	N/A	Repaired 3 culverts	Records are available on request
		Grate Inlets Inspected	As needed	N/A	300 inlets/year	Records are available on request
		Lakes/detention Ponds Maintained	3 units/mos	YES	3 units mos	Records are available on request
	North Lauderdale	Canals Inspected	15 miles once/mos	YES	15 miles once/mos	Records available upon request
		Canals Maintained	As needed	N/A	15 miles once/mth	Records available upon request

R0013015

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Inlets and Catch Basins	As needed		283 units once/yr	Records available upon request
		Channel Control Structures	As needed	N/A	2 outfalls once/ 2 weeks	Records available upon request
		Storm Sewer Pipes Culverts	As needed	N/A	24 miles once/weekly	Records available upon request
	Oakland Park	Canals Inspected	4.5 miles, once/mos	YES	4.5 miles, once/mos	Reports are available on request
		Canals Maintained	4.5 miles once/mos	YES	4.5 miles once/mos	Reports are available on request
		Inlets and Catch Basins Inspected	750 units, twice/year	YES	750 units twice/yr	Reports are available on request
		Inlets and Catch Basins Maintained	As needed	YES	450 units once/yr	Reports are available on request
		Lakes Inspected	5 (193 acres)once/mos	YES	5(193 acres) once/mos	Reports are available on request
		Lakes Cleaned of Debris Inspected	5(193 acres) once/mos	YES	5(193 acres) once/mos	Reports are available on request
		Exfiltration Trenches Inspected	15 miles/inspected twice/yr	YES	15miles/inspected twice/yr	Reports are available on request
		Stormwater Structures Inspected	3 inspect/clean mos	YES	3 inspect/clean mos	Reports are available on request
		Weir Units	1 inspect/clean mos	YES	1 inspect/clean mos	Reports are available on request
	Parkland	Dry Retention Pond Inspect, Maintain	1 unit twice/yr	YES	1 unit twice/yr	Reports are available on request
		Canals	inspect 4 times/yr	YES	inspect 4 times/yr	Reports are available on request
	Pembroke Park	Lakes/ponds Inspected	2 acres twice/mos	YES	2 acres twice/mos	Reports are available on request
		Storage Ponds Inspected	2 acre twice/mos	YES	2 acre twice/mos	Reports are available on request
	Pembroke Pines	Canals Inspected	60 miles once/week	YES	60 miles once/week	Primary and secondary canals
		Canals Maintained	As needed	YES	60 miles 5 times/yr	Aquatic spraying
		Stormwater Pump Station Inspected	9 pump twice/week	YES	9 pump twice/week	Reports are available on request
		Stormwater Pump Station Maintained	As needed	YES	9 pump station	Reports are available on request
		Stormwater Treatment Ponds Inspected	1750 acres/ quarterly	YES	1750 acres/ quarterly	Reports are available on request
		Channel Control Structures Inspected	5 units once/month	YES	5 units once/month	Reports are available on request

R0013016

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Channel Control Structures Maintained	As needed	YES	5 units	Reports are available on request
		Weir Units Inspected	10 units once/month	YES	10 units once/month	Reports are available on request
	Plantation	Canals Inspected/maintained	20.5 miles/mos	YES	20.5 miles/mos	Records are available on request
		Inlets & Catch Basins	1783 Units/twice yr	YES	1783 Units/twice yr	
		Outfalls Inspected/maintained	11 units/6 mos	YES	11 units/6 mos	Records are available on request
	Pompano Beach	Canals Inspected	32 miles once/mos	YES	32 miles once/mos	Reports are available on request
		Canals Maintained	As needed	N/A	1 mile maintained	Reports are available on request
		Retention/wetland System maintained	10 retention twice/mos	YES	10 retention twice/mos	Reports are available on request
		Lakes/detention Ponds	4 ponds once/mos	YES	4 ponds once/mos	Reports are available on request
		Storm Drain Inlets Inspected	40 inlets once/6 months	YES	40 inlets once/6 months	Reports are available on request
	Sea Ranch Lakes	Inlets/catch Basin Inspected	20 units/ week	YES	20 units/week	Records are available on request
		Inlets/catch Basin Maintained	As needed	N/A	1 unit	Records are available on request
		Lakes/ponds Inspection/maintenance.	2 lakes once/mos	YES	2 lakes once/mos	Records are available on request
	Sunrise	Canals and Lakes	900 acres once/yr	YES	900 acres once/yr	aquaticweed control, litter, trash and debris removal
		Pump Station inspection	7 units once/week	YES	7 units once/week	Reports are available on request
		Stormwater Treatment - Wet Ponds Inspected	4 wet detention pond every 10 days	YES	4 wet detention pond every 10 days	Aquatic plant control
	Tamarac	Canals Inspected	Two-month citywide cycle	YES	311 Acres once/two mos	Records are available upon request
		Canals Maintained, Acres	Two-month citywide cycle	YES	726 once/two mos	Records are available upon request
		Inlets and Catch Basins inspected	Two-month citywide cycle	YES	27,509 units in one year period.	The latest total count of catch basins within the City totaled 3,631 units. Copies of the catch basin inspection forms are available upon request
		Inlets and Catch Basins Maintained	As needed	N/A	2,540 units in one year period	Records are available upon request

R0013017

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Storm Water Pump Station Inspected	3 pump stations	N/A	Normally, once/month and once/week during hurricane season	Records are available upon request
		Storm Water Pump Station Maintained	3 pump station as needed	YES	3 pump stations 250 times in one-yr. Period.	All three pump stations are being re-designed for complete rehabilitations next year
		Canal Control Structures inspected	10 unit once/month	YES	10 unit once/month	Records are available upon request
		Canal Control Structures Maintained	As needed	N/A	None in one yr period.	No maintenance was required during the one year period
		Retention/wetland System Inspected	2 cells - once every 3 months	YES	2 cells- once every 3 months	Records are available on request
		Storm Sewer Pipes Culverts Inspected	As needed	N/A	As need	Pipes are cleaned using a vacuum truck Every pipe running between inlets maintained was cleaned Culverts only maintained as needed
	Weston	Canals inspected/ maintained	Twice/yr	YES	Twice/yr	Records are available on request
		Catch Basin Inspected	1000/yr	YES	1000/yr	Records are available on request
		Retention Ponds	N/A	N/A	N/A	Records are available on request
	Wilton Manors	Canals Inspected	6 miles once/yr	YES	4 miles once/yr	Records are available on request
		Canals Maintained	As needed	YES	4 miles	Records available upon request
		inlets and Catch Basin Inspected	6 per month	YES	6 per month	Records available upon request
	Broward County	Retention Ponds Inspected	4 ponds 9 times/yr	YES	4 ponds 9 times/yr	Records available upon request
	FDOT District 4	Drainage Structure	40,071 ft/ yr	YES	40,071 ft/ yr	Records available upon request
		Ditches Cleaned	13,992 ft/ yr	YES	13,992 ft/ yr	Records available upon request
		Ditches & Slopes repaired	1773 C Y/ Yr	YES	1773 C Y/ Yr	Records available upon request
	FDOT Turnpike	Turnpike Outfall inspected	1/3 of all outfalls in yr 3,4and 5	N/A	All 15 major outfall	Records available upon request
		Turnpike Canals Inspected	25% of system	YES	25% of system	Records available upon request
		Turnpike Canals Maintained	As needed	YES	4400 acres maintained	Records available upon request
		Drainage Structure Inspected	25% of system	YES	25% of system	Records available upon request

R0013018

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Drainage Structures Maintained	As needed	YES	25,00 linear foot maintained	Records available upon request
		Stormwater Treatment Ponds Inspected	12 acres/year	YES	12 acres/year	Records available upon request
		Stormwater Treatment Ponds Maintained	As needed	YES	12 acres maintained	Records available upon request
		D4 Canals Inspected	25% of system	YES	25% of system	Records available upon request
		D4 Canals Maintained	As needed	YES	4213 linear foot	Records available upon request
		Drainage Structure Inspected	25% of system	YES	255 of system	Records available upon request
Roadway Maintenance	Coconut Creek	Street Sweeping/ Litter Control	22 miles once/month	YES	50 miles twice/month	Records are available on request
		Swales Maintained	As needed	N/A	10 miles once/month	Records are available on request
		Storm Drains Inspected	As needed	N/A	0.5 miles once/yr	Records are available on request
	Cooper City	Litter Control Miles	32.96 miles	YES	32.96 miles	no street sweeping done
		Catch Basins Inspected	216 units	YES	448 units	Records available on request
		Swales Maintained	32.96 miles	YES	61 75	Records available on request
		Storm Drains Maintained	2.5 miles	YES	2 5 miles	Records available on request
	Coral Springs	Street Sweeping	118 mile 4 times/yr	YES	118 miles 4 times/yr	Records are available on request
		Storm Drain Cleaned	As needed	N/A	6400 feet once/mos	Records are available on request
		Storm Drain Repaired	As needed	N/A	37 units once/yr	Records are available on request
	Dania	Street and Highway Sweeping	Major roads swept twice/ month. Secondary roads swept once/month City street swept	YES	All streets swept as per target	Records are available on request
		Swales Inspect/maintain Once/month	As needed	YES	75 miles Swales inspected once/mos and maintained as needed	Records are available on request
		Roadside Ditches, Pipes and Culverts Inspected	As needed	YES	6.1 miles of pipe were inspected and maintained as needed	Records are available on request
	Davie	Street Sweeping/litter Control Miles	292 once/mos	YES	292 once/mos	Records are available on request

R0013019

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Catch Basins Units Inspected	1286 once/yr	YES	1286 once/yr	Records are available on request
		Swales Miles Inspected	268 once/mos	YES	268 once/mos	Records are available on request
	Deerfield Beach	Street Sweeping	105 miles/ biweekly	YES	105 miles/biweekly	Records are available on request
		Catch Basins Inspected	725 twice/yr	YES	725 twice/yr	Records are available on request
	Hallandale	Street Sweeping	15 miles once/week	YES	15 miles once/week	Records are available on request
		Catch Basins Inspected	528 units twice/yr 296 units once/yr	YES	528 units twice/yr 296 units once/yr	Records are available on request
		Roadside Ditches, Pipes and Culverts Inspected and Maintained	4 units once/mos	YES	4 units once/mos	Records are available on request
	Lauderdale by the Sea	Streets Sweeping	10 miles once/week	YES	10 miles/week	Records are available on request
	Lauderdale Lakes	Litter Control	22 curb miles/Week	YES	22 curb miles/week	Records are available on request
	Lauderhill	Catch basins units	As needed	N/A	1165 units once/yr	Records are available on request
		Swales	As needed	N/A	8 miles once/mos	Records are available on request
		Street Sweeping/ Litter Control	11.5 miles once/mos	YES	11.5 miles, once/mos	This task is performed daily
	Lighthouse Point	Street Sweeping /Litter Control	41.1 miles once/mos	YES	41.1 miles once/mos	Records are available on request
		Catch Basins Inspected	As needed	YES	457 units once/yr	Records are available on request
		Swales Inspected	As needed	YES	41.1 miles once/yr	Records are available on request
		Storm Drain Inspected	As needed	YES	9 miles once/yr	Records are available on request
	Margate	Inlets and Catch Basins Maintained	1856 units twice/yr	YES	1856 units twice/yr	Cleaned 4 times a year on major roadways Cleaned twice a year on minor roadways
		Street Sweeping and Litter Control 104 Miles	5 miles once/week 12 miles 3/mos 9 miles 2/mos 78 miles once/month	YES	5 miles once/week 12 miles 3/mos 9 miles 2/mos 78 miles once/month	Sweeping and Litter control is also done as needed
		Roadside Drainage Swales Inspected	twice/mos	YES	twice/mos	The Grass is cut twice a month Litter and debris is removed prior to cutting grass and as needed
	Miramar	Street sweeping/Litter Control	93.6 miles once/mos	YES	93.6 miles once/mos	Records are available on request

R0013020

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
		Storm Drain	As needed	YES	2/mos	Records are available on request
		Stormwater Structures Unit	As needed	YES	10/mos	Records are available on request
		Catch Basins Inspected	As needed	N/A	300 units	Records are available on request
		Swales Inspected	50 miles once/mos	N/A	50 miles once/mos.	Records are available on request
	North Lauderdale	Street Sweeping/ Litter Control	N/a	N/A	22 miles	Records are available on request
		Stormwater Water Structure Inspected	16 once/yr	N/A	16 once/yr	Records are available on request
	Oakland Park	Street Sweeping/litter Control	87.4 miles once/mos	YES	87.4 miles once/mos	Records are available on request
		Swales Cleaned and Maintained	As needed	YES	10 miles once/mos	Records are available on request
	Parkland	Streets Sweeping	24 miles twice/mos	YES	24 miles twice/mos	Records are available on request
		Catch Basin Inspect/maint	100 units once/yr	YES	100 units once/yr	Records are available on request
		Roadside Ditches Inspected	once/yr	YES	once/yr	Records are available on request
		Swales Inspected	32 miles 4 times/yr	YES	32 miles 4 times/yr	Records are available on request
	Pembroke Park	Street Sweeping	4 times/yr	YES	4 times/yr	Records are available on request
		Catch Basins Inspected	50 units twice/mos	YES	50 units twice/mos	Records are available on request
		Roadside Ditches Inspected	3.5 miles once/mos	YES	3 5 miles once/mos	Records are available on request
	Pembroke Pines	Street Sweeping/litter Control	165 miles once/2 weeks	YES	165 miles once/2 weeks	Records are available on request
		Swales Inspected	165 miles once/week	YES	165 miles once/week	Records are available on request
	Plantation	Streets and Highways Swept	187 miles once/week	YES	187 miles once/week	Records are available on request
		Catch Basins Inspected/maintained	17 units/3 mos	YES	1779 units/3 mos	Records are available on request
	Pompano Beach	Street Sweeping/ Litter Control	600 miles once/mos	YES	600 miles once/mos	Records are available on request
		Swales Inspected	As needed	YES	110 miles once/mos	Records are available on request
		Inlets & Catch Basins Inspected	2125 Unit once/each rainfall	YES	2125 Unit once/each rainfall	Records are available on request
		Inlets & Catch Basins maintained	As needed	YES	560 units once/ yr	Records are available on request
		Stormwater Structure Units Inspected	As needed	YES	15 units/mos	Records are available on request
	Sea Ranch Lakes	Street Sweeping/litter, Miles	4 mile/daily	YES	4 miles/daily	Inspected daily and maintained as needed

R0013021

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
	Sunrise	Streets Sweeping/litter Control	140 miles/ quarterly	YES	140 miles/quarterly	Records are available on request
		Catch Basins Maintained	2500 unit once/yr	YES	2500 unit once/yr	Records are available on request
		Swales Maintained	3 times / mos	YES	3 times/mos	Records are available on request
		Ditches, Pipes and Culverts Inspected	Twice/yr	YES	Twice / yr	Records are available on request
	Tamarac	Street Sweeping/ Litter Control	Curbed streets: twice/month, uncurbed streets: once/quarter.	YES	46.3 miles of curbed streets twice/month,225 miles of uncurbed streets once/quarter	Records are available on request
		Swales Maintained	As needed	N/A	11360 linear feet of swale re-graded	Drawings of this NW 78 St swale re-grading project available upon request
		Storm Drains Maintained	As needed	N/A	As needed	Storm drains and inlets adjacent to roadways are sprayed to remove weeds. Litter, debris and vegetation is removed as needed to maintain proper flow
	Weston	Street Sweeping/ Litter control	5.5 miles once/week	YES	5.5 miles once/week	Records are available on request
		Swales	100% once/two week	YES	100% once/two week	44.2 miles, Records are available
		Catch Basin Maintained	As needed	YES		Records are available on request
	Wilton Manors	Street Sweeping/ Litter Control	3 mile once/week	YES	3 mile once/week	Records are available on request
		Catch Basins Inspected	4 per month	YES	4 per month	Records are available on request
		Storm drain pipes cleaned	1000 feet semi-annually	YES	1000 feet semi-annually	Records are available on request
		Swales Maintain	5 per month	YES	5 per month	Records are available on request
	Broward County	Street Sweeping	329 miles per/ mos	YES	329 miles/mos	Records are available on request
		Catch Basins Inspected	2115 units once/4mos	YES	2115 units once/4 mos	Records are available on request
		Swales Inspected	7883 acres once/ 5 weeks	YES	7883 acres once/ 5 weeks	Records are available on request
	FDOT District 4	Mowing	1207 acres/yr	YES	1207 acres/yr	Records are available on request
		Sweeping	338 miles/yr	YES	338 miles/yr	Records are available on request
		Litter removal	2369 acres/yr	YES	2369 acres/yr	Records are available on request
		Roadside shoulders, slopes, ditches	327 acres/ yr	YES	327 acres/ yr	Records are available on request

R0013022

PROGRAM ELEMENT	PERMITTEE	REQUIREMENT	ACTIVITY SCHEDULE			COMMENTS
			Activities Required by SWMP	Complied with	Activities Accomplished during calendar year	
	FDOT Turnpike	Mowing	As needed	YES	95,555 ha/yr	Records are available on request
		Clearing & Grubbing	As needed	YES	2,654 ha/yr	Records are available on request
		Litter removal	As needed	YES	2,233 ha/yr	Records are available on request
		Clean and reshape ditch	As needed	YES	6,331 m/yr	Records are available on request
		Modify external drainage structure	As needed	YES	1 unit/yr	Records are available on request
		Mechanical Sweeping	As needed	YES	5,738 Km/yr	Records are available on request
		Sodding	As needed	YES	15,159 sm/yr	Records are available on request
		Clean Manholes & Inlets	As needed	YES	246 units/yr	Records are available on request
		Landscape	As needed	YES	61,445 sm/yr	Records are available on request
		Tree removal	As needed	YES	217 ea/yr	Records are available on request
		Storm sewer inspection	As needed	YES	23.4 m/yr	Records are available on request
		Pipe Desilting	As needed	YES	2,900 m/yr	Records are available on request
Monitoring	DPEP	Dry Weather Screening	100% system, once/5 years.	YES	20% system	Copies of Screening Field Reports
		Out fall Monitoring	5 outfall Twice/yr	YES	5 Outfalls Twice/yr	Records are available

R0013023

D. NARRATIVE REPORT

The narrative report is set up in the following manner. The SWMP element's objective (in bold) is followed by each individual NPDES MS4 Permit annual report requirement (in italics) under general discussion of element, strengths and weaknesses, assessment of controls, revisions, and compliance status of the elements. The Narrative Report section of the Annual report primarily discuss those SWMP Elements which were not included within the SWMP Summary Table.

1. Operation and Maintenance of Structural Controls and Storm Water Collection Systems

Objective: reduce the discharge of pollutants to the maximum extent practical

General Discussions:

Conduct inspections and maintenance of the structural controls and storm water collection systems discharging to the MS4 within each permittee's jurisdictional area. Maintain an internal record keeping system to track inspections and maintenance activities performed on structural controls during the permit term. Annually, assess the accomplishments of your inspection and maintenance program as compared to the target goals outlined in Table II.A.1.b. on pages 5 - 13 of this permit.

The Summary Table in Section C of this report, entitled "Co-Permittees Activities Accomplished During Calendar Year" summarizes the co-permittee inspection and maintenance (I&M) activities at structural controls and storm water collection systems. This program is very effective. Some of the co-permittees have added more staff and resources to fulfill this requirement.

Strengths and Weaknesses:

Co-permittees achieved the target goals outlined in Table II.A.1.b. This enables entities responsible for the system to evaluate the condition of the facilities and the need for maintenance repairs and replacement. A weaknesses of the program is that level of detail varies from co-permittee to co-permittee based on the level of information given at the time of permit application.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

2. *Control of Discharges from Areas of New Development and Significant Redevelopment*

Objective: to reduce discharge of pollutants from MS4s, which receive discharges from areas of new development and significant redevelopment.

Activities completed:

Broward County achieves compliance through stormwater management construction/operation licensing from DPEP, and FDOT achieves compliance through their drainage connection permits. FDOT District four has updated the report form for outfall inspections (Appendix I-1 of Attachment 23) to identify connections to FDOT District Four's MS4 and other relevant information.

General Discussion:

Continue to implement the Broward County Land Use Plan which contains objectives and policies relating to drainage and storm water management that provide controls for areas of new development and significant redevelopment. For areas of new development, adhere to the treatment performance standards set forth in the State Water Policy.

Broward County continues to implement the land use plans. An updated Broward County Land Use Plan was adopted on November 19, 1996. The Plan's Drainage and Natural Aquifer Groundwater Recharge Element contains the following objectives:

- $ Objective 7.1. The Office of Environmental Services (OES) shall implement drainage improvement to remove Group One Deficiencies by 2010, and South County (SC) and Central County (CC) deficiencies by 2015.
- $ Objective 7.2. Stormwater management facilities shall be provided to meet the County's short-term and long-term future surface water management needs.
- $ Objective 7.3. Continue to maximize the use of Stormwater management system facilities so as to encourage compact urban growth patterns.
- $ Objective 7.4. Stormwater management facilities shall be designed, constructed and operated in a manner that conserves potable water resources.
- $ Objective 7.5. Maintain and protect groundwater recharge of the surficial aquifer systems so as to maintain all of the functions of the Biscayne Aquifer.

New development in the areas outside of the independent districts must receive a stormwater management construction/operation license from DPEP. These licenses must comply with State Water Policy, as stated in Broward County Code, Section 27-200 (b)(1)h:

> No surface water management license shall be issued in the absence of reasonable assurances by the applicant that the surface water management system is consistent with the state water policy, Chapter 62-40, F.A.C.

Employ new FDOT Drainage Connection Permit requirements which include a "certification of water quality" to be provided by the connecting entity.

The FDOT Turnpike District has implemented the drainage permit requirement as per Chapter 14-86 which includes a "certification of water quality" to be provided by the connecting entity. Procedures and maintenance responsibilities for post-development operation and maintenance are established in Chapter 14-86 of Florida Statutes, and outlined in drainage connection permit application issued by the FDOT.

FDOT District Four accomplishes the control of development and significant redevelopment through the Drainage Connection Permit. A blank copy of the Drainage Connection Permit Application and Permit are provided in Appendix B of District Four report in Attachment 23. It should be noted that receipt of a Drainage Connection Permit does not alleviate the applicant from obtaining a state Stormwater management permit. FDOT District Four is planning to document applicants that actually connect to the MS4, by using the database being developed, and in the review of the Drainage Connection Permit applications (see Appendix I-1 of Attachment 23).

Strengths and Weakness:

This SWMP protects the environment and the plan consistent with all drainage districts throughout Broward County. The weakness of the program is only 19 co-permittees receive stormwater management licenses from DPEP and rest of them receive licenses from independent drainage districts. The independent drainage districts are not co-permittees with Broward County.

The strength of the FDOT Drainage Connection Permit is that it requires applicants to certify compliance with Florida Administrative Code Rule 14-86 that states that "the quality of water conveyed by the connection meets all applicable water quality standards or minimum design and performance standards." Thus the permit serves to minimize impacts of new and significant redevelopment on the water quality. A weakness of the Drainage Connection Permit is that there is no distinction between on-site retention and an actual "connection" to the MS4. Generally, FDOT District Four does not permit new connections to the MS4; however, the wording of the permit does not allow for identification of the few exceptions, the actual connections to the MS4. The review process has been updated to rectify this weakness (see Appendix I-1 in Attachment 23).

Assessment of Controls:

Broward county meets compliance requirements in its jurisdiction. FDOT employs non-structural controls to adequately meet compliance in this area. These controls are the Drainage Connection Permit and the general practice not allowing new connections by permittees to the FDOT MS4. Issuance of Drainage Connection Permits has enabled the FDOT to inventory drainage connections tied to the FDOT systems and to control the quality of discharges to FDOT MS4.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance Achieved

3. Operation and Maintenance of Public Streets, Roads, and Highways

Objective: Operate and maintain public streets in a manner to reduce the discharge of pollutants to the maximum extent possible.

Activities Completed:

All the co-permittees achieved their target during the third year period of this report.

General Discussion:

Implement the litter control program(s) for highways and streets within each permittee's jurisdictional area, as described within the SWMP of the Part 2 application, and properly dispose of the collected material. Perform scheduled maintenance on storm water structures (i.e. catch basins, etc.) and roadside ditches and properly dispose of accumulated sediments. Maintain an internal log documenting these maintenance activities. If these activities are performed by others under a contractual agreement, then the permittee shall retain copies of the contractual agreement which specifies the maintenance activities to be performed and the schedule of frequency.

The Summary Table in Section C of this report, entitled "Co-Permittee Activities Accomplished During Calendar Year" summarizes the co-permittee maintenance schedule and inspection and maintenance (I&M) activities associated with public streets and roads.

Provide a description, for incorporation into the permit, of the standard practices employed to reduce the pollutants in storm water runoff from areas associated with road repair and from all municipally-owned or operated equipment yards and maintenance shops that support road maintenance activities.

This was provided in the First Annual report as required by the permit.

Actively support and promote on a regular basis participation in the Broward Clean and Beautiful Program (an affiliate of Keep America Beautiful, Inc). Provide a summary of the activities performed under this program, within jurisdictional limits, to maintain the public streets, roads and highways.

Formed in 1993, Broward Beautiful (formerly Broward Clean and Beautiful Program) is a public service organization whose goal is to initiate, develop, coordinate, and direct programs for county-wide beautification in cooperation with the citizens, local governments, and businesses of Broward County, Florida. A 14-member Broward Beautiful Board of Directors, appointed by the Broward County Board of County Commissioners, approves of Broward Beautiful fund disbursements.

Broward Beautiful relies on partnerships of business, government, and local groups and employs proven techniques to improve the community appearances. Broward Beautiful's Award Program

recognizes businesses that implement landscaping that beautifies and conforms to basic Broward Beautiful design criteria. The Broward Beautiful Community Grant Program has been established to provide financial assistance to qualifying organizations looking to improve and preserve the natural beauty and environment of Broward County. Grant applications were made available in the year 1999.

The Broward Beautiful Program continues to receive the support of Broward County and the other co-permittees:

- $ The Executive Director of Broward Beautiful is Jennifer Fields Schaufele, Assistant to the DPEP Director.
- $ Roy Gold of Coral Springs is a member of the Broward Beautiful Board of Directors.
- $ The Broward County Commission has supplied $149,000 to support the Broward Beautiful program in Fiscal Year 1999 (October 1998 to September 1999).
- $ Staff support, postage, office space, copying, and other services have been provided in-kind by the DPEP.
- $ As part of the Great Florida Cleanup, Broward Beautiful and DPEP performed a one-day beach cleanup on September 18, 1999. DPEP provided $3,224 of support for the program for T-shirts, publicity, etc.
- $ Florida Department of Transportation has designated $350,000 of "beautification money" to Broward Beautiful.
- $ DPEP and Broward Beautiful sponsored the annual Waterway Cleanup, where debris is removed from Broward County waterways.

Some of the co-permittees like the City of Oakland Park started a program called "Adopt a Street" for beautification. Flyers distributed to the public are in Attachment 25 which gives the list of streets adopted in the year 1999 and available streets for future adoption.

Coordinate the "Adopt-A-Highway" program for local organizations to be identified with specific highway cleanup and beautification projects. Conduct routine inspections of each FDOT maintenance facility to verify that BMPs are operational and to determine changes necessary to improve runoff quality.

The FDOT statewide "Adopt -A-Highway" program has been in place since 1990. This program is effective on allowing the general public to participate on cleaning up state roadways and promoting a cleaner environment. The FDOT has coordinated, through the local maintenance offices, 2340 volunteers who have cleaned up around 300 miles of roadway within the District Four and Turnpike. This program is effective on allowing the general public to participate on cleaning up state roadways and promoting a cleaner environment. FDOT has a web-page address is http: www.dot.state.fl.us moreDOT adopt.htm.

The FDOT District four and FDOT Turnpike don't have maintenance yards facilities within the limits of Broward County MS4 Permit area.

Strengths and Weakness:

The litter control program eliminates blockages in storm drains and reduces the possibilities of flooding. The work is labor intensive. There has been some concern that sediments removed may be considered hazardous material which is very expensive to dispose of.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved by all co-permittees.

4. Ensure Flood Control Projects Consider Water Quality Impacts

Objective: Assess water quality impacts on receiving water for flood management projects

Activities Completed:

Areas of new development and new flood control projects in Broward County received a Stormwater Management Construction/Operation license. The list of those sites inspected this year is in Attachment 13.

The association of water quality facilities and flood control facilities for FDOT is governed by state regulations (Chapters 62-25 and 62-40) which require the treatment of stormwater runoff within all facilities constructed after 1985. FDOT structures comply with these requirements and require systems that connect to FDOT facilities to comply as well. It should be noted, however, that FDOT District Four has no requirements under this section of the permit.

General Discussion:

Ensure that all new developments, significant redevelopments and new flood control projects adhere to the performance standards set forth in the State Water Policy.

Areas of new development, significant redevelopment, and new flood control projects must receive a stormwater management construction/operation license. These licenses must comply with State Water Policy, as stated in Broward County Code, Section 27-200 (b)(1)h:

> No surface water management license shall be issued in the absence of reasonable assurances by the applicant that the surface water management system... is consistent with the state water policy, Chapter 62-40, F.A.C.

Provide a copy of the municipality's adopted "Comprehensive Plan" required in accordance with Chapter 163 of the Florida Statutes, which states that the Comprehensive Plan should set forth goals, objectives and policies for water quality, master planning and flood protection.

Copies of the pertinent portions of the co-permittee municipal comprehensive plans were submitted along with the First Annual Report.

Strength and Weakness :

The regulation ensures that all construction projects obtain the license. The presumption that the water quality regulation standards will result in discharges that will meet state water policy.

The strength of this element is in FDOT's linkage of permit requirements and state regulations. As described in the Part 1 and 2 permit applications, within the state of Florida, stormwater facilities built since about 1985 are required to provide for stormwater runoff treatment. This state regulation (Chapter 62-25, Florida Administrative Code) is required for new facilities as well as significantly modified ones. Therefore, the construction or modification of FDOT District Four Stormwater facilities must meet state regulatory requirements to obtain a permit. No weaknesses have been identified thus far.

Assessment of Controls:

The current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

5. ***Identification, Monitoring, and Control of Discharges from Municipal Waste Treatment, Storage, or Disposal (TSD) Facilities not covered by an NPDES Storm Water Permit***

Objective: Identify measures to monitor and reduce pollutants in storm water discharges from municipal waste TSD facilities

Activities Completed:

There were 32 Broward County municipal waste handling and landfill sites identified which were not

covered by NPDES storm water permit. Monitoring and control of discharges from these facilities are regulated by county and state regulations.

General Discussion:

Provide a description of the program employed to evaluate, for each co-permittee, through inspections and monitoring, municipal waste treatment, storage and disposal (TSD) facilities which are not covered by NPDES permit(s). This requirement may be satisfied through cooperative efforts with other co-permittees. Implement the program designed to reduce pollutants in storm water discharges from municipal waste treatment, storage and disposal facilities which are not covered by NPDES permits.

State permitting and county licensing programs ensure that municipal waste handling facilities and landfills comply with storm water programs. Surface water at the 32 Broward County municipal waste handling facilities and landfills are regulated through Florida Department of Environmental Protection (FDEP) rules in Chapter 62, F.A.C. and Broward County Code, Chapter 27. Please see the table below.

Broward County Solid Waste Facilities	Address	City
Airport Recycling Specialists	3551 SW 2nd Ave.	Ft. Lauderdale
Broward County (BC) Interim Contingency Sanitary LF	7101 SW 205 Ave.	Pembroke Pines
BC Sanitary Landfill (closed)		Davie
BC Residential Transfer Unit - Central	5490 Reese Rd.	Davie
BC Residential Transfer Unit -North	2780 Powerline Rd.	Pompano Beach
BC Residential Transfer Unit - South	5601 W. Hallandale Rd	Hollywood
Central Sanitary Landfill - Ash Monofill	3000 NW 48th St.	Pompano Beach
Central Sanitary Landfill and Recycling Center	3000 NW 48th St.	Pompano Beach
Central Sanitary Landfill - Material Rec. Fac.	3000 NW 48th St.	Pompano Beach
Central Sanitary Landfill - Trash Transfer St.	3000 NW 48th St.	Pompano Beach
Central Sanitary Landfill - Yard Trash Compost	3000 NW 48th St.	Pompano Beach
Chambers Waste Systems of Florida	SW Pembroke Rd & 208 Ave.	Pembroke Pines
Coral Springs Trash Transfer Station	NW 121 st Ave & Wiles Rd	Coral Springs
Deerfield Beach Trash Transfer Station	360 SW 4th St.	Deerfield Beach
Fort Lauderdale Trash Transfer Station A	2101 NW 6th St.	Ft. Lauderdale
Fort Lauderdale Public Service Trash Transfer	201 SW 12th Ave.	Ft. Lauderdale
Fort Lauderdale Snyder Park Trash Transfer Station	3299 SW 4th Ave.	Ft. Lauderdale
Hallandale Residential Trash Transfer	NW 8th Ave. & 2nd St.	Hallandale
Hollywood 56th Ave. Mulch Processing	3400 NW 56th Ave.	Hollywood
Hollywood Residential Trash Transfer	3400 NW 56th Ave.	Hollywood
Plantation Residential Trash Transfer	750 NW 91st Ave.	Plantation
Envirocycle, Inc.	849 SW 21st Terrace	Ft. Lauderdale
J & A Transfer, Inc.	2241 NW 15th Ct.	Pompano Beach

Broward County Solid Waste Facilities	Address	City
Pompano Park Compost Facility	1800 SW 3rd St.	Pompano Beach
Pompano Silica and Sand	1951 N. Powerline Rd.	Pompano Beach
Recycle America of Broward County	810 NW 13th Ave.	Pompano Beach
Reuter Recycling of Florida	20701 Pembroke Rd.	Pembroke Pines
Rocklake, Inc..	3300 NW 27th Ave.	Pompano Beach
Tire Recycling of Florida	6116 NW 2nd Ave.	Ft. Lauderdale
Transfer/ Recycling Services	7061 SW 22nd Ct.	Davie
UHEL Polly Hauling, Inc.	2201 NW 16th St.	Pompano Beach
Waste Magic Recyclers Central, Inc.	1501 NW 12th Ave.	Pompano Beach

Surface water licenses are either issued separately, such as the Broward County Department of Planing and Environmental Protection (DPEP) Surface Water Management License, or together with licenses for other programs, such as DPEP County Resource Recovery and Management License. Presented below are descriptions of the Stormwater stipulations of various licenses and permits required of solid waste management facilities.

$ DPEP Resource Recovery and Management License: Issued by the Solid Waste section of DPEP, the license applies to all Broward County landfills, compost facilities, transfer stations, yard trash and wood incinerators, and material recovery facilities. A license requirement is that "sanitary landfills shall provide for the collection, control and treatment of surface runoff from the site to meet established water quality standards of receiving waters." (Broward County Code 27-215(f)(3)) The County has been designated by the State to license all solid waste management facilities accept landfills, which are licensed by both the DPEP and Florida Department of Environmental Protection (FLDEP). In addition, DPEP Solid Waste Section follows the FLDEP Solid Waste Management regulations in issuing the license to landfills and other solid waste facilities.

$ FLDEP Solid Waste Management Facility Permit: Issued by the Solid Waste Section of the FLDEP, the permit is issued to Broward County landfills. Permit requirements for solid waste management facilities that incorporate surface water issues include the following: 1) Landfill surface water monitoring points installed at locations to yield semi-annual samples[1] of surface water -standing water, flowing water bodies, discharges from detention ponds - that may be affected by the landfill. (Florida Administrative Code (FAC) Chapter 62-701.510); 2) Landfill surface water management systems shall be properly designed, constructed, and maintained.[2] (FAC Chapter 62-701.700); and 3) stormwater management systems for all solid

[1] The samples shall be analyzed for specific conductivity, unionized ammonia, pH, total hardness, dissolved oxygen, biochemical oxygen demand, turbidity, copper, temperature, iron, colors, sheens, mercury, nitrate, zinc, total dissolved solids, and total organic carbon.

[2] Surface water management systems.

(a) A Stormwater management system shall be designed, constructed and maintained which, at a minimum, prevents Stormwater from the peak discharge of the 25 year storm event from running onto those portions of the landfill which have not been closed.

(b) A Stormwater management system shall be designed, constructed and maintained which collects and controls, at a

waste management facilities shall be operated and maintained as necessary to meet applicable standards of FAC Chapter 62-302 (Surface Water Quality Standards), FAC 62-330 (Regulation of Stormwater Discharge) and FAC 62-25 (Environmental Resource Permitting).

In addition to surface water stipulation imbedded in solid waste regulations, municipal waste facilities also are subject to the following surface water programs:

- $ FLDEP Surface Water Discharge Permit: The permit ensures surface water management units,except those already permitted by the South Florida Management District, comply with the technical requirements of (FAC Chapter 62-25).
- $ DPEP Surface Water Management License: Issued by the Surface Water Management Section of the DPEP, the license ensures that all surface water management units outside the independent drainage districts comply with the technical requirements of Broward County Code 27-200 (b).
- $ South Florida Water Management District (SFWMD) Surface Water Management License. The license applies to solid waste facilities that are greater than ten acres or have more than two acres of impervious surface.

Provide a description of the program to monitor pollutants in runoff from the City of Tamrac Sewer Treatment Plant and Sludge Farm which was closed in 1987.

This description was provided in the First Annual Report.

Strengths and Weakness:

The Broward County had similar policies, programs and regulations for a number of years before the MS4 permit was issued. It consistent throughout the Broward County. The Broward County Code prohibits discharges from these types of facilities.

Assessment of Control:

The Broward County Code adequately meets compliance in this area.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

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minimum, the volume of runoff from a 25 year, 24 hour storm event.

(c) Stormwater controls shall include retention or detention ponds, and drainage ways specifically designed and sized according to local drainage patterns, soil permeability, annual precipitation, area land use, and other characteristics of the contributing watershed.

(d) Stormwater management systems shall be designed to avoid mixing of Stormwater with leachate. Stormwater or other surface water which comes into contact with the landfilled solid waste or mixes with leachate shall be considered leachate and is subject to the requirements of Rules 62-701.500(8) and 62-701.510(5), F.A.C.

Broward County has achieved compliance.

6. Control of Pollutants Related to Application of Pesticides, Herbicides, and Fertilizers

Objective: Implement controls to reduce, to the MEP, the discharge of pollutants related to the storage and application of pesticides, herbicides, and fertilizers applied by employees or contractors, to public rights-of-way, parks, and other municipal property.

Activities completed:

Applicators are trained and certified in county. Broward County has provided training to the pesticides applicators.

General Discussion:

Implement the program, as described within the SWMP in the Part 2 permit application, to reduce pollutant loads associated with the application of pesticides and herbicides.

Broward County and Florida Department of Transportation (FDOT) continue to implement the program as described within the SWMP in the Part 2 permit application related to pesticides, herbicides, and fertilizers. The application of pesticides, herbicides, and fertilizers is regulated under Broward County Department of Planing and Environmental Protection (DPEP) Article XIII wellfield protection Chapter 27-380(d) and 27-380(e).

Require evidence of proper certification for all applicators contracted by the municipality to apply pesticides and herbicides on municipal and FDOT property.

Co-permittees have submitted copies pesticide applicator licenses issued by the Florida Department of Agriculture and Consumer Services. (Copies are available in Attachment 3.)

Provide a description, for incorporation into the permit, of the existing public education program(s), employed within jurisdictional areas,. to encourage the public to reduce their use of pesticides, herbicides, and fertilizers. This requirement may be satisfied through cooperative efforts with other permittees, public agencies, or private entities.

It was provided in the first year report as per the requirement.

Provide a description of the program and procedures implemented by municipal staff, within each jurisdictional area, to minimize the use of pesticides, herbicides and fertilizers and to properly apply, store and mix these products. Where no comprehensive program of this nature exists, the permittee(s) shall develop and implement a program to include proper training and/or on-the-job supervision for municipal employees who apply, store or mix these products. In a summary of the program developed in the subsequent ANNUAL REPORT.

This element has been completed in the second year of the permit. Please see the second year permit

for detail. No changes have been made.

Implement the program, described in the FDOT Statewide SWMP, to minimize the use of pesticides, herbicides, and fertilizers and to properly apply, store, and mix these products.

FDOT District Four minimizes the use of pesticides, herbicides and fertilizers as well as properly trains and certifies FDOT applicators. Certification is required of any applicator with which FDOT contracts. FDOT requires that all applicators obtain Florida Department of Agriculture Public Applicator certification for use of Restricted Pesticides before applying any pesticides in accordance with Chapter 5E-9, F.A.C. The District 4 is developing procedures to improve the documentation of pesticide, herbicide and fertilizer application in Stormwater pond areas to in conjunction with the MMS more efficiently track the use of such chemicals in sensitive areas. The FDOT encourages the use of manual vegetation removal and track driven roller wiper application methods over spraying to minimize the potential for environmental degradation.

The Turnpike District contracts out these services when required. As a contract requirement, the contractor must be certified to apply chemicals in order to be considered for the job. Limited use of herbicides is used for nuisance control around concrete structures or hard-to-reach places. Minimal use of herbicides is also used in some mitigation sites to control regrowth of nuisance species, such as cattails.

Strengths and Weakness:

This SWMP is good for safety, health of the public and the environment. There was no comprehensive plan of this type before this permit was issued.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved by all co-permittees.

7. a.) Illicit Discharges and Improper Disposal: Inspections, Ordinances, and Enforcement Measures

Objective: Effectively prohibit non-storm water discharges to the MS4 by the permittees through the use of inspections, ordinances, and enforcement

Activities Completed:

Two golf courses were investigated as part of the requirement to implement DPEP's random inspection program for illicit connections and illegal dumping into the MS4.

FDOT District Four and Turnpike have developed programs to achieve compliance with this requirement of the MS4 permit. The inspection and illicit connection inspection programs are shown in Appendix I-2 and Appendix I-3 respectively in District 4 report and Appendix H of Turnpike report.

General Discussion:

Identify those of the non-storm water discharges listed under Part II.7.a. on page 16 of the permit which will be allowed to be discharged to the MS4. Describe conditions, if any, to be placed on allowable non-storm water discharges. Provide a copy of this identification.

This element has been discussed in the First Annual Report.

Continue to Implement the Broward County DPEP random inspection program to identify potential illicit connections and illegal dumping into the MS4. Maintain a log documenting inspections.

This year's study aims at determining whether there is any excessive nutrients and pesticides in golf course runoffs. Two golf courses in Broward County were selected for this purpose. They are Palm Air Country Club located at the central part of the Broward County and Deer Creek Golf Club which is located in the northern part of the Broward County. The report "Pesticides and Nutrients Occurrence at Golf Courses" is in Attachment 5. The report concludes that the phosphorous levels are high in surface water at both the golf courses. There is no increase in total Nitrogen level. That shows there is no effect of nutrients that were used at golf courses on surface water quality. Diazinon, Atrazine and Ethion were detected in the surface water. However, the levels are below the Broward County standards for fresh water.

Develop a program to inspect drainage connections to the FDOT MS4 after project completion to ensure continued compliance with drainage connection permit requirements and to ensure that no illicit or non-permitted connections have been made. In cases where another regulatory agency requires a periodic certification of compliance, the program developed may allow FDOT to accept this certification of compliance in lieu of further inspections by FDOT. After development, include a description of the inspection program in the subsequent ANNUAL REPORT for incorporation into the permit.

FDOT Districts have developed programs to achieve compliance with this requirement of the MS4 permit. The inspection and illicit connection inspection programs are shown in Appendix I-2 in Attachment 23 and Appendix I-3 in the Attachment 23 respectively.

The procedures developed are consistent with the protocol documented in the Statewide SWMP for investigation of potential illicit connections. The three-fold procedure is: determine if the discharge is definitely an illicit discharge; determine the source of the discharge through the use of the Drainage Connection Permit; and notify EPA, FDEP and co-permittees, as appropriate.

Implement developed program to inspect drainage connections to the FDOT MS4 after project completion. Maintain an internal log documenting inspections and enforcement actions performed and provide a summary of these records in each subsequent ANNUAL REPORT.

Final inspection of the completed drainage connection is already in place for FDOT. Drainage Connection Permits are rarely issued in District four. Only two drainage connection permits were issued in 1998. They are Golden Bear Golf centers Inc., 5601 West Mcnab Road, North Lauderdale and Broward County School Board at I-595 and Nobhill Road in Davie. These drainage connection were inspected after the constructions. The Turnpike district conducted inspections and found 36 drainage connections. Some of them were not permitted by Turnpike as they were connected before the permit requirement. Log of the inspections are in Appendix N of attachment 23 of Turnpike.

Strengths and Weakness:

This SWMP allowed us to develop a random inspection program for airports, seaport and golf course facilities. There is a duplication of resources between Broward County, Hollywood and Fort Lauderdale because each has a MS4 Permit.

Assessment of Controls:

Controls are adequate for complying with the permit requirements.

Revision:

FDOT request that the permit be modified to exclude FDOT from enforcement procedures beyond its jurisdiction and limit its responsibilities in these instances to that of notification to the appropriate agency or municipality.

Compliance Status:

Compliance Achieved by all co-permittees.

7. b.) Illicit Discharges and Improper Disposal - Field Screening

Objective: Continue ongoing efforts to detect the presence of illicit connections and improper discharges to the MS4

Activities Completed:

Dry field screening has been completed successfully for the 50 sites in the third year of the permit. has been completed successfully. The FDOT Turnpike District has developed a program to field screen all major outfalls.

General Discussion:

Perform on-going field screening, as described in the SWMP within the Part 2 application, to detect the presence of improper disposal and illicit connections to the MS4s throughout the term of the permit. Provide, in the first ANNUAL REPORT, a schedule of the on-going field screening to be performed throughout the term of the permit. Perform field screening, as described on page 17 of the Permit, to detect the presence of improper disposal and illicit connections to the FDOT MS4. Collect inventory information on outfall and on portions of the MS4 not mapped and update municipal mapping data on an ongoing basis.

Field screening was undertaken to detect the presence of improper disposal and illicit connections to the MS4 throughout the year. Fifty major outfall dry field screening sites were selected in 1998-99. Dry field screening consisted of inspecting these major outfalls for illicit discharges. All fifty locations were inspected by April 1999. Attachment 6 contains a table describing the results of those inspections.

A positive result of the dry field screening was that no evidence of illicit connections or improper disposal (as evidenced by discharges during the dry season) was discovered during the dry field screening. Hence, no enforcement activity was required. However, dry field screening often revealed that the locations of the major outfalls as indicated in the inventory were inaccurate.

Strengths and Weakness:

This program helps to identify illicit discharges. The dry field screening revealed that some of the major outfall locations had been shown incorrectly. Upon locating the major outfalls during dry field screening, major outfall locations were updated. A large percentage of outfalls are under water and their inspection will not assist dry field screening.

Assessment of Controls:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

7. c.) Illicit Discharges and Improper Disposal - Investigation of Suspected Illicits and/or Improper Disposal

Objective: Develop and implement standard procedures to be followed to investigate portions of the MS4 that, based on the results of the field screen or other appropriate information, indicate a reasonable potential of containing illicit discharges or other sources of non-storm water

Activities Completed:

A log of violation reported to DPEP were maintained and inspections were carried out. If there were any violation found, enforcement actions were taken. The FDOT Turnpike District has developed a pamphlet titled "Don't Pollute Our Florida Waterways" which informs the general public on the importance of reporting illicit discharges and directs the general public to call the Turnpike's Public Information offices to report spills and/or illicit discharges.

General Discussion:

Report all suspect conditions and violations (regarding illicit connections and improper disposal to the MS4s) to Broward County Department of Planing and Environmental Protection for investigation and elimination. Continue to implement the investigative procedure, as described in the SWMP in the Part 2 application, to identify and terminate any source(s) of illicit connections or discharges to the MS4. Based on the results from the field screening or citizen reports, establish a schedule to begin inspections. Maintain a log of violations reported to DPEP along with the enforcement action taken.

Broward County Department of Planing and Environmental Protection (DPEP), Enforcement Administration receives complaints from other governmental agencies and the public for possible violations to the Broward County Code. DPEP has over 70 Natural Resource Environmental Officers (NREO) from six divisions to respond and investigate any Code violations and issue citations, warning notices or a notice of violation to enforce ordinances/regulations regarding illicit discharges to the MS4. The DPEP Enforcement Administration maintains a file describing the complaint, source location, findings and enforcement action taken.

Once a complaint is received by DPEP, Natural Resources Enforcement officer (NREO) is dispatched from one of DPEP's Divisions to conduct a complete investigation of a possible contamination or degradation of the environment. During the course of the investigation or inspection, inspectors may make observations, conduct interviews, obtain statements review and copy records, take physical samples, take photographs, and write notes describing the incident. The final report is submitted to the Enforcement Administration for closure or enforcement action.

Attachment 23 Appendix TK1 describes the Turnpike District's Hazardous Materials Emergency Response Procedures.

The table entitled "Log of Violations Reported to DPEP and Enforcement Action Taken," located in Attachment 7, illustrates the following about DPEP notification, reporting, investigation and enforcement actions applicable to the MS4:

$ From December 1998 to December 1999, fifty-three storm drainage related complaints were received by DPEP.

$ As indicated in the "Division Code" column of the table, either the Water Resources Division's Surface Water Section (abbreviated WR-SW in the table), Water Resources Division's Non-domestic Wastewater Section (WR-IW), Water Resources Division's Domestic Wastewater Section (WR-DW), Biological Resource's Dredge and Fill Section (BR-DF) or Pollution Prevention and Remediation Division's Hazardous Materials Section (PP-HM) responded to MS4 complaints based upon the type of complaint.

$ Five out of the fifty-three complaints resulted in Warning Notices being issued to the facility out of compliance.

Develop investigative procedures to identify the source(s) of illicit connections or discharges to the FDOT MS4. These procedures shall include notification to FDEP and EPA of illicit connections. After development, include a summary of the investigative procedures in the subsequent ANNUAL REPORT.

The Statewide Storm Water Management Plan describes methods and procedures to reduce the discharge of pollutants to the maximum extent practical (MEP) using management practices, control techniques and system, design and engineering methods.

As described in the previous page that the final report is submitted to Enforcement Administration for closure or enforcement action after the inspection is done by NREO. Broward County Chapter 27-193(4)Surface water management :

a. Use of storm sewers and sanitary sewers: No domestic wastewater, non-domestic wastewater, or other wastewater shall be discharged into any sewer designated to carry stormwater, unless the discharger has an NPDES permit and existing county license, nor shall stormwater be discharged into a sewer designated to carry domestic wastewater.

b. Construction without a license: Where a surface water management license is required, no water management works within Broward County shall be excavated, created, constructed, altered, or abandoned unless a surface water management license has been obtained.

Broward County Department of Planing and Environmental Protection (DPEP) performs ongoing field screening to detect the presence of improper disposal and illicit connections to the FDOT MS4. When there is the presence of an improper disposal from an illicit connection, DPEP will investigate the source and proceed with corrective and/or enforcement action. DPEP will notify FDOT for notification to FDEP and EPA of illicit connections.

Implement the investigative procedures developed to identify the source(s) of illicit connections or discharges to the MS4.

From December 1998-November 1999 about sixty FDOT outfall inspections were performed. The areas around the outfalls were checked for natural habitat, head wall repair, pipe size and waterway conditions. The objective of the field investigation was to determine if there was any type of illicit discharging. At the time of inspection, conditions of the outfalls and head walls appeared to be in good repair. Vegetation was growing on the banks of the canals, fish were visible and we did not witness any discoloration of the water. Attachment 18 documents the inspection reports.

The Turnpike's HAZMAT Emergency Response Procedures indicates emergency contact information by Mile Post location. Broward County is in between Mile Post 48 and 72. Usually, the general public contacts the Florida Highway Patrol (FHP) Troop "K" for any spills or illicit discharges along the roadways. Zone managers are notified to coordinate an appropriate response with the responsible party, cleanup contractor, and environmental agencies. A list of spills reported in Broward County during permit year three (1999) is included in Appendix L of Turnpike District report.

Strengths and Weakness:

The Broward County DPEP had citizen complaint hotline prior to the issuance of the NPDES MS4 Permit. This program is very labor intensive. The co-permittees may be reluctant to report a discharge from their own facility.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance status:

Compliance achieved.

7. d.) Illicit Discharges and Improper Disposal - Spill Prevention and Response

Objective: Implement procedures to prevent, contain, and respond to spills that may discharge into the MS4

Activities Completed:

Spill prevention procedures were followed within jurisdiction of Broward County municipalities and FDOT. Continue to maintain the Broward County DPEP's 24-hour emergency response hotline. FDOT District Four has contracted with WRS & Infrastructure and Handex of Florida, Inc., to respond to any spill response emergency assigned to them. The contract with WRS & Infrastructure and Handex of Florida, Inc., is handled through the Ft. Lauderdale Operations facility using the protocols defined in the FDOT District 4 On-Call Supervisors Procedure for Haz-Mat or Petroleum

Spills. Turnpike District has developed its own emergency procedures to respond to spill along the Turnpike Roadways network (please see Appendix J of Attachment 23 Turnpike report).

General Discussion:

Implement the various municipal procedures for handling and disposing of chemical spills within each permittee's jurisdictional area. Include notifying the Broward County DPEP Response Team to provide technical support or remediation assistance for hazardous materials or chemical spills. If no procedures of this type exist, the permittee(s) shall develop spill prevention and spill response procedures to effectively mitigate pollutant discharges from spills to surface waters and the MS4. Include training personnel to recognize and quickly assess the nature of spills and to promptly report all hazardous material spills and chemical spills to the Broward County DPEP. Provide a description of the existing or developed spill prevention and response programs or procedures to mitigate pollutant discharges from spills to the MS4 and surface waters.

If a spill has occurred in Broward County, the notifying party -- a citizen, other government agency, or local Police or Fire Department -- contacts Broward County Central Dispatch (BCCD) at (954) 765-5124. (In most cases of spills the local Fire Department is the notifying party.) BCCD then routes the call to the DPEP Hotline which is housed within the DPEP's Enforcement Administration. Enforcement Administration then notifies the appropriate divisions within DPEP. For instance, for a pollutant discharge to the MS4 the Pollution Prevention and Remediation Program Division's Environmental Response Section (ERS) and the Water Resource Divisions's Non-Domestic Discharge Licensing Section would be notified. (After hours, BCCD would contact an on-call ERS site investigator if any emergencies occurred.) ERS will send a site investigator depending on the "Zone" that the spill occurred. Please see the table below.

Emergency Response Section Zones	
Zone 1 (north)	Area between Oakland Park Blvd. To West Palm Beach County Line
Zone 2 (central)	Area between Griffin Rd. and Oakland Park Blvd.
Zone 3 (south)	Area between Griffin Rd. And Dade County Line

During the site check, the site investigator will provide the local authority (police or fire department) with technical support, take samples if necessary, and complete an investigator's report that details the case specifics. Depending on the circumstances of the case, ERS issues a Warning Notice, Notice of Violation, or Citation or refers the case to another Division.

Continue to maintain the Broward County DPEP's 24-hour emergency response hotline to provide assistance in cases of hazardous waste clean-up and emergency chemical spills.

Broward County DPEP's 24-hour emergency response hotline is directed to the Environmental Response Team (ERT) or appropriate Divisions for suspected discharges to the MS4. After hours calls are directed to the DPEP ERT on-call Coordinator. On-call personnel respond to all complaints for investigation on a 24 hours a day, 7 days a week. The ERT investigates and provides technical

assistance for all hazardous waste cleanup and emergency chemical spills.

Implement the FDOT's Emergency Operations Procedures which effectively mitigate potential pollutant discharges to surface waters.

Spill prevention procedures were followed within FDOT jurisdiction in Broward County.
FDOT District Four has continued to implement FDOT District four On-Call Supervisors Procedure for Haz-Mat or Petroleum Spills. This protocol is provided in Appendix D of FDOT District 4 report in Attachment 23.
FDOT District Four has contracted with WRS & Infrastructure and Handex of Florida Inc. to respond to any spill response emergency assigned to them. The contract with WRS & Infrastructure and Handex of Florida, Inc., is handled through the Ft. Lauderdale Operations facility using the protocols defined in the FDOT District 4 On-Call Supervisors Procedure for Haz-Mat or Petroleum Spills.
FDOT District Four responds to emergencies according to specific, documented protocols. This protocol is provided in Appendix D. In addition, FDOT uses WRS & Infrastructure and Handex of Florida, Inc., to handle spill responses in the event that the party responsible for the spill does not take action to clean up the spill. WRS & Infrastructure and Handex of Florida, Inc., are qualified contractors that will cleanup or direct the cleanup of spills in a timely manner.

The Turnpike's Hazardous Materials Emergency Response Procedures, included as Appendix K of Turnpike District, was developed as a guide for Turnpike personnel to respond to HAZMAT spills within the Turnpike's right-of-way. A list of spills that were reported in Broward County during permit year three is included as Appendix L of Turnpike District Report in Attachment 23

Strengths and Weakness:

This is a cooperative effort throughout Broward County. Sometimes it is very difficult to identify responsible party for cleanup.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Compliance Status:

Compliance achieved.

7. e.) Illicit Discharges and Improper Disposal - Public Notification

Objective: Develop and implement a program to promote, publicize, and facilitate public reporting of illicit discharges of water quality impacts associated with discharges to the MS4.

Activities Completed:

Continue to make available literature informing public about problems associated with illicit discharges

to the MS4.Continue to maintain DPEP 24 - hour hotline for the public to report of illicit discharges and improper disposal. The FDOT maintains complaint lines at the local maintenance yard located in the Ft. Lauderdale Operations facility. FDOT maintains a database on illicit connections and responsible parties.

General Discussion:

Provide Broward County co-permittees with a copy of the Broward County DPEP's brochure describing the proper disposal of toxic materials and phone numbers to report the presence of illicit discharges and improper disposal of materials into the MS4. The brochure shall include information on the problems associated with illicit connections or discharges, what to look for and how to report incidents. Continue to maintain the Broward County DPEP 24-hour hotline for the public to report the presence of unpermitted discharges to the MS4. Continue to make available literature informing the public about problems associated with illicit connections or discharges to the MS4, how to spot them, how to report incidents, and the 24-hour Broward County DPEP pollution complaint hotline.

Efforts made by the Broward County DPEP to describe the proper disposal of toxic materials is described in the Attachment 9. The 24-hour hotline has been maintained throughout the year . Literature regarding the illicit discharges or improper disposal to the MS4 is contained in the DPEP brochure entitled "Where Should the Water Go?" (Please see Attachment 8.) In simple language, the brochure describes how to go about disposing of wastewater from outdoor cleaning operations as well as a providing stern warning regarding polluting water bodies. Some of the co-permittees have also distributed some flyers to the public regarding surface water protection (Please see Attachment 8).

DPEP also has a volunteer program which encourages people to inform DPEP about any illicit discharges throughout the Broward County. Volunteers are called Earth Keepers. The brochure about this program is included in Attachment 8.

There is Broward Urban River Trails (BURT) program for Broward County residents. This is a new volunteer program started by DPEP's Water Resources Division. Mr. Kevin Carter of DPEP is a key contact in the program. At present 5 Broward County citizens have volunteered for this program. Their job is to report any contamination observed in a outfall located in their neighborhood after any storm. A brochure has been included in the Attachment 8 about this program.

As part of public outreach program, a presentation was given to the Painting and Decorating Contractors of America. The presentation was about pollution prevention due to paint chemicals. The details of the presentation are in Attachment 19. About thirty people from painting industries around the county attended the presentation.

DPEP is co-sponsor of the waterways cleanup program. Every year on the third weekend of March about 80-100 volunteer work at the DPEP sponsored site to cleanup debris from New River at Delevoe Park. This way people get educated about not throwing trash into water ways.

Maintain a citizen complaint log for FDOT documenting all reports of illicit discharges and what actions were taken to investigate and resolve the problem. Include a summary of this log in each

ANNUAL REPORT.

The District four maintains complaint lines at the local maintenance yard located in the Ft. Lauderdale Operations Facility. FDOT District Four maintains a database on illicit connection reported through citizen complaint lines in place at the local District Four Ft. Lauderdale Operations Facility. Reporting of illicit connections is made through the local maintenance yard to standardize on phone lines which citizens can file all FDOT related complaints within Broward County.

Establish a direct dial local telephone number at the District Office to be used for the reporting of illicit connections, accidental spills, illegal dumping, or other water quality violations to the FDOT District NPDES Coordinator for investigation and action as needed. This requirement may be satisfied through cooperative efforts with other permittees.

FDOT District Four currently has direct phone lines in place at local maintenance yards for complaints and reporting of illicit connections, spills, illegal dumping, or any other water quality violations needing reporting to FDOT by the public. Hence, FDOT District Four request to remove the requirement of the establishment of a direct dial local telephone number within 36 months at the District Office.

FDOT Turnpike District has a direct line 1-800-749-7453 for illicit discharge reporting at the Public Information office. Also, spills and illicit discharges are currently reported to Turnpike zone managers, as indicated in the Turnpike's HAZMAT Emergency Response Procedure in Appendix J of Turnpike report in Attachment 23.

Strengths and Weakness:

The public outreach for educational purposes already existed before this permit. This program is very expensive to implement.

Assessment of Controls:

Current controls are adequate for complying with the permit requirements.

Revisions:

FDOT District Four currently has direct phone lines in place at local maintenance yards for complaints and reporting of illicit connections, spills, illegal dumping, or any other water quality violations needing reporting to FDOT by the public. Hence, FDOT District Four requests to remove the requirement of the establishment of a direct dial local telephone number within 36 months at the District Office.

Compliance Status:

Compliance achieved.

7. f.) ***Illicit Discharges and Improper Disposal - Oils, Toxic, and Household Hazardous Waste Control.***

Objective: Effectively prohibit the discharge or disposal of used motor vehicle fluids, household hazardous wastes, grass clippings, leaf litter, and animal wastes into the MS4

Activities Completed:

Literatures were distributed to the general public about the proper disposal of used motor oil, left over hazardous house hold products, used vehicle tires and lead acid batteries. Continue to implement the Broward County Used oil Recovery program. FDOT distributes information on hazardous waste disposal, used oil recycling, and spill reporting in every Drainage Connection Permit (Appendix F of FDOT report).

General Discussion:

Continue to make available to the public information (by means of literature, lectures, television ads, radio announcements, etc.) on the proper disposal of used motor oil, leftover hazardous household products, used vehicle tires and lead acid batteries. Include information informing the public of the locations of the Broward County recycling facilities, and collection sites for used motor oil, hazardous household products, used vehicle tires, and lead acid batteries and the hours of operation. Continue to implement the Broward County Household Hazardous Waste program which instructs the public on responsible environmental management and proper handling and disposal of household hazardous material. Continue to implement the Broward County Used Oil Recovery program.

Broward County's Office of Integrated Waste Management (IWM) has developed a Household Hazardous Waste Program which allows Broward County residents to bring house hold hazardous waste (for example: paints, thinners/strippers, used oil, automotive fluids, gasoline, solvents, pesticides, insecticides, fertilizers, pool chemicals, spot removers, oven drain cleaners, furniture and metal polish, mercury, batteries and tires) to waste transfer stations. Brochures describing collection site locations and schedules were distributed to Broward County municipalities at the Technical Advisory Committee meetings. IWM has also developed a Used Oil Recycling Recovery Program brochure which describes how and where to drop off your used oil for recycling. In September 1997 approximately 13,000 brochures were mailed to the municipalities of Broward County. This program is advertised in local news papers like Miami Herald and Sun Sentinel. In addition to brochures, television, radio and newspaper ads, the two programs have made available information through the Internet at "www.broward.org" and at a IWM hotline number (954) 765-4999. Please see Attachment 9.

With each FDOT Drainage Connection Permit, include information on used oil recycling, proper hazardous waste disposal, storm water regulations, and spill reporting.

FDOT distributes information on hazardous waste disposal, used oil recycling, and spill reporting with every Drainage Connection Permit (Appendix F Attachment 23).

Strengths and Weakness:

Broward County and co-permittees continue to have pro-active programs of public information. The program is costly to administer and the county assumes the financial responsibility for disposal of the hazardous wastes.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

7. g.) ***Illicit Discharges and Improper Disposal - Limitation of Sanitary Sewer Seepage***

Objective: Minimize un-permitted discharges of dry and wet weather overflows from sanitary sewers into the MS4.

Activities Completed:

Utility owners are required to report DPEP any spill occurred in the Broward County effective November 24, 1998.

Advise appropriate utility owners, municipality, and/or State Agency of violation if constituents common to wastewater contamination are discovered in the MS4 during field screening, routine inspections, regular maintenance or public reporting.

No constituents common to wastewater were discovered during field screening, routine inspection, or regular maintenance. If they were discovered during inspection or by any other means then it was reported to the appropriate utility owner for correction. On November 24, 1999, the wastewater program of DPEP sent a letter to all owners & operators of domestic wastewater treatment plants and collection/transmission facilities about discharge reporting and immediate cleanup activity. The letter is in attachment 10. There were twenty nine sanitary sewer spills reported in the year 1999 which is listed in attachment 10.

Continue to implement the programs conducted by the Broward County Office of Environmental Services Water Supply Division, as described in the SWMP within the Part 2 Permit Application, for limiting infiltration of seepage from sanitary sewers to the MS4s.

Broward County Office of Environmental Services (OES) has embarked on a Sewer System

Rehabilitation Program. This program will rehabilitate the sewer collection systems owned and operated by the twelve Large Users party to the North East Regional Wastewater Treatment Plant User Agreements. The goal of the program is reduce sewer system overflows, exfiltration, infiltration, and inflow while efficiently transporting raw wastewater through the local and regional pumping transmission systems. The program will identify repairs to collection systems to reduce infiltration and inflow, assess the impact of exfiltration during line repairs, and study the impacts of local and regional pumping and transmission modifications. For a complete listing of the Scope of Services for the project, please see Attachment 10 of the First Annual Report.

Advise appropriate utility owners, municipality, and/or State Agency of violation if constituents common to wastewater contamination are discovered in the MS4 during field screening, routine inspections, regular maintenance or public reporting.

On November 24, 1999 the domestic wastewater program of DPEP sent a letter to all owners & operators of Domestic Wastewater treatment plants and collection/transmission facilities about discharge reporting and immediate cleanup activity. The letter is in Attachment 10.

No constituents common to wastewater were discovered during field screening, routine inspection, regular maintenance. If they were discovered during inspection or by any other means then it will be reported to appropriate utility owners for correction. On November 24, 1999 the wastewater section of DPEP sent a letter to all owners & operators of domestic wastewater treatment plants and collection/transmission facilities about discharge reporting and immediate cleanup activity. The letter is in Attachment 10. There were twenty-nine sanitary sewer spills reported in the year 1999 which is listed in Attachment 10. Out of twenty-nine incident only three spills went to storm drains. The storm drains were vacuumed and disinfected immediately so that spill had no affect on nearby surface water bodies.

Include plan of action and schedule, to be detailed in the subsequent Annual Report, to correct the deficiencies.

As per Broward County Code 27B58(b)(3), verbal notification is requir within eight hours of the event ed by calling DPEP (954) 519-1490. Voice mail services are provided. A Fax notification is also acceptable. If there is or has been a discharge to the surface waters (inclusive of storm drain) or abnormal event with a waste water facility outside the weekly hours of 8:00 a.m. to 4:30 p.m. then notification shall also be made to County's emergency dispatch by calling (954) 765-5124. Within three working days of the event, a written report is required that describes the incident, its cause, the measures taken to correct the problem and measures taken to prevent its reoccurrence and the owner's intention toward repair, replacement or reconstruction of affected facilities and a schedule of events leading toward operation within the license conditions and compliance with all provisions of the current version of the Chapter 27 of the Code of Ordinances, Broward County.

Strengths and Weakness:

This program enable the utilities to evaluate the condition of their systems. The high groundwater table limits the seepage of waste water into the water table. Force main breaks underwater are difficult to detect.

Assessment of Controls:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

8. a.) Industrial and High Risk Runoff - Identification of Priorities and Procedures for Inspections

Objective: Identify all targeted facilities and determine priority sites in accordance with the schedule provided in Part III.A.8.a. on of the permit.

Activities Completed:

The high risk facilities in Broward County have been prioritized as per the permit requirement. High Risk facilities are inspected for permit requirements. A procedure for inspection of highrisk facilities has been developed. No drainage connection permits have been issued by the FDOT Districts to any high-risk facilities in Borward County.

General Discussion:

Inventory and prioritize all existing high risk facilities discharging into the MS4 within each permittee's jurisdictional area. High risk facilities shall include municipal landfills, hazardous waste treatment, storage, disposal and recovery facilities, facilities that have reported under the requirements of EPCRA Title III, Section 313, private and municipal waste handling facilities and any other industrial or commercial discharge which the permittee determines is contributing a substantial pollutant loading to the MS4. This inventory shall identify the outfall and surface water body into which each high risk facility drains.

Please see the table entitled "Log of Broward County Industrial High Risk Facility Inspections" in Attachment 17. The table lists the name and location of the industrial facility, the name of the MS4 operator, the receiving water body, the facility SIC code and the results of the latest inspections performed.

Implement procedures, within each permittee's jurisdictional area, to determine if the identified high risk facilities are in compliance with all appropriate aspects of the storm water program (e.g. no illicit connections; compliance with local storm water regulation requirements; and if the facility is required to have NPDES permit coverage, a copy of the NPDES storm water pollution prevention plan on site).

Maintain a list of all industrial storm water sources discharging to the MS4 and include an update in each ANNUAL REPORT of any additionally identified industrial facilities not previously listed. Maintain a log documenting the results of the inspections performed.

Develop procedures for the inspection of high risk facilities which hold FDOT drainage connection permits to verify compliance with FDOT Drainage permit requirements. In cases where another regulatory agency requires a periodic certification of compliance, the program developed may allow FDOT to accept this certification of compliance in lieu of further inspections by FDOT.

FDOT District Four will notify Broward County should a contaminant be discovered during field screening in a FDOT outfall or structure that is near to a identified high risk facility. FDOT District Four is currently working on a database system that will identify drainage areas for FDOT's MS4 and flag high risk facilities in the vicinity of these drainage areas. Under the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986, provision of detailed information concerning hazardous substances substantially stored in the permit area was made mandatory. EPCRA increases the public's knowledge of hazardous substances contained in the permit area and allows for quicker and more informed responses in cases of spills.

Broward County Department of Planing and Environmental Protection is the regulatory agency for Broward County including FDOT and regulates many of the high risk runoff sites - municipal landfills, hazardous waste treatment, storage and disposal and recovery facilities, and private and municipal waste handling facilities - directly in the Pollution Prevention and Remediation Programs (PPRP) Division's Solid Waste and Hazardous Materials Sections. In addition to DPEP involvement, other agencies are involved in the regulation of high risk facilities.

Hazardous Materials

Covering over 5,000 sites in Broward County, the DPEP Hazardous Materials Section regulates generation, use, storage, handling, processing, manufacturing, and disposal of hazardous materials. Per Broward County Code 27-354 (f), hazardous material disposal sites cannot be permitted or licensed in Broward County. Therefore, the high-risk hazardous material facilities in Broward County are transfer stations, small quantity generators, solid waste and oil recycling facilities. In addition to the County regulations, Florida Department of Environmental Protection (FLDEP), delegated authority by the EPA, implements a Hazardous Waste Program as well. Although the programs generally overlap, the FLDEP program is not as stringent as the County Program. DPEP issues three different types of facility licenses through the Hazardous Material Section.

$ A hazardous material facility operating license is required for an existing, new or proposed facility

that generates, stores, uses, handles, or manufactures hazardous materials in quantities of twenty-five (25) gallons or more within any one (1) month period of time.

$ A Hazardous Material Transfer Station License is issued to any facility whose primary purpose is to store, hold, or process hazardous material prior to or during transport to a processing or disposal facility.

$ Public Used Oil Collection Facility Registration is required for facilities that store or transfer used oil.

All three of these licenses are monitored once every two years and require that secondary containment shall be "provided with a roof to prevent rainwater from entering the area or, as an alternative, be equipped with a lockable valve to enable the controlled release of any accumulation of clean rainwater." (Broward County Code 27-356 (b)(4)b.3.b) Additionally, any floor drains leading to the Stormwater system in the hazardous material handling area must be sealed. (Broward County Code 27-356 (b)(4)b.4.)

Storage Tank

Storage tank facilities that contain or will contain solid and liquid hazardous materials are regulated by the county to prevent discharge to the ground and surface waters of the county; and to provide specifications for facility design, early detection of a discharge, to provide for containment of discharge, to provide for recovery of discharge, and to provide for maintenance, replacement, and closure. Storage tank facilities are monitored and inspected once a year for compliance with all County, State and Federal regulations.

Solid Waste

State permitting and county licensing programs ensure that municipal waste handling facilities and landfills comply with storm water programs. Surface water at the 32 Broward County municipal waste handling facilities and landfills is regulated through Florida Department of Environment Protection (FDEP) rules in Chapter 62, F.A.C. and Broward County Code, Chapter 27. Please see the table below for the solid waste facilities, and inspection / monitoring schedule.

Broward County Solid Waste Facilities	Address	City	Inspections/Year
Airport Recycling Specialists	3551 SW 2nd Ave.	Ft. Lauderdale	Four times per year
Broward County (BC) Interim Contingency Sanitary LF	7101 SW 205 Ave.	Pembroke Pines	Four times per year
BC Residential Transfer Unit - Central	5490 Reese Rd.	Davie	Once per year
BC Residential Transfer Unit -North	2780 Powerline Rd.	Pompano Beach	Once per year
BC Residential Transfer Unit - South	5601 W. Hallandale Rd	Hollywood	Once per year
Central Sanitary Landfill - Ash Monofill	3000 NW 48th St.	Pompano Beach	Four times per year

Broward County Solid Waste Facilities	Address	City	Inspections/Year
Central Sanitary Landfill and Recycling Center	3000 NW 48th St.	Pompano Beach	Four times per year
Central Sanitary Landfill - Material Rec. Fac.	3000 NW 48th St.	Pompano Beach	Four times per year
Central Sanitary Landfill - Trash Transfer St.	3000 NW 48th St.	Pompano Beach	Four times per year
Central Sanitary Landfill - Yard Trash Compost	3000 NW 48th St.	Pompano Beach	Four times per year
Chambers Waste Systems of Florida	SW Pembroke Rd & 208 Ave.	Pembroke Pines	Once per year
Coral Springs Trash Transfer Station	NW 121 st Ave & Wiles Rd	Coral Springs	Once per year
Deerfield Beach Trash Transfer Station	360 SW 4th St.	Deerfield Beach	Once per year
Fort Lauderdale Trash Transfer Station A	2101 NW 6th St.	Ft. Lauderdale	Once per year
Fort Lauderdale Public Service Trash Transfer	201 SW 12th Ave.	Ft. Lauderdale	Once per year
Fort Lauderdale Snyder Park Trash Transfer Station	3299 SW 4th Ave.	Ft. Lauderdale	Once per year
Hallandale Residential Trash Transfer	NW 8th Ave. & 2nd St.	Hallandale	Once per year
Hollywood 56th Ave. Mulch Processing	3400 NW 56th Ave.	Hollywood	Once per year
Hollywood Residential Trash Transfer	3400 NW 56th Ave.	Hollywood	Once per year
Plantation Residential Trash Transfer	750 NW 91st Ave.	Plantation	Once per year
Envirocycle, Inc.	849 SW 21st Terrace	Ft. Lauderdale	Four times per year
J & A Transfer, Inc.	2241 NW 15th Ct.	Pompano Beach	Four times per year
Pompano Silica and Sand	1951 N. Powerline Rd.	Pompano Beach	Four times per year
Recycle America of Broward County	810 NW 13th Ave.	Pompano Beach	Four times per year
Reuter Recycling of Florida	20701 Pembroke Rd.	Pembroke Pines	Four times per year
Rocklake, Inc..	3300 NW 27th Ave.	Pompano Beach	Four times per year
Tire Recycling of Florida	6116 NW 2nd Ave.	Ft. Lauderdale	Four times per year
Transfer/ Recycling Services	7061 SW 22nd Ct.	Davie	Four times per year
UHEL Polly Hauling, Inc.	2201 NW 16th St.	Pompano Beach	Four times per year
Waste Magic Recyclers Central, Inc.	1501 NW 12th Ave.	Pompano Beach	Four times per year

Surface water regulation can come under licenses dedicated to surface water exclusively, such as the Broward County Department of Planing and Environmental Protection (DPEP) Surface Water Management License, or licenses that have surface water requirements as part of the overall permit, such as DPEP County Resource Recovery and Management License. Presented below are descriptions of the Stormwater stipulations of various licenses and permits required of solid waste management facilities.

$ DPEP Resource Recovery and Management License: Issued by the Solid Waste section of DPEP, the license applies to all Broward County landfills, compost facilities, transfer stations, yard trash and wood incinerators, and material recovery facilities. A license requirement is that "sanitary landfills shall provide for the collection, control and treatment of surface runoff from the site to meet established water quality standards of receiving waters." (Broward County Code 27-

215(f)(3)) The County has been designated by the State to license all solid waste management facilities accept landfills, which are licensed by both the DPEP and Florida Department of Environmental Protection (FLDEP). In addition, DPEP Solid Waste Section follows the FLDEP Solid Waste Management regulations in issuing the license to landfills and other solid waste facilities.

$ FLDEP Solid Waste Management Facility Permit: Issued by the Solid Waste Section of the FLDEP, the permit is issued to Broward County landfills. Permit requirements for solid waste management facilities that incorporate surface water issues include the following: 1) Landfill surface water monitoring points installed at locations to yield semi-annual samples[3] of surface water -standing water, flowing water bodies, discharges from detention ponds - that may be affected by the landfill. (Florida Administrative Code (FAC) Chapter 62-701.510); 2) Landfill surface water management systems shall be properly designed, constructed, and maintained.[4] (FAC Chapter 62-701.700); and 3) Stormwater management systems for all solid waste management facilities shall be operated and maintained as necessary to meet applicable standards of FAC Chapter 62-302 (Surface Water Quality Standards), FAC 62-330 (Regulation of Stormwater Discharge) and FAC 62-25 (Environmental Resource Permitting).

In addition to surface water stipulation imbedded in solid waste regulations, municipal waste facilities also are subject to the following surface water programs:

$ FLDEP Surface Water Discharge Permit: The permit ensures surface water management units. accept those already permitted by the South Florida Management District, comply with the technical requirements of (FAC Chapter 62-25).

$ DPEP Surface Water Management License: Issued by the Surface Water Management Section of the DPEP, the license ensures that all surface water management units outside the independent drainage districts comply with the technical requirements of (Broward County Code 27-200 (b)).

$ South Florida Water Management District (SFWMD) Surface Water Management License. The

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[3]The samples shall be analyzed for specific conductivity, unionized ammonia, pH, total hardness, dissolved oxygen, biochemical oxygen demand, turbidity, copper, temperature, iron, colors, sheens, mercury, nitrate, zinc, total dissolved solids, and total organic carbon.

[4] Surface water management systems.

(a) A Stormwater management system shall be designed, constructed and maintained which, at a minimum, prevents Stormwater from the peak discharge of the 25 year storm event from running onto those portions of the landfill which have not been closed.

(b) A Stormwater management system shall be designed, constructed and maintained which collects and controls, at a minimum, the volume of runoff from a 25 year, 24 hour storm event.

(c) Stormwater controls shall include retention or detention ponds, and drainage ways specifically designed and sized according to local drainage patterns, soil permeability, annual precipitation, area land use, and other characteristics of the contributing watershed.

(d) Stormwater management systems shall be designed to avoid mixing of Stormwater with leachate. Stormwater or other surface water which comes into contact with the landfilled solid waste or mixes with leachate shall be considered leachate and is subject to the requirements of Rules 62-701.500(8) and 62-701.510(5), F.A.C.

license applies to solid waste facilities that are greater than ten acres or have more than two acres impervious surface.

Resource Recovery Management Facility Licenses for the above facilities require sampling semi-annually in the event of an emergency and/or discharge. The regular surface water sampling event may be omitted if no discharge has occurred. During the passed year there has not been a reported discharge at the Resource Recovery Management Facilities.

Strengths and Weakness:

This program facilitates the development of a list of high risk facilities. This program is very labor intensive. A large percentage of the high risk facilities are located in the City of Fort Lauderdale and the City of Hollywood and this an overlap of resources.

Assessment of Controls:

Current controls are adequate for complying with the permit requirements.

Revisions:

FDOT does not have the authority to conduct monitoring of high risk facilities suspected of contaminating the MS4 and thus request to remove the requirement for the development of a monitoring program. FDOT request that its responsibility be limited to notification of the appropriate agency with authority to conduct such a monitoring program.

Compliance Status:

Compliance Achieved.

8. b.) Industrial and High Risk Runoff - Monitoring for High Risk Industries

Objective: Implement the monitoring program for facilities identified under this section in accordance with the schedule provided in Part III.A.8.b. of the permit.

Activities Completed:

Identified high risk facilities were inspected as per the permit requirement.

General Discussion:

Begin implementing Broward County's DPEP monitoring program for identified high risk industrial facilities. Initiate enforcement action on those facilities having storm water discharges to the MS4 which violate water quality standards. Send to EPA a copy of each Notice of Violation at the address shown in Part V.E.2., page 55 of the permit.

The table entitled "Log of Violations Reported to DPEP and Enforcement Action Taken", located in Attachment 7 and "Log of Broward County Industrial High Risk Facility Inspections" located in Attachment 17, illustrates the following about DPEP notification, reporting, investigation and enforcement actions applicable to the MS4:

Non-domestic wastewater program (WR-IW), Water Resources Division's domestic wastewater program (WR-DW), Biological Resource's dredge and fill Section (BR-DF) or Pollution Prevention and Remediation Division's hazardous materials section (PP-HM) responded to MS4 complaints based upon the type of complaint.

The procedures to inspect high risk facilities are part of the hazardous material and the storage tank program facility license requirements of DPEP. The facilities are inspected for compliance with the Broward County Code Chapter 27-356.

$ From December 1998 to December 1999, 53 related complaints were received by DPEP.

$ As indicated in the "Division Code" column of the table, either the Water Resources Division's surface water program (abbreviated WR-SW in Table), Water Resources Division's Non-domestic Wastewater program (WR-IW), Water Resources Division's domestic wastewater Section (WR-DW), Biological Resource's dredge and fill program (BR-DF) or Pollution Prevention and Remediation Division's hazardous materials section (PP-HM) responded to MS4 complaints based upon the type of complaint.

Initiate enforcement action on those facilities having storm water discharges to the MS4 which violate water quality standards.

$ Seven out of the 53 complaints resulted in warning notices being issued to the facility in question.

$ None of the warning notices resulted in a notice of violation (NOV).

Develop a monitoring program which addresses the water quality criteria included in the FDOT permitting process for those high risk industrial facilities which hold FDOT drainage connection permits. Include a description of the specific enforcement steps to be taken to require compliance with permit conditions if violations are identified. After development, include a summary of the monitoring program in the subsequent ANNUAL REPORT for incorporation into the permit. Implement the monitoring program for high risk industrial facilities.

The monitoring procedures of FDOT roads and highways are described in the Florida Department of Transportation Statewide Storm Water Management Plan Attachment 23. It specifically describes requirements of sampling and record keeping. FDOT will notify Broward County DPEP when it is determined that high risk industrial facility is discharging to a FDOT-MS4 facility. Corrective and/or enforcement actions will be coordinated between the discharging facility and Broward County DPEP.

FDOT is not aware of any high risk facilities with Drainage Connection Permits or that are located in FDOT area of control. FDOT Districts have an inter-local agreement with Broward County to perform both the inspection and monitoring of high risk facilities.

Strengths and Weakness:

Broward County has an enforcement program which existed prior to this permit. A large percentage of the high risk facilities are located in the City of Fort Lauderdale and the City of Hollywood and this is an overlap of resources.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

9. a.) Construction Site Runoff - Site Planning & Structural and Non-structural Controls

Objective: Require the use and maintenance of appropriate structural and non-structural best management practices to reduce pollutants discharged to the MS4 during the time of construction.

Activities Completed:

Broward County controls construction site runoff through the requirements of stormwater management construction/operation license. FDOT controls construction site runoff through the requirements of the Drainage Connection permit (see Appendix B) which complies with state water policy. FDOT Districts have an inter-local agreement for NPDES construction inspection services with Broward County in order to meet compliance with this component of the NPDES MS4 permit.

General Discussion:

New storm water management systems owned or operated by permittee(s) shall adhere to the treatment performance standards set forth in the State Water Policy. In addition, new land development and construction projects shall incorporate Broward County DPEP's BMP guidelines for erosion, sediment, and runoff control and surface stabilization as described in the Part 2 application.

Areas of new development, significant redevelopment, and new flood control projects must receive a Stormwater management construction/operation license. These licenses must comply with State Water Policy, as stated in Broward County Code, Section 27-200 (b)(1)h, *"No surface water management license shall be issued in the absence of reasonable assurances by the applicant that the surface water management system... is consistent with the state water policy, Chapter 62-40, F.A.C."* Therefore, new storm water management systems owned or operated by permittees adhere to treatment

performance standards set forth in the State Water Policy.

Broward County DPEP has developed a document entitled "Stormwater Control Best Management Practices for Broward County Construction Sites". The document provides the reader with detailed information on techniques to control construction site Stormwater pollution. The controls selected are by no means all inclusive but instead are a subset of controls suitable for the conditions of Broward County. Most of the information was taken from *Stormwater Pollution Management for Construction Activities* (EPA- 832-R-92-005). The report divides best management practices (BMPs) into three categories - erosion and sedimentation stabilization controls, erosion and sedimentation structural controls, and other pollution controls - and provides detailed information on specific techniques.

As per the FDOT Statewide SWMP, employ new FDOT Drainage Connection Permit conditions which require connecting entities subject to the NPDES storm water regulations to submit a copy of their NPDES Storm Water Pollution Prevention Plan to FDOT.

FDOT SWMP has been modified concerning the requirement for a Storm Water Pollution Prevention Plan (SWPPP). A Notification of Intent (NOI) is now required of an applicant wishing to connect to FDOT drainage. FDOT does not require a copy of the SWPPP at the time of application. Submittal of an NOI by an applicant is satisfactory proof that the applicant is knowledgeable of the NPDES regulations. Should FDOT have concerns about the storm water quality during construction that would be the appropriate time to request to see the SWPPP.

Through a requirement of the BCDPEP and as stated in the Broward County Code, Section 27-200(b)(1)h, surface water must be consistent with State Water Policy. Therefore, all projects must receive a Stormwater management construction/operational license through BCDPEP. Currently, FDOT construction projects are built according to the Florida Development Manual : A Sound Guide to Land and Water Management (FDER 1988). EPA refers to it in the Federal Register for the NPDES Industrial Permit. They also refer to erosion control and sedimentation techniques and Best Management Practices that are listed in this manual. FDOT Construction concurs that these are the current guidelines used for all work. EPA should have the complete manual, but should extra copies be needed, applicable parts of the guide will be sent upon request.

Strengths and Weakness:

This program already exists in Broward County.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

9. b.) Construction Site Runoff - Inspection and Enforcement

Objective: Implement a program for inspecting construction sites with runoff to the MS4s and for enforcing the requirement for control measures for runoff from construction sites to the MS4s.

Activities Completed:

Continue to inspect and enforce construction site runoff. Surface water management licenses were issued.

General Discussion:

Continue to implement the inspection program, as described in the SWMP within the Part 2 application, at construction sites where runoff discharges to the Broward County MS4, to maintain compliance with local storm water ordinances and codes. Include verification that construction site(s), subject to the NPDES Storm Water Regulations, within Unincorporated Broward County's jurisdictional limits, have a Storm Water Pollution Prevention Plan on site. Maintain a log documenting the inspections conducted.

Through the surface water management program, Broward County continues to issue surface water management licenses that authorize the construction, alteration or abandonment of a water management systems in accordance with license conditions. As outlined in Broward County Code 27-200(b), the license assures that the system will meet general criteria (i.e., provide adequate flood protection, do not adverse impact to surface and/or groundwater, etc.) as well as specific design criteria (i.e., one inch of runoff detention, one half inch of dry runoff retention, etc). A log of the construction projects investigated and issued is included in the table entitled "Construction Site Inspections Performed by DPEP Surface Water Management Licensing" in Attachment 13. In 1999, 158 construction projects have been issued surface water management licenses.

Additionally, a list of construction sites in Broward County subject to NPDES Storm Water Regulations was obtained from EPA. (Please see Attachment 14.) Only one of these sites, Griffin Road. in between SR7 and University Drive in the Town of Davie is in the area covered by this MS4 permit. The site was inspected on August 19, 1999. A Stormwater Pollution Prevention Plan was found on site. The best management practices for erosion and sediment control were applied.

There were some construction sites inspected in the county where permits were issued by drainage districts but no Notice of Intent was sent to EPA. The sites were inspected for construction sites runoff. Construction supervisors were educated about erosion and sedimentation control best management practices and other EPA requirements like NOI.

Provide a copy of the municipal program for inspecting construction projects for compliance with their licensing conditions and which provides for enforcement action against those in violation of their municipal permit stipulations. If none exist, develop and implement an inspection program for construction sites where runoff discharges to the MS4, to verify compliance with local storm water

ordinances and codes. The program shall include systematic inspection procedures, and proper enforcement mechanisms.

In the first year of the report it was mentioned that this program does not exist on the municipal level. An inspection and enforcement program for construction sites were developed and distributed to the municipalities. The program was also discussed at the training for construction site operators and inspectors DPEP on October 15, 1999. The program discusses in detail the role of the inspector, preparation for an inspection, causes of noncompliance and effectiveness of erosion and sedimentation control best management practices.

Develop and implement a program to inspect construction projects that propose to directly discharge storm water to the FDOT MS4 and have been granted an FDOT drainage connection permit for compliance with FDOT permit conditions. Require connection entities, who are found or suspected of discharging storm water of unacceptable quality during or following construction, to sample and test the discharge to prove compliance with FDOT permit conditions.

An inspection program has been developed and implemented. The details of the programs are in Attachment 12.

Strengths and Weakness:

This licensing program already existed in Broward County. High growth and development makes this program labor intensive.

Assessment of Control:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

9. c.) Construction Site Runoff - Site Operator Training

Objective: Conduct appropriate education and training measures for permittee's employees involved in either construction, site operations, inspections, or regulations of construction sites which discharge to the permittee's MS4.

Activities Completed:

Municipal construction site operators were given training for erosion and sediment control. Applicants

for DPEP surface water management licenses will be sent information concerning the NOI process if the construction site is more than five acres.

General Discussion:

Provide a description of any currently implemented curriculum and/or certification programs(s) for construction site operators.

On October 15, 1999 Broward County DPEP gave training to construction site operators and inspectors concerning erosion and sedimentation control. Sixty-five people from different municipalities and contractors registered for the course but only thirty five people were able to attend the training because of Hurricane Irene. A best management practices manual for sedimentation and erosion control were given to all attendees. The training was conducted by four certified trainers. Two weeks after the training an examination was conducted to certify the attendees. Lists of the people registered for the class and the people who took the examination are in the Attachment 4. The Florida Department of Environmental Protection (DEP), Tallahassee, has a similar training and the certification program. Every year they give the training to construction inspectors and operators in south Florida area.

Develop and implement a procedure to notify building permit applicants, in developments subject to the storm water regulations, of their application responsibilities under the NPDES permitting program for construction site runoff. After development, include a summary of procedures in the subsequent ANNUAL REPORT. This requirement may be satisfied through cooperative efforts with other permittees, public agencies or contracted entities.

Building permit applicants go through the surface-water program of the DPEP for an approval process. At the time of approval the applicants are notified about their responsibility for construction site runoff. The applicant will be required to submit best management practices for sedimentation and erosion control along with their construction drawing if the site is more than 5 acres. Applicant will be provided with the best management practices manual. At the time of construction, sites will be inspected for erosion and sedimentation control practices.

Strengths and Weakness:

This program improves the quality of inspection. It is very difficult to co-ordinate training for all inspectors at the same time.

Assessment of Controls:

Current controls are adequate for complying with the permit requirements.

Revisions:

No revisions are required or requested for this element.

Compliance Status:

Compliance achieved.

E. MONITORING

1. Surface Water Ambient Monitoring Program (SWAMP)

Objective : SWAMP is a collaborative effort between various agencies monitoring water quality and provides information to the public, elected officials and ecosystem managers. The SWAMP program has the following specific goals:

- $ Identifying and documenting the existing conditions of surface waters
- $ Support state water-quality criteria
- $ Identifying water quality changes over time in significant water bodies
- $ Documenting potential problem areas
- $ Establishing relatively pristine eco-region reference sites for comparison with affected waters
- $ Collecting biological data at the reference sites to establish preliminary techniques for measuring biological integrity and establishing bio-criteria
- $ Establishing a network of stations to monitor trends and water chemistry
- $ Providing information for managers, legislators, other agencies, and the public

In 1995, through a cooperative effort between Florida DEP, EPA, US Fish and Wildlife, US National Marine Fisheries Service, and DPEP, the following four quarterly monitoring sites were selected for inclusion in the SWAMP Trend Site Monitoring Network. The following five sites were chosen for inclusion in the network:

Monitoring Station Number	Location
3	Hillsboro Canal at 441
8/109	Pompano Canal at 441
27	South New River Canal at the Salinity Control Structure
32	Snake Creek Canal at US 27
43	Miami Canal-Conservation Area 3A

The five sites were sampled on a quarterly basis for Chlorophyll A, Conductivity, pH, Turbidity, Organic Nitrogen, Total Phosphorous, Total Nitrogen, Organic Phosphate, Flow Direction, Fecal Coliform, Fecal Streptoccoccus, Pheophytin A, Salinity, Temperature, Ammonia, Total Kjeldahl Nitrogen, Nitrite, Nitrate, Dissolved Oxygen, Total Organic Carbon, Flow Velocity, and Total Coliform.

Summary chart of the data: SWAMP monitoring data from December 1, 1996 to December 1, 1999 has been tabulated in attachment 21. The site Number 43 at Miami Canal-Conservation Area 3A is monitored by Florida Department of Environmental Protection and the other sites are monitored by Broward County DPEP. Station #8 has been moved to east of the original location and renamed station #109.

Discussion of the monitoring results:

		Monitoring Sites				
		#3	**#8/ #109**	**#27**	**#32**	**#43**
Samples		7	7	7	7	7
Miles		4.76	3.35	4.14	6.05	Not available
1996 to 1997	WQI_TSI	41	50	56	41	54
	Water Quality	Good	Good	Poor	Good	Fair
1997 to 1998	WQI_TSI	50	39	48	44	58
	Water Quality	Fair	Good	Fair	Good	Poor
1998 to 1999	WQI_TSI	43	49	49	35	59
	Water Quality	Good	Fair	Fair	Good	Poor

The water quality index (WQI) was developed to assess the quality of water relative to the overall Florida water quality. For the computation of the WQI, Florida DEP used data from 2,000 streams throughout the state (DEP 1994). A WQI= 50 represents the average stream in Florida from a water quality standard point of view. Lower indexes identify the best water quality conditions, while WQI's higher than 50 identify poorer water quality conditions.

Status of Monitoring: Compliance schedule in Part V.B.1 of the permit achieved.

Revisions: No revisions are required or requested for this element.

2. Outfall Monitoring

(A) The table entitled "Major NPDES Outfalls" in Attachment 15 contains an inventory of all the MS4[5] major outfalls[6] in Broward County. This table will be updated in the upcoming years of the permit.

(B) The NPDES Site #5, Site #6 and Site #7 were investigated for organic pollutants as described in the Table V.A.2.

TABLE V.A.2.

PARAMETERS	SITE	PERMITTEE(S)
Arsenic Chromium	NPDES Site #5	City of Margate
Benzo(b)fluoranthene Thallium Chrysene	NPDES Site #6	City of Lauderdale Lakes
Total Recoverable Phenolic Arsenic	NPDES Site #7	City of North Lauderdale (MCNAB Industrial)

Each site was sampled at least twice a year for the past three years and the organic pollutants were detected below the standard of violation limit in the samples. The sampling results are in the Attachment 22.

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[5] "Municipal Separate Storm Sewer" means a conveyance, or system of conveyances (including roads with drainage systems, municipal street made channels, and storm drains):

(i) owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursua disposal of sewage, industrial wastes, storm water, or other wastes, including special districts under State Law such as a sewer distri district, or similar entity, or an Indian Tribe or an authorized Indian tribal organization, or a designated and approved managemer that discharges to waters of the United States;

(ii) designed or used for collecting or conveying storm water;

(iii) which is not a combined sewer; and

(iv) which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR 122.2.

[6] An outfall is defined as a "point source" as defined y 40 CFR 122.2 at the point where a municipal separate storm sewer discharges to waters of the United States and does not include any open conveyances connecting two municipal separate storm sewers, or pipes, tunnels, or other conveyances which are in the middle of a stream or other waters of the United States and are used to convey waters of the United States. From EPA "Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from MS4"

F. SUMMARY OF SWMP AND MONITORING MODIFICATIONS

1. The Broward County NPDES MS4 Permit co-permittees currently includes 24 municipalities, FDOT, and Broward County. A new city, Weston, has been created from a portion of the unincorporated area of the County formerly the responsibility of Broward County. The corporate boundaries of the city of the Weston include the Indian Trace Development District (Indian Trace) and the West Lauderdale Water Control District (Bonaventure). Broward County will no longer be responsible for the storm water management program implementation for the streets and highways in Weston. Weston, rather than Indian Trace (which is not presently one of the co-permittees), is now responsible for the planing and regulation of storm water management activities within their corporate boundaries. We request that the City of Weston be added as a co-permittee for the Broward County NPDES-MS4 permit.

2. NPDES Site #5, Site #6 and Site #7 were sampled for organic pollutant as shown in the TABLE V.A.2 of this report on the page 62. The parameters were detected below the standard of violation in the last three years samples. Based upon sampling results, DPEP requests to eliminate the parameters from sampling for Site #5, Site #6 and Site #7.

3. The FDOT does not have any legal jurisdiction to enforce findings of illicit connections; therefore it is requested that the permit be modified to read " the requirement may be satisfied through cooperative efforts with other permittees".

4. The FDOT does not have legal jurisdiction to inspect or monitor high risk facilities. This requirement is satisfied through cooperative efforts of the lead permittee. Therefore, the FDOT request the permit be modified.

G. FISCAL ANALYSIS

Attachment 16 contains the fiscal analysis submitted by each of the co-permittees. The co-permittees have indicated budgets and funding sources for the year, FY99 and the upcoming FY00.

Permittee	1998-99	1999-00	Funding Sources
Broward County	$641,274.23	$641,274.23	Operating Funds
Coconut Creek	$1,281,810.00	$1,137,233.00	General Funnd
Cooper city	$176,585.00	$139,072.00	Stormwater Utility
Coral Springs	$910,000.00	$910,000.00	General and Water & Sewer
Dania	$661,707.00	$772,937.00	Utility and Public Works
Davie	$262,000.00	$256,000.00	General Fund
Deerfield Beach	$215,000.00	$225,750.00	General Fund
Hallandale	$282,779.00	$378,729.00	Stormwater drainage Fee
Lauderdale By the Sea	$12,600.00	$13,230.00	General Fund
Lauderdale Lakes	$109,000.00	$1,407,780.00	Stormwater Fund
Lauderhill	$965,000.00	$4,533,058.00	Utilities
Lighthouse Point	$100,000.00	$117,000.00	Public Works
Margate	$660,000.00	$688,000.00	Stormwater Utility
Miramar	$382,200.00	$417,593.00	General Fund
North Lauderdale	$55,000.00	$50,000.00	Capital and General
Oakland Park	$1,759,856.00	$2,426,498.00	Stormwater
Parkland	$20,000.00	$17,300.00	General Fund
Pembroke Park	$52,700.00	$52,700.00	Stormwater
Pembroke Pines	$1,945,950.00	$2,055,500.00	General Fund
Plantation	$128,500.00	$134,000.00	Gas Tax
Pompano Beach	$2,069,216.00	$2,173,265.00	General Fund
Sea Ranch lakes	$40,069.48	$101,000.00	General Fund
Sunrise	$1,531,047.00	$1,530,441.00	Stormwater Utility Fund
Tamrac	$1,483,895.00	$6,508,500.00	Storm Water Utility Fund
Wilton Manors	$579,575.00	$536,659.00	Stormwater Fund
Florida DOT	$858,634.00	$588,140.00	General Fund
Total	$13,903,906.76	$16,857,801.48	

H. FDOT STATEWIDE MANAGEMENT PROGRAM

Table **V.C.8.a.** - Table for FDOT Statewide Storm Water Management Program Element Status

FDOT STATEWIDE STORM WATER MANAGEMENT PROGRAM ELEMENT (To Be Conducted at State Office)	ACTIVITY ACCOMPLISHED DURING THE PERMIT YEAR?	DESCRIPTION OF RESULTING PROGRAM MODIFICATIONS	PROGRAM POLICY INCORPORATED AT DISTRICT OFFICE?
Evaluate the feasibility of the FDOT drainage connection permit becoming an operating permit requiring long-term storm water facility management by the connecting entity.	YES / NO (If no, list anticipated completion date)	State NPDES team evaluated drainage connection permit and agreed not to make it an operating permit.	NO
Add information specific to storm water runoff protection and reduction of chemical usage to the FDOT's *Turf Management Manual* and *Chemical Weed and Grass Control Manual.*	YES / NO (If no, list anticipated completion date)	No change will be made. Turf management manual is only a reference. SWAMP has been modified to reflect this.	YES
Evaluate, on an ongoing basis, innovative structural and non-structural BMPs and new technologies as they evolve to determine their efficiency and cost effectiveness in the field. Comment on those which are found suitable & adopted for use in FDOT projects in the District.	ONGOING ACTIVITY	No new technologies reviewed during permit year 3.	None

R0013067

Identify those of the non-storm water discharges listed under Part II.A.7.a. on page 16 of the permit, as well as any other non-storm water discharges, which will be allowed to be discharged into the FDOT MS4.	YES / NO (If no, list anticipated completion date)	Landscape irrigation from Turnpike maintenance activities, and unavoidable rising ground water due to shallow water table.	YES / NO

R0013068

Comments on Table V.C.8.a.

Evaluate the feasibility of the FDOT drainage connection permit becoming an operating permit requiring long-term storm water facility management by the connecting entity.

Comments: FDOT feels drainage connection permits should not be made into operating permits because: (1) FDOT does not have the regulatory authority to enforce environmental laws outside our right-of-way limits, and (2) District 4 does not issue drainage permits for actual connections. For district 4 , most sites are self-contained and not designed to flow onto state roadways. Since there is no true connection, there is no need for a long-term operating drainage permit. Most drainage permits on file already serve a purpose as a record of references for business along highways (should the need arise to know who is in the area of suspected illicit). No program policy will be incorporated at this district office for this element.

Add information specific to storm water runoff protection and reduction of chemical usage to the FDOT's Turf Management Manual and Chemical Weed and Grass Control Manual.

Comments: No change will be made to these manuals as they are for reference only. This element has been dropped from FDOT's Statewide Storm Water Management Program. No program policy will be incorporated at this district office for this element; it no longer exists in the SWMP.

Evaluate, on an ongoing basis, innovative structural and non-structural BMPs and new technologies as they evolve to determine their efficiency and cost effectiveness...

Comments: To review Best Management Practices in this district, please see the attached submittals on pay item 104-15 Soil Tracking Prevention Device and Rock bagging. Also, sumps are being used within manholes to keep them free of debris. This is being done in the field without a standard design or procedure on an as needed basis in order to alleviate any problems that might affect storm flow. These BMPs have been found to be effective for erosion control and help to keep storm water clean. New technologies that prove to be useful in the field are adopted and incorporated into program policy here at District 4.

Identify those of the non-storm water discharges listed under part II.A.7.a on page 16 of the permit, as well as any other non-storm water discharges, which may be allowed to be discharged into the FDOT MS4.

Comments: There are few non-storm water discharges that are actually allowed to flow into FDOT MS4. The ones we in Permits are aware of are air conditioning condensate from a beach condominium along A-1-A in Pompano Beach and a few city's irrigation water from medians on state roads.

Table **V.C.8.b.** - Table for FDOT Statewide Storm Water Management Program Training Status

FDOT STATEWIDE STORM WATER MANAGEMENT PROGRAM TRAINING (Conducted through State Office)	TRAINING CONDUCTED DURING THE PERMIT YEAR?	DESCRIPTION OF TRAINING COURSE	NO. OF DISTRICT EMPLOYEES COMPLETING TRAINING COURSE?
Conduct training for FDOT maintenance and construction inspectors in the identification and detection of potential storm water related problems, signs of illegal dumping and illicit connections, proper containment methods, and reporting procedures.	YES / NO (If no, give anticipated schedule.)	FDEP's certified erosion & sedimentation control	24 construction maintenance inspectors
Conduct training for the FDOT Emergency Coordinator assigned to each FDOT maintenance facility. Training shall not only educate the FDOT Emergency Coordinator in the proper containment of spills and spill reporting procedures, but shall include storm water remediation activities, storm water regulations, and storm water retrofitting necessary to eliminate polluted storm water discharges from FDOT maintenance facilities.	YES / NO (If no, give anticipated schedule.)	Hazardous Materials Emergency Response, 40hours training.	7 Emergency Coordinators
Conduct training for all FDOT personnel involved in the chemical weed and grass control program to ensure a safe and effective program. Incorporate into the training of these applicators an emphasis on storm water implications of the use of pesticides, herbicides, and fertilizers.	YES / NO (If no, give anticipated schedule.)	Herbicides / Pesticides Certification Refresher	7
Conduct training for all FDOT personnel involved in hazardous waste handling. Incorporate into the training a segment on the identification, detection, and reporting of illicit storm water connections and potential storm water related problems such as visible water quality degradation and signs of illegal dumping.	YES / NO (If no, give anticipated schedule.)	Hazardous Materials Emergency Response, 40 hours training, and implementation of the Turnpike's Hazardous Materials Emergency Response Procedures.	112 Emergency Coordinators

R0013070

Environmental Protection Agency
National Pollutant Discharge
Elimination System

PERMIT YEAR 4

JOINT ANNUAL REPORT & RE-APPLICATION for MUNICIPAL SEPARATE STORM SEWER SYSTEM PERMIT COVERAGE

AUGUST 2001

submitted by
Northern Palm Beach County
Improvement District
as Lead Permittee

prepared by
Mock•Roos

Palm Beach County MS4
Permit No. FLS000018

NPDES

R0013071

Environmental Protection Agency
National Pollutant Discharge
Elimination System

Palm Beach County MS4
Permit No. FLS000018

PERMIT YEAR 4
JOINT ANNUAL REPORT

submitted by

Northern Palm Beach County Improvement District
as Lead Permittee

prepared by
Mock•Roos

August 2001

R0013072

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C	City of Belle Glade	X	City of Pahokee
D	City of Boca Raton	Y	Town of Palm Beach
E	City of Boynton Beach	Z	City of Palm Beach Gardens
F	Town of Cloud Lake	AA	Town of Palm Beach Shores
G	City of Delray Beach	BB	Village of Palm Springs
H	Town of Golfview **(deleted)**	CC	City of Riviera Beach
I	City of Greenacres	DD	Village of Royal Palm Beach
J	Town of Gulf Stream	EE	City of South Bay
K	Town of Haverhill	FF	Town of South Palm Beach
L	Town of Highland Beach	GG	Village of Tequesta
M	Town of Juno Beach	HH	City of West Palm Beach
N	Town of Jupiter	II	Village of Wellington
O	Town of Jupiter Inlet Colony	JJ	Indian Trail Improvement District
P	Town of Lake Clarke Shores	KK	North Palm Beach Heights WCD
Q	Town of Lake Park	LL	NPBCID
R	City of Lake Worth	MM	South Indian River WCD
S	Town of Lantana	NN-1	Florida Department of Transportation – District 4
T	Town of Manalapan	NN-2	Florida Department of Transportation – Turnpike District
U	Town of Mangonia Park		

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STORMWATER MANAGEMENT PROGRAM:
8.a.) Industrial and High-Risk Runoff - Identification of priorities and procedures for inspections.

PERMITTEE(S)	ACTIVITY	DATE DUE/ FREQUENCY	COMPLETED	COMMENTS
City of Boynton Beach, City of Delray Beach, City of Lake Worth, Village of Palm Springs, City of Riviera Beach, Village of Royal Palm Beach, City of West Palm Beach and NPBCID	88) Inventory and prioritize all existing high-risk facilities discharging into the MS4. High-risk facilities shall include municipal landfills, hazardous waste treatment, storage, disposal and recovery facilities, facilities that have reported under the requirements of EPCRA Title III, Section 313, private and municipal waste handling facilities and any other industrial or commercial discharge which the permittee determines is contributing a substantial pollutant loading to the MS4. This inventory shall identify the outfall and surface water body into which each high-risk facility drains.	Within 24 Months of the Effective Date of the Permit	YES	Inventory completed; priority ranking established. No high-risk facilities identified for Boynton, Palm Springs
	89) For the high-risk facilities identified, develop procedures for inspections. Provide a description of the procedures developed in the subsequent ANNUAL REPORT	Within 36 Months of the Effective Date of the Permit	YES	
FDOT	90) Develop procedures for the inspection of high-risk facilities which hold FDOT drainage connection permits to verify compliance with FDOT Drainage permit requirements. In cases where another regulatory agency requires a periodic certification of compliance, the program developed may allow FDOT to accept this certification of compliance in lieu of further inspections by FDOT. After development, include a summary of the procedures & inspection schedule in the subsequent ANNUAL REPORT for incorporation into the permit.	Within 24 Months of the Effective Date of the Permit	NOT APPLICABLE	This requirement has been eliminated.

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STORMWATER MANAGEMENT PROGRAM:
8.a.) Industrial and High-Risk Runoff - Identification of priorities and procedures for inspections.

PERMITTEE(S)	ACTIVITY	DATE DUE/ FREQUENCY	COMPLETED	COMMENTS
City of Boynton Beach, City of Delray Beach, City of Lake Worth, Village of Palm Springs, City of Riviera Beach, Village of Royal Palm Beach, City of West Palm Beach, NPBCID and FDOT	91) Begin performing inspections of identified high-risk facilities, implementing procedures to determine if they are in compliance with all appropriate aspects of the stormwater program (e.g. no illicit connections; compliance with local stormwater regulation requirements; and if the facility is required to have NPDES permit coverage, a copy of the NPDES stormwater pollution prevention plan on site). Maintain a list of all industrial stormwater sources discharging to the MS4 and include an update in each ANNUAL REPORT of any additionally identified industrial facilities not previously listed. Maintain a log documenting the results of the inspections performed.	Within 36 Months of the Effective Date of the Permit	YES	High-risk facilities inventory updated annually by co-permittees. No high-risk facilities noted by Boynton Beach, FDOT or Palm Springs. No high-priority, high-risk facilities noted by NPBCID, Riviera Beach, or Royal Palm Beach. Inspection programs in place for all permittees.

STORMWATER MANAGEMENT PROGRAM:
8.b.) Industrial and High-Risk Runoff - Monitoring for High-Risk Industries.

PERMITTEE(S)	ACTIVITY	DATE DUE/ FREQUENCY	COMPLETED	COMMENTS
City of Boynton Beach and City of Delray Beach	92) Develop and Implement a monitoring program for high-risk industrial facilities. Provide, in the subsequent ANNUAL REPORT, a summary of the municipal stormwater monitoring program developed for high-risk industrial facilities which discharge into the MS4.	Within 24 Months of the Effective Date of the Permit	NOT APPLICABLE	No high-priority, high-risk facilities discharging into MS4.
City of Lake Worth, Village of Palm Springs, Village of Royal Palm Beach, and NPBCID	93) Provide a summary of the municipal stormwater monitoring program for high-risk industrial facilities which discharge into the MS4.	Provide in second ANNUAL REPORT	YES	
NPBCID	94) Provide a summary of the surface water monitoring study of the closed landfill.	Provide in first ANNUAL REPORT	YES	

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STORMWATER MANAGEMENT PROGRAM:
8.b.) Industrial and High-Risk Runoff - Monitoring for High-Risk Industries.

PERMITTEE(S)	ACTIVITY	DATE DUE/ FREQUENCY	COMPLETED	COMMENTS
FDOT	95) Develop a monitoring program which addresses the water quality standards included in the FDOT permitting process for those high-risk industrial facilities which hold FDOT drainage connection permits. Include a description of the specific enforcement steps to be taken to require compliance with permit conditions if violations are identified.	Within 24 Months of the Effective Date of the Permit	NOT APPLICABLE	This requirement has been eliminated.
	After development, Include a summary of the monitoring program in the subsequent ANNUAL REPORT for incorporation Into the permit.	Within 36 Months of the Effective Date of the Permit		
	Begin implementing the monitoring program for high-risk industrial facilities.			

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television advertisements, tours and the hazardous waste hotline. Additionally, the SWA participates in or hosts various special events within the community to increase public awareness of hazardous waste. The co-permittees are informed about SWA activities and are provided literature about the programs through a number of avenues such as the NPDES Steering Committee, Palm Beach County Municipal League and the SWA itself.

The SWA also offers disposal services for eligible small businesses or Conditionally Exempt Small Quantity Generators (CESQG), for a fee. CESQGs often have difficulty obtaining cost-effective disposal services due to the relatively small amount of waste they generate.

4.12 Sanitary Sewage Seepage

The co-permittees have instituted programs to minimize discharges of dry and wet weather overflows from sanitary sewers into the MS4. During the dry weather field-screening program, the MS4 system is evaluated for any signs of wastewater contamination. If wastewater contamination is suspected, the appropriate utility authority is notified so that corrective actions can be taken. All co-permittees with operation and maintenance responsibilities for sanitary sewer systems indicated they have ongoing sanitary sewer evaluations for investigation of leaks. These programs include monitoring lift station pumping rates to detect greater than normal flow rates, televising sewer systems to detect leaks and scheduling corrective maintenance. Additionally, utilities have established procedures, including containment, reporting and cleanup, to handle sewage spills.

4.13 High-Risk Industrial Facilities

The NPDES permit requires the co-permittees to maintain an inventory, establish a priority ranking, and develop procedures for the inspection of high-risk facilities discharging into the co-permittee's MS4. A high-risk facility, as defined by the NPDES permit, is any one of the following:

- Operating and closed municipal landfills
- Hazardous waste treatment, storage, disposal and recovery facilities
- Facilities that have reported under the Emergency Planning and Community Right-to-Know Act (EPCRA).
- Private and municipal waste handling facilities
- Any industrial or commercial facility that a co-permittee determines is contributing a substantial pollutant loading to the MS4.

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The NPDES permit identified nine co-permittees, the City of Boynton Beach, the City of Delray Beach, the City of Lake Worth, the Village of Palm Springs, the City of Riviera Beach, the Village of Royal Palm Beach, the City of West Palm Beach, Northern Palm Beach County Improvement District and the Florida Department of Transportation as entities having the potential of high-risk facilities discharging into their MS4s. However, both the Village of Palm Springs and the FDOT have stated in their annual reports that high-risk facilities do not exist within their outfall drainage areas. To assist the municipalities in further clarification of the high-risk facility inventory, the above-referenced process (EPA and Palm Beach County databases) was provided to the co-permittees in Year 2 of the permit. In subsequent years the co-permittees conducted their own independent evaluation to develop their inventory of potential high-risk facilities. The inventory for these co-permittees may be found in the individual annual reports. The attached Table 4-4 identifies 20 co-permittees with high-risk facilities and the number of facilities identified during the fourth year of the permit. The high-risk facility inventory provides the co-permittees with information on potential pollutant sources for use when conducting investigations of the MS4 to identify and eliminate illicit discharges.

Inventory

In order to develop an inventory of high-risk facilities, databases developed by the Environmental Protection Agency (EPA) and Palm Beach County were searched by the Steering Committee staff. The Environmental Protection Agency's electronic databases include the Industrial NPDES permits, the Toxic Release Inventory, the Superfund List and the Resource Conservation and Recovery Information System. Palm Beach County hardcopy databases included the operating and closed landfill list; EPCRA Section 3.02 Facilities; and a list of businesses, commercial and industrial facilities located within wellfield protection zones.

The Steering Committee staff sorted the Palm Beach lists by municipality and provided this information to each co-permittee. The co-permittees were then charged with determining if each of the facilities were in fact located within their jurisdiction and would discharge to their MS4.

One approach used by some of the co-permittees is to map the location of each facility in a Geographic Information System. This data is then overlaid with the location of the drainage area associated with each of the co-permittee's MS4 outfalls. The facilities located within a co-permittee's drainage area can then be associated with the correct NPDES outfall and the receiving water body. For the fourth year inventory update, the co-permittees conducted their own research of available databases and developed their list of potential high-risk facilities discharging into their

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MS4. Databases used to develop the high-risk facility inventory have been organized into the following categories:

Municipal Landfills: A list of operating and closed landfills in the County may be obtained from the Palm Beach County Solid Waste Authority. This list was provided to the Environmental Protection Agency in the Part 2 MS4 Permit Application, General Volume, Section 6. For updated information on landfills within Palm Beach County, contact the Solid Waste Authority at (561) 930-2727 or www.swa.org.

Hazardous Waste Generation, Transportation, Treatment, Storage, Disposal and Recovery Facilities: These facilities are required to report to the appropriate State agency under the Resource Conservation and Recovery Act. Reported information is collected, validated and maintained by EPA regional offices in an information system (RCRIS) that can be accessed through the Environmental Protection Agency Internet site (www.epa.gov/enviro/index_java.html). This site allows queries of the database for all facilities located within Palm Beach County or a specific municipality. Adjacent municipalities should also be checked to ensure all contributors to the MS4 are accounted for.

Facilities reporting under the Emergency Planning and Community Right-to-Know Act (EPCRA): The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) mandates that certain facilities report information on various substances stored or used at that facility. Section 3.02 of EPCRA requires reporting from any facility that has present a quantity that meets or exceeds the threshold planning quantity of any Extremely Hazardous Substance. A list of these facilities within Palm Beach County is available from the Palm Beach County Emergency Response Commission (Emergency Management Coordinator at (561) 712-6400). Section 3.13 of EPCRA requires that certain businesses submit annual Toxic Chemical Release Forms for each toxic chemical above the threshold amount. Reporting must be made to both the EPA and the respective State Emergency Response Commission. A list of the Section 3.13 facilities is found in the Toxic Release Inventory, accessible through the EPA Internet site (www.epa.gov/enviro/index_java.html).

The EPA site also maintains a list of abandoned and/or inactive or uncontrolled Superfund sites. The CERCLA Information System may be searched for these sites.

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Private and Municipal Waste Handling Facilities: A list of these facilities can be obtained from the EPA's database of industrial NPDES permits, available at the EPA Internet site (www.epa.gov/enviro/html/pcs/pcs_query_java.html).

Any Industrial Commercial Facility that the Co-Permittee Determines is Contributing a Substantial Pollutant Loading into Its MS4: Each co-permittee may add facilities to its inventory based on experience. Palm Beach County's wellfield operating permit database is an example of an inventory of facilities that co-permittees may review in developing their potential high-risk facility inventory. A list of the County's wellfield operating permit database is available only in hardcopy from the Palm Beach County Department of Environmental Resource Management at (561) 233-2400. Information on Palm Beach County Wellfield Protection Program including the Wellfield Protection Maps can be obtained by accessing the Internet site (www.co.palm-beach.fl.us/erm/divisions/protection/wellfield/index.htm).

Inspections

Co-permittees are required to develop and perform inspections of high-risk facilities to determine if these facilities are in compliance with all appropriate aspects of the stormwater management program (e.g. no illicit connections, compliance with local stormwater regulation requirements, and, if the facility is required to have NPDES permit coverage, a copy of the NPDES stormwater pollution prevention plan onsite). Additionally, a log documenting the results of the inspections must be maintained and an annual update of the inventory must be provided. Existing local inspection programs include the following: local fire departments inspect EPCRA Section 3.02 facilities; Palm Beach County Department of Environmental Resource Management (ERM) inspects businesses and industrial operations that are located within wellfield protection areas; Palm Beach County ERM also inspects pollutant storage tanks; Palm Beach County Health Department inspects facilities reported as small quantity generators. A copy of the Palm Beach County ERM Wellfield Protection Compliance Report form is attached to this report as Figure 4-3. This report form is completed by a Palm Beach County ERM representative while inspecting high-risk facilities within applicable wellfield protection zones. Also attached (as Figure 4-4) is a copy of the High-Risk Facility Inspection Checklist developed through coordination with the City of West Palm Beach Fire Rescue Department. This form is being reviewed by the Fire Rescue Department for incorporation into their existing inspection program and can be used by co-permittees during inspections.

The high-risk industrial facilities have been prioritized based on their potential to discharge pollutant loadings to the MS4. High-risk facilities identified as retail facilities and small quantity

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generators are considered to have a low-risk of contributing a pollutant loading to the MS4. Low-risk sites are facilities identified on the EPA's Resource Conservation and Recovery Information System (RCRIS) list; NPDES industrial permits list; municipal landfills; and Palm Beach County's inventories for Section 3.02 facilities. Priority high-risk facilities are those with a higher risk of contributing a substantial pollutant loading to the MS4s, such as those identified on the EPA's Toxic Release Inventory (TRI) or the Superfund List. Additionally, Palm Beach County's co-permittees can add any other facilities to the high-risk inventory as necessary. Palm Beach County co-permittees will conduct inspections on those facilities identified as priority/high-risk facilities. Options for conducting inspections include separate co-permittee inspections or utilization of existing programs conducted by local fire departments, Palm Beach County and/or other governmental entities. Table 4-4 provides a list of the number of low risk and priority high risk facilities with potential to discharge into the co-permittees MS4s.

During the current year, co-permittees reviewed and updated their high-risk inventory as necessary. The updated inventory identified 438 low-risk facilities and four priority high-risk facilities. Three co-permittees with priority high-risk facilities within their MS4 (Lake Worth - 1, Palm Beach Gardens - 1, and West Palm Beach – 2). Please refer to the individual annual reports for inspection and monitoring activities for these priority facilities.

4.14 Monitoring Activities

Palm Beach County co-permittees have identified seven main elements of the monitoring from the nine stormwater management programs. These elements include:

- Stormwater Collection Systems
- Sanitary Sewer Systems
- Dry Weather Field Screening of Outfalls
- High-Risk Facilities
- Illicit Investigations
- Water Quality Monitoring
- Construction Inspections

The inventory, inspection and monitoring associated with these elements provides a means to evaluate, synthesize and integrate the monitoring results within the required nine stormwater management programs to identify strengths, weaknesses, and revisions. Strengths associated with the above elements include an increase in the frequency of inspections, maintenance activities,

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Table 4-4
High-Risk Facility Inventory

Appendix		Permittee	Low-Risk Facilities	Priority High-Risk Facilities
01	A	Palm Beach County	0	0
02	B	City of Atlantis	1	0
03	C	City of Belle Glade	0	0
04	D	City of Boca Raton	NI	0
05	E	City of Boynton Beach	0	0
06	F	Town of Cloud Lake	0	0
07	G	City of Delray Beach	44	0
08	I	City of Greenacres	1	0
09	J	Town of Gulf Stream	0	0
10	K	Town of Haverhill	0	0
11	L	Town of Highland Beach	0	0
12	M	Town of Juno Beach	0	0
13	N	Town of Jupiter	18	0
14	O	Town of Jupiter Inlet Colony	0	0
15	P	Town of Lake Clarke Shores	0	0
16	Q	Town of Lake Park	0	0
17	R	City of Lake Worth	64	1
18	S	Town of Lantana	1	0
19	T	Town of Manalapan	0	0
20	U	Town of Mangonia Park	14	0
21	V	Village of North Palm Beach	6	0
22	W	Town of Ocean Ridge	2	0
23	X	City of Pahokee	4	0
24	Y	Town of Palm Beach	3	0
25	Z	City of Palm Beach Gardens	15	1
26	AA	Town of Palm Beach Shores	0	0
27	BB	Village of Palm Springs	0	0
28	CC	City of Riviera Beach	25	0
29	DD	Village of Royal Palm Beach	4	0
30	EE	City of South Bay	0	0
31	FF	Town of South Palm Beach	0	0
32	GG	Village of Tequesta	3	0
33	HH	City of West Palm Beach	169	2
34	II	Village of Wellington	16	0
35	JJ	Indian Trail Improvement District	2	0
36	KK	North Palm Beach Heights WCD	0	0
37	LL	Northern Palm Beach County Improvement District	37	0
38	MM	South Indian River WCD	10	0
39	NN	FDOT	NI	NI
		Totals	**438**	**4**

NI - No information available at this time.

R0013085

www epa/oigearth
Report No. 2001-P-00013
August 2001

Office of Inspector General

Audit Report

Water Enforcement:

State Enforcement of Clean Water Act Dischargers Can Be More Effective



R0013086

Inspector General Divisions Conducting the Audit:	Western Audit Division, San Francisco, CA Southern Audit Division, Atlanta, GA Central Audit Division, Kansas City, KS
Program Office and Regions Involved:	Office of Enforcement and Compliance Assurance EPA Regions 4, 8, and 9

Cover Photo: Wastewater discharge from a California facility into Suisun Bay
(Photo by Dan Cox, EPA OIG)

R0013087

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF THE INSPECTOR GENERAL FOR AUDIT
WESTERN DIVISION
75 HAWTHORNE STREET
MAIL CODE IGA-1, 7TH FLOOR
SAN FRANCISCO, CA 94105-3901

August 14, 2001

MEMORANDUM

SUBJECT: Final Report No. 2001-P-00013
State Enforcement of Clean Water Act Dischargers Can Be More Effective

FROM: Charles McCollum /s/
Divisional Inspector General for Audit
Western Division

TO: Sylvia Lowrance
Acting Assistant Administrator for
Enforcement and Compliance Assurance

Attached is our final report, "*State Enforcement of Clean Water Act Dischargers Can Be More Effective.*" The purpose of the audit was to determine whether EPA-authorized state enforcement programs protect the environment and human health. Our audit included your office, three regions, and one state within each region. We also took into account the results from a National State Auditors' Association joint review of state water programs.

This audit report contains findings that describe problems we have identified and corrective actions we recommend. This report represents the opinion of the OIG; the findings in this report do not necessarily represent the final EPA position. Final determinations on matters in this report will be made by EPA managers according to EPA audit resolution procedures.

ACTION REQUIRED

According to EPA Order 2750, you (as the action official) are required to provide this office with a written response to this report within 90 days of its issuance. For corrective actions planned but not completed by the response date, please provide the specific milestone dates for completing these actions.

If you or your staff have any questions, please contact me at (415) 744-2445, or Katherine Thompson, Team Leader, at (916) 498-6535. Additional copies of this report may be obtained from us or our website, www.epa.gov/oigearth/.

Executive Summary

Objective

The objective of the audit was to determine whether state enforcement of Clean Water Act discharge programs protect human health and the environment. This audit resulted from concerns over the effectiveness of state enforcement programs.

Forty-four states play a major role in implementing the Clean Water Act's National Pollutant Discharge Elimination System program. These states have EPA approval to issue and enforce permits that set limits on pollutants that can be discharged into our nation's surface waters. We evaluated state enforcement of discharge programs in three regions; within each region, we evaluated one EPA-approved state program. We also took into account information from five state audits.

Results in Brief

We believe that state enforcement programs could be much more effective in deterring noncompliance with discharge permits and, ultimately, improving the quality of the nation's water. EPA and the states have been successful in reducing point source pollution since the Clean Water Act passed in 1972. However, despite tremendous progress, nearly 40 percent of the nation's assessed waters are not meeting the standards states have set for them.

Strategies Need Reconsideration

The state enforcement strategies we evaluated needed to be modified to better address environmental risks, including contaminated runoff. Contaminated runoff, including agricultural and urban runoff, was widely accepted as causing the majority of the nation's remaining water quality problems. Although many sources of contaminated runoff were regulated, some were not.

EPA's Office of Enforcement and Compliance Assurance had set national enforcement priorities for urban and agricultural runoff, including storm water dischargers, sewer overflows, and concentrated animal feeding operations. However, its core program and monitoring systems have emphasized major industrial facilities and larger sewage treatment plants. State strategies were also inhibited by:

- Inadequate water quality data.
- Incomplete permit data.
- EPA-state relationships.
- State concerns over regulating small and economically vital businesses and industries.

R0013090

Compliance and Enforcement Systems Deficient

The states we evaluated did not have sufficient information on dischargers to effectively implement their programs. A major barrier to state program management was the lack of information about hundreds of thousands of dischargers that contributed to water quality problems.

One critical missing component of the Permit Compliance System was electronic transmission of self-monitoring reports. Without electronic reporting by dischargers, it was virtually impossible for states to monitor compliance with all permits.

EPA's Permit Compliance System—its national permitting and enforcement system—was incomplete, inaccurate and obsolete. The growth, variety and complexity of the regulated community had greatly outstripped the system capabilities. Hundreds of thousands of dischargers were not monitored by the system. Although many states were developing their own systems, they did not fill the information void.

State Enforcement Program Deficiencies

- Compliance systems lacked data for hundreds of thousands of smaller dischargers
- Serious toxicity violations and other violations were not reported
- Strategies for identifying unpermitted storm water dischargers were incomplete
- Enforcement actions were issued a year or more after violation
- Penalties failed to recover economic benefit of noncompliance
- Proactive strategies to avoid serious violations needed further development

States also had weaknesses in their compliance monitoring and enforcement systems, including not reporting serious, significant violations. The states we evaluated did not implement effective storm water compliance monitoring programs to detect and correct noncompliance in higher risk areas. Moreover, states needed to improve their enforcement response to significant violations to prevent further violations. Most of the enforcement actions we reviewed did not meet EPA's criteria for timeliness and often did not recover the economic benefit gained by violators.

Finally, to ensure fair and effective enforcement of the Clean Water Act, EPA regions need to improve their in-depth program evaluations and annual performance evaluations of state performance. These evaluations need to be consistent, continue toward a goal of measuring the effectiveness of performance, and be made easily accessible to the public.

Other Matters

In determining the status of EPA's plan to modernize its Permit Compliance System, we found that the Office of Enforcement and Compliance Assurance had not successfully collaborated with the Office of Water and the states in the design of the new system requirements.

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Recommendations

> *"A modernized [Permit Compliance] system should fulfill many programmatic needs and contribute to the demonstration of environmental outcomes and results."*
> -EPA Office of Water

We are recommending that the Office of Enforcement and Compliance Assurance, in partnership with the Office of Water and EPA regions, collaborate with states to develop risk-based enforcement priorities. EPA also should make modernizing its Permit Compliance System a high priority. Teaming with EPA's Office of Water and the states, the Office of Enforcement and Compliance Assurance should ensure that the new system will meet both federal and state needs.

We are also recommending that the Office of Enforcement and Compliance Assurance revise its enforcement guidance to better define significant violations for toxicity test failures, minor facilities, and storm water dischargers.

Lastly, the Office of Enforcement and Compliance Assurance should routinely determine whether states are fulfilling their obligations to monitor and enforce discharge programs. To do so, the Office should develop consistent criteria for in-depth program evaluations of state programs. These evaluations, along with state performance measures, should be accessible to the public.

Agency Comments

The Office of Enforcement and Compliance Assurance agreed with several of the conclusions in the report, including that states need to implement risk-based approaches to water enforcement and that it would be useful to have a process for periodic evaluation of the Clean Water Act program in each state. It agreed that modernizing the Permit Compliance System should be a high priority.

However, the Office expressed concern about the way some of the issues, as well as EPA's role, were characterized in the report, and claimed that many of the findings were based on "anecdotal information." The Office stated the draft report did not recognize that (1) it had an exhaustive process for setting national enforcement priorities, (2) states should be responsible for setting watershed-specific enforcement priorities, and (3) permit program requirements had flexibility that supported state enforcement strategies. The Office also believed the issues related to the Permit Compliance System were oversimplified.

The Office of Enforcement and Compliance Assurance believed that existing national enforcement guidance had the necessary flexibility to address toxicity, minors, and storm water violations. It agreed to work with EPA regions to ensure that the states were aware of the guidance. The Office agreed to consider the OIG's specific recommendations

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when guidance is updated in the future. The Office also agreed that elements of state compliance and enforcement programs need to be periodically evaluated.

OIG Position

The Office of Enforcement and Compliance Assurance either specifically agreed with the vast majority of our conclusions or did not dispute them. However, in many cases it did not agree to a specific course of action to correct the problem. Instead, the Office defended existing guidance, processes, and systems. It agreed to reassess some of its guidance, but did not state when. It proposed alternative recommendations, but did not agree to take them.

In short, the Office was reluctant to change its current way of conducting business. However, the current way of conducting business was marginally effective.

We agree that states have helped develop national priorities and that they are responsible for developing risk-based strategies. However, states cannot be fully effective until the Office of Enforcement and Compliance Assurance allows states more latitude in the redirection of their resources.

Also, EPA had taken too long to modernize the Permit Compliance System, leaving huge information gaps for minor and storm water dischargers that rendered the system inadequate. Further, the existing guidance and processes for ensuring the prevention or correction of significant toxicity, minor discharger, and storm water violations were not working – thousands of toxicity violations occurred nationally and numerous facilities had recurring violations. The guidance needs updating.

Although the Office of Enforcement and Compliance Assurance asserted our conclusions in this report were based on "anecdotal" evidence, we disagree. Anecdotal information was only used to provide examples. As discussed with the Office, our audit was based on extensive data analysis, document reviews, interviews, surveys, and observations. Details on our scope and methodology are in Exhibit 1, page 65.

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Part I
Introduction

Chapter 1
Objective, Background, and Scope and Methodology

Objective

The objective of the audit was to determine whether state enforcement of Clean Water Act discharge programs protects human health and the environment.

Background

The purpose of the Clean Water Act's discharge permit program is to protect human health and the environment by setting limits on pollutants that can be discharged into our nation's surface waters. The goal of the Clean Water Act is for all rivers, lakes, and estuaries to be swimmable and fishable.

Citizens, industries, states, local governments, and the federal government have done much to improve the quality of our nation's waters in the last 30 years:

- More than a trillion dollars, much of it authorized under the Clean Water Act, was spent to build, upgrade, and expand wastewater treatment facilities.
- EPA and the states have written and enforced over 70,000 permits to limit pollutants.

Controlling point sources has removed billions of pounds of pollutants from our waters and doubled the number of waters safe for drinking and swimming. Much of this success can be credited to the Clean Water Act, which was enacted in 1972.

Despite the successes of the Act, EPA reports that a majority of Americans live within 10 miles of a polluted river, lake, stream or coastal area. Although there is not an accurate portrayal of water quality conditions nationwide, the 1998 National Water Quality Inventory found that nearly 40 percent of the nation's assessed waters were not meeting the standards states have set for them.

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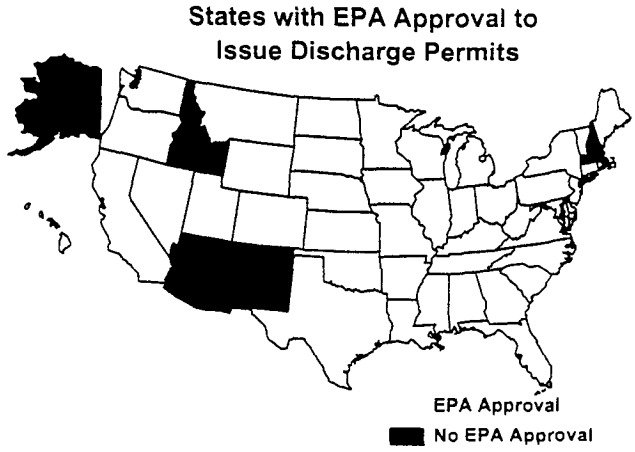
Discharge System



Much of the Clean Water Act's improvements can be attributed to the National Pollutant Discharge Elimination System, a program to control discharges from "point sources" of pollution. Point sources are discrete conveyances, such as pipes or man-made ditches.

Forty-four states play a major role in implementing the Clean Water Act's discharge program. These states have EPA approval to issue and enforce permits that set limits on pollutants that can be discharged into our nation's surface waters. EPA regions issue permits in the remaining states.

Several categories of discharges are covered under the permit program, including municipal waste water and industrial process waste water. These facilities are generally classified as major or minor, depending on size and nature of the discharges. For example, a major municipal treatment plant typically discharges one million gallons or more per day.

Runoff Permits

In 1987, Congress added provisions to the Clean Water Act that called attention to another source of problems that was believed to be responsible for continuing water quality problems: contaminated runoff from agriculture, airborne pollution, forestry, and urban development.



Idaho animal feeding operation runoff drains into a Snake River tributary

Amendments to the Clean Water Act and subsequent regulations require permits for storm water runoff from industrial activity, large and medium municipal storm water systems, and construction activities. Also, certain concentrated animal feeding operations, primarily those with over 1,000 animals and those discharging into waters,

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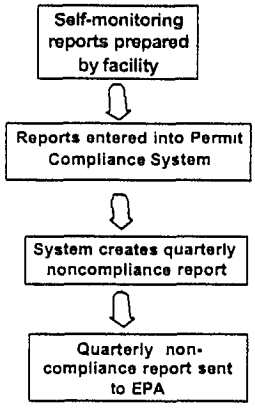
are subject to permit requirements. By law, most irrigated agricultural discharges have been excluded from permit requirements.

State Enforcement Systems

In order for states to have effective enforcement systems, they need sound enforcement strategies and compliance monitoring systems. They also need to take prompt and appropriate enforcement actions that deter future noncompliance not only at the facility, but at other facilities. EPA has developed an enforcement management system which sets criteria for identifying and reporting significant violations. In addition to enforcement guidance, the Office of Enforcement and Compliance Assurance issues the *Memorandum of Agreement Guidance* that establishes national priorities for enforcement programs.

Self-Monitoring Reports



States monitor facility compliance through inspections and self-monitoring reports. EPA recommends that states inspect major facilities annually. Also, facilities are required to regularly analyze their discharge and report the results on self-monitoring reports. States compare self-monitoring reports to permit limits to determine compliance. In addition, major dischargers are required to report significant violations to states within 24 hours.

States report significant violations to EPA in a quarterly noncompliance report. This report identifies major dischargers with significant violations, the nature of the violation, and the type of enforcement actions taken in response to those violations. EPA has defined violations of a sufficient magnitude or duration as "significant" in order to target those violations for a high enforcement priority.

EPA has established standards for taking enforcement actions on significant violations. Generally, if a major facility has two significant violations in two consecutive quarters, a state is expected to take a formal enforcement action before the end of the following quarter. EPA also recommends assessing penalties that recover the economic benefit of noncompliance gained by the violator.

Issues Impacting Enforcement Effectiveness

Nationally, there are two important issues that impact the effectiveness of permit enforcement in protecting human health and the environment.

- The backlog of expired discharge permits.
- The implementation of the Total Maximum Daily Load Program.

• Expired Permits

A backlog of expired permits is an ongoing, national problem that impairs enforcement. In fiscal 2000, about 25 percent of discharger permits for major facilities nationwide were expired. Federal law requires permits to be updated every five years. Permits are updated and reissued in order to

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conform with changing state and federal laws, pollution control technology, and water quality conditions. Outdated permits may not reflect new technology or water quality objectives, thereby impairing enforcement effectiveness.

- **Total Maximum Daily Load Program**

In the future, permit compliance will take on more importance in meeting water quality standards because of the Clean Water Act's Total Maximum Daily Load Program. A total maximum daily load is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources.

Total maximum daily load = sum of non-point sources + sum of point sources + margin of safety

States are required to:

- Identify water bodies not meeting water quality standards;
- Set priorities for calculating total maximum daily load;
- Develop a total maximum daily load for each pollutant in each listed waterway; and,
- Allocate loadings to both permitted dischargers and to non-point sources.

States have just begun to implement this program for water bodies identified as impaired. It is likely that permit limits for some pollutants will be more stringent after total maximum daily load calculations are completed. And, if limits are exceeded, it may prevent the water body from meeting water quality standards.

Scope and Methodology

This audit resulted from concerns over the effectiveness of state enforcement programs. We focused on the Clean Water Act discharge program because of a lack of recent audit coverage in this area.

In addition to evaluating national data, we evaluated three EPA regions: 4, 8, and 9. In each region, we evaluated one state with EPA approval to issue discharge permits: California (Region 9), North Carolina (Region 4), and Utah (Region 8). We also took into account recent audit reports from the following states: Arkansas, Colorado, Louisiana, Maryland, and Oregon. Our scope and methodology are further discussed in Exhibit 1, page 65.

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Part II
Strategies Need Reconsideration

Chapter 2
State Enforcement Strategies Need to Be Modified

"...nearly 40 percent of the nation's assessed waters are not meeting the standards states have set for them."
-Office of Water, May 2000

State enforcement strategies and systems needed to be modified to meet the goals of the Clean Water Act and to better protect human health and the environment. In the three states we reviewed, there were opportunities to better align enforcement strategies and resources with water quality impairments.

EPA and the states have been successful in reducing point source pollution since the Clean Water Act passed in 1972. However, despite tremendous progress, nearly 40 percent of the nation's assessed waters are not meeting the standards states have set for them. Contaminated runoff, both regulated and unregulated, is widely accepted as causing the majority of the nation's remaining water quality problems.

In the past, EPA and the states have focused their efforts on major dischargers because they were relatively few in number but discharged large quantities of pollutants. We believe enforcement strategies should be environmentally risk-based and better address:

- The relative risks presented by contaminated runoff, such as storm water and concentrated animal feeding operations.
- A rapidly growing number of smaller dischargers.
- Unique problems causing impairments in individual watersheds.

EPA's Office of Enforcement and Compliance Assurance had set national enforcement priorities and developed strategies for addressing runoff, including storm water dischargers, sewer overflows, and concentrated animal feeding operations. However, its core program and monitoring systems emphasized major industrial facilities and larger sewage treatment plants. State strategies were also inhibited by:

- Inadequate water quality data.
- Incomplete permit data.
- EPA-state relationships.

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- State concerns over regulating small and economically vital businesses and industries.

EPA's Strategic Plan

EPA's Strategic Plan lays out the Agency's 10 long-term goals for protecting human health and safeguarding the environment. In addition to long-term goals for achieving clean air, clean water, and safe food, one of EPA's 10 goals is to ensure full compliance with laws intended to protect human health and the environment.

EPA cannot achieve its goals without partnerships with states. States play a major role in implementing the Clean Water Act's discharge program. Forty-four states have EPA approval to issue and enforce Clean Water Act discharge permits. EPA regions issue discharge permits in the remaining states. States write more than 90 percent of all federal environmental permits and take over 75 percent of enforcement actions.

Need for New Strategies

In the past, EPA and the states have focused their efforts on major dischargers because they were relatively few in number but discharged large quantities of pollutants. We believe enforcement strategies should be environmentally risk-based and better address:

- Changing sources of pollution;
- An increasing universe of permit holders; and
- Watershed approaches to improving water quality.

Changing Sources of Pollution

Contaminated runoff, such as agricultural and urban runoff, was widely accepted as causing the majority of the nation's remaining water quality problems. Agricultural runoff (crops and animal husbandry) was ranked as the number one cause of impaired rivers, streams, and lakes. Some of these sources have been regulated; others, such as irrigation runoff, have not.



Swimmers frolic in Southern California waters often posted as unsafe due to urban runoff. (Photograph by Chas Mativier, Orange County Register.)

EPA issued regulations in 1976 to permit discharges from concentrated animal feeding operations; since that time, the livestock industry substantially increased both the number and size of these large animal feeding operations. Combined releases of more than 30 million gallons of animal waste to surface

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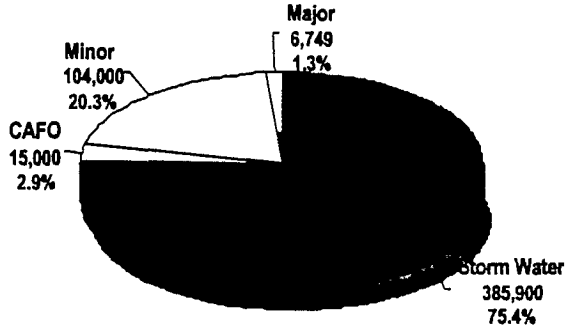
water in a number of states have highlighted the adverse environmental impacts of concentrated animal feeding operations. By law, agricultural storm water discharges and return flows from irrigated agriculture have been excluded from permit requirements.

In order to address urban runoff, the Clean Water Act was amended in 1987 to regulate municipal and industrial storm water discharges. Phase II of these regulations was added in 1999, thereby regulating a large number of smaller facilities. Storm water is a continuing concern; it was the largest source of water pollution in urban areas, such as Los Angeles.

Clean Water Act Permits
(Includes Phase II Storm Water Permits)



CAFO is concentrated animal feeding operation
Source: EPA Office of Water

In response to changing regulations and sources of water impairments, the Office of Enforcement and Compliance Assurance has suggested enforcement strategies for storm water dischargers and concentrated animal feeding operations. These strategies are accessible by states.

Increasing Permit Universe

The addition of storm water regulations more than tripled the regulated universe. The ballooning regulated universe, along with other issues, such as the backlog of out-of-date permits and the lack of data systems, has made it virtually impossible for states to fully permit, monitor, and enforce the regulated universe.

Watershed Strategies

The watershed approach to solving water quality problems calls for individual strategies tailored to each watershed rather than a focus on major dischargers or types of agricultural or urban runoff.

"To achieve the nation's clean and safe water goals, EPA will implement the watershed approach...."
-EPA's Fiscal 2001 Annual Plan

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EPA's annual plan calls for a watershed approach to fulfill the goal of the Clean Water Act. EPA regions have partnered with states, local governments, private industry, and environmental organizations to create some effective watershed strategies.

States Can Improve Effectiveness

The states we reviewed continued to emphasize inspecting and monitoring major dischargers, although contaminated runoff, including storm water runoff, was widely accepted as causing the majority of the nation's remaining water quality problems. EPA and the states could improve the effectiveness of state enforcement programs by developing risk-based enforcement strategies. EPA has a role in evaluating the effectiveness of state strategies and supplementing them, when necessary and feasible.

> Contaminated runoff is widely accepted as causing the majority of the nation's water quality problems.

In the three states we reviewed, there were opportunities to better align enforcement strategies and resources with water quality impairments.

California

> *"The polluted runoff problem is the number one water pollution problem in California."*
> -California Resources Secretary

California identified storm water as its most serious water quality problem. However, it had invested relatively little resources in inspecting and monitoring storm water. Meanwhile, storm water runoff continued to cause water impairments and beach closures. At the same time, the state had a relatively significant investment in monitoring and enforcing its major dischargers, although the state reported a relatively high compliance rate. In fiscal 2000, the state increased its storm water staffing; however, it needed to further evaluate whether its enforcement resources would yield a better return by monitoring other sources.

North Carolina

North Carolina had not developed a strategy for monitoring compliance with storm water permits, although storm water was a significant contributor to its water quality impairments. As discussed in Chapter 6 (page 53), North Carolina was taking actions to better measure the effectiveness of its enforcement strategies.

Utah

We found indicators that Utah could more effectively use its enforcement resources to address the risks that agricultural and urban runoff presented to Utah's water quality. Specifically, agricultural practices, land development, and urban runoff were listed as sources of impairments of surface waters or ground water. However, we found that monitoring strategies were not fully

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developed for either its storm water or concentrated animal feeding operation dischargers.

Reasons for Emphasis on Major Dischargers

We believe the emphasis on major dischargers was typical of many states because EPA's implementation of the Clean Water Act focused on major dischargers. Due to limited resources, EPA and the states had decided many years ago to focus on major dischargers because they were relatively few in number but discharged large quantities of waste water. Subsequently, EPA and state management systems were well developed for major dischargers but not for other sources, such as storm water, which had new types of permit limits.

States needed more latitude in the redirection of their resources. The state programs we reviewed did not have the resources and systems to permit, monitor, and fully regulate smaller dischargers, such as storm water. States did not have mechanisms to evaluate tradeoffs in different enforcement strategies. Also, states were not encouraged to divest in major dischargers.

Implementation Focuses on Major Dischargers

Much of the Clean Water Act's implementation over the last quarter of a century focused on addressing point sources, particularly major dischargers:

- EPA and many of the EPA regions emphasized inspecting, monitoring, and enforcing major discharger permits in program guidance, performance measures, and oversight reviews.

- The Code of Federal Regulations required states to have the capability to inspect all major dischargers annually. EPA and its regions stressed and monitored the annual inspection of all major dischargers. Utah cited EPA's 100 percent inspection requirement of major dischargers as one reason it was difficult to shift to other priorities.

- EPA's Permit Compliance System included little data for nonmajor dischargers. Because of states' concerns over the cost of data entry requirements, EPA policy did not require data from other dischargers to be entered into the system.

- National standards were set for taking action on significant violations by major dischargers but standards were unclear for other dischargers.

Contaminated Runoff Not Easily Regulated

The state programs we reviewed did not have the resources and information systems to permit, monitor, and fully enforce regulated runoff, such as storm water. As discussed more fully in Chapter 4 (page 35), the states we

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reviewed had minimal coverage of storm water dischargers. The addition of storm water regulations greatly increased the size of the regulated universe without a commensurate increase in resources or information systems. Thus, states were limited in their ability to implement, monitor, and enforce storm water regulations. Further, as one EPA region noted, states were expected to fully implement the "core" program before moving onto programs to regulate contaminated runoff.

Mechanisms for Evaluating Tradeoffs Not in Place

The states we evaluated did not have mechanisms in place to weigh the relative merits of divesting in major discharger enforcement in order to more heavily invest enforcement resources in minor dischargers, agricultural feeding operations, storm water dischargers, industrial sectors, or watersheds. Although the Office of Enforcement and Compliance Assurance's program guidance allowed states to change their enforcement priorities, it did not encourage divesting in major dischargers.

Best Practice: Strategy Evaluation Process

One notable "best practice" we found was in Region 10's process for evaluating the impacts of different state enforcement strategies. Region 10 issued the Clean Water Act discharge permits for Idaho and Alaska.



Region 10 Best Practice: Strategy Evaluation Process

- Evaluated shifting resources between monitoring different types of permits.
- Changed enforcement priorities.
- Quantified improvements to water quality resulting from shifting resources.

The Region had established a process to evaluate the effectiveness of investing resources in monitoring and enforcement of all categories of permit holders, including minor facilities and concentrated animal feeding operations.

As a result of its evaluation, the Region changed its enforcement priorities and ultimately caused improvements in water quality. The Region moved some of its resources from monitoring major dischargers to other sources, such as storm water. It also created a cost-effective system to monitor minor dischargers. As a result, the Region:

- Realized substantial reductions of pollutant loadings.
- Significantly increased compliance rates.
- Provided an impetus for municipality infrastructure investments that were necessary for long-term improvements in water quality.

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State Enforcement Priorities Need Development

EPA, its regions and the states need to jointly develop priorities that address each state's risks to water quality and maximize the effectiveness of enforcement resources.

> *"Section 106 grants continue to support the compliance and enforcement efforts undertaken at the State level to protect surface water quality."*
>
> -EPA Office of Water

EPA impacts state enforcement priorities in several ways. First, EPA must approve state enforcement programs before they can operate. EPA also provides states with Clean Water Act water pollution control grants and negotiates related grant agreements. For fiscal 2001, Congress appropriated about $170 million for states, territories, and Indian tribes for administering water pollution control programs. Further, the Office of Enforcement and Compliance Assurance sets national priorities in its program guidance; regions use this guidance to develop enforcement priorities with states.

In its program guidance, the Office of Enforcement and Compliance Assurance set national priorities for enforcing "wet weather" dischargers, including sewer overflows, concentrated animal feeding operations, and storm water. It also identified two industrial sectors as priorities: petroleum refineries and metal electroplating.

EPA's Wet Weather Enforcement Priorities

- Combined sewer overflow policy
- Sanitary sewer overflow enforcement system
- Concentrated animal feeding operations sector strategy
- Storm water regulations

-Fiscal 2000/2001 guidance

The Office of Enforcement and Compliance Assurance consulted with states (and EPA regions and Office of Water) in setting these priorities. It also considered public health and environmental risk as reported by states and the Office of Water. As a result of its process, wet weather issues, such as sewer overflows and contaminated urban and agricultural runoff, along with storm water, were identified as national enforcement priorities for fiscal years 2000 and 2001.

However, these enforcement priorities did not necessarily reflect a state's or region's watershed-specific impairment problems. For example, some watersheds were impacted by surface mining. Also, wet weather priorities encompassed a large universe of dischargers that could not be easily

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addressed by states without finding new resources or divesting in other areas. Divesting in major dischargers was somewhat difficult because EPA grant work plans continued to contain requirements for inspecting major dischargers, a resource-intensive requirement.

Finally, agreed-upon state enforcement priorities were not necessarily followed. For example, for fiscal 1999, Utah agreed that three industrial sectors would be given priority: refineries, mineral mining, and steel making. We were unable to substantiate that the state took any priority actions for these sectors, which included some minor permit holders. The state's year-end report stated that the mineral mining and steel making sectors ended the year with zero and 50 percent compliance rates, respectively.

Barriers to Strategy Development

EPA and the states have been hampered by a number of significant barriers to developing and evaluating the effectiveness of enforcement strategies. They include:

- **Water Quality Data Gaps.** The General Accounting Office's (GAO) survey of all 50 states found that their abilities to identify and set priorities among water quality problems were impacted by (1) a lack of water quality assessments and (2) data limitations on causes and sources of water impairments. These data gaps were particularly serious in the case of diffuse non-point sources, which were widely accepted as contributing to the majority of the nation's water quality problems.

> *"Only six states reported that they have a majority of the data they need to assess whether their waters meet water quality standards."*
>
> -GAO, March 2000

- **Incomplete Compliance Data.** Due to limited resources, EPA's Permit Compliance System and state systems had incomplete data on smaller dischargers, concentrated animal feeding operations, and storm water dischargers. There were serious data gaps on the amounts and types of pollutant discharges, the number of facilities without required permits, and compliance rates. These gaps hampered the development of risk-based strategies. (This issue is discussed further in Chapter 3, page 19.)

- **Compliance Standards Not Established.** EPA and the states we reviewed had not set compliance standards for types of

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dischargers, sectors, watersheds, or other specific categories. Without some standard, there was no objective basis for making decisions to invest or divest in certain sectors, areas, or programs.

- **Environmental Outcomes Difficult to Measure**. GAO found environmental outcomes were inherently difficult to measure for a number of reasons: the absence of baseline data, the inherent difficulty and expense involved in quantifying the outcomes, and the difficulty in establishing causal links that isolate the effect of a particular strategy.

- **Reluctance to Address Certain Sectors**. EPA enforcement officials told us some states were reluctant to address small businesses and economically vital industries.

We recognize these impediments impact EPA's and the states' abilities to set priorities and improve the effectiveness of enforcement investments. Nonetheless, as evidenced by the actions taken by Region 10, there is much that can be done to improve the effectiveness of enforcement with some relatively minor system changes and resource realignments. Further, the establishment of compliance standards would greatly aid the decision-making process.

State Partnerships Need Strengthening

EPA, its regions, and states needed to forge strong partnerships in order to improve the effectiveness of enforcement and help solve environmental problems. State enforcement priorities were sometimes not made in a partnership fashion.

"It is of great importance to the states and to the nation that our partnership [with EPA] be strengthened."
-Environmental Council of the States

As pointed out by the National Academy of Public Administration, there are many impediments to a performance-based EPA-state relationship. Certainly, the lack of data is a major impediment. The Academy concluded that other impediments were EPA's state oversight role and a concern that states will weaken environmental protection.

However, actions by Region 10 and some states show that enforcement effectiveness can be greatly improved. We believe EPA-state collaboration is essential to maximize the effectiveness of limited enforcement resources, to

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reach EPA's goal of compliance with environmental laws, and to improve our nation's waters.

Recommendations

We recommend that the Assistant Administrator for Enforcement and Compliance Assurance:

3- 1. In partnership with the Office of Water and EPA regions, collaborate with states to develop risk-based enforcement priorities. Encourage states to develop mechanisms to evaluate tradeoffs in enforcement investments.

3- 2. Provide states more latitude in the redirection of their resources. In this respect, eliminate the goal to inspect all major dischargers annually.

Agency Response and OIG Position

*2-1. **Risk-Based Priorities**. The Office of Enforcement and Compliance Assurance explained that it already has a consultation process in place in which EPA regions, states, EPA's Office of Water, and other stakeholders are extensively consulted in determining the national water enforcement priorities for each 2-year cycle. A major factor in identifying the candidates for priorities is the element of risk. This consultation process was being used to shape the 2002/2003 Memorandum of Agreement guidance. The Office believed the OIG should recognize state involvement in identifying national priorities and recommend that the Office of Enforcement and Compliance Assurance develop a process to ensure states are implementing its risk-based strategies.*

The Office of Enforcement and Compliance Assurance asserted that its actions are not keeping the states from implementing a risk-based approach or from addressing watershed priorities. Its guidance and strategies provide states with the flexible framework they need to implement a risk-based program. While EPA regions can and do recommend that states participate in national water priorities, suggest where states might focus their resources, and meet with states to conduct joint work planning, the Office stated that, ultimately, it is a state's decision as to the priorities it will set. The Office stated that a "constructive" recommendation would be that EPA should place more emphasis on program reviews and improve its efforts to share best practices with the states.

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The Office disagreed with the finding that the "core" permit program inhibits the development of state strategies. The Office's guidance allows regions and states flexibility in shifting a portion of their total inspection resources from major to minor facilities, particularly in priority watersheds, where those minor facilities represent a significant risk. The Office also defended the Agency goal to inspect 100 percent of all major point sources annually because:

- *Major point sources generate the majority of effluent flow and toxic pollutant loadings which can significantly affect water quality in receiving waters.*
- *Significant environmental benefits associated with higher levels of compliance among majors would be lost if "we were to allow a total shift to minors."*

OIG Position: The Office's response partially addresses our recommendations. We recognize that states have been involved in setting national priorities. We agree that EPA should evaluate state enforcement strategies and share best practices. However, the Office of Enforcement and Compliance Assurance needs to further collaborate with EPA's Office of Water, regions, and states so that each state has an effective, risk-based enforcement strategy that addresses its unique risks to water quality. Further, the Office should foster the development of tools that states can use to evaluate tradeoffs in enforcement investments.

States have not been allowed total flexibility in deciding how to best invest their enforcement resources. EPA does, to some extent, control state enforcement programs. It authorizes states to operate these programs and sets rules, regulations, and goals for permitting, inspecting, monitoring, and enforcing discharge permits, especially those for major facilities. EPA state grants were typically contingent upon work plans which required states to perform a certain number of inspections of major and minor dischargers and perform other actions.

2-2. ***Inspections.*** *The Office of Enforcement and Compliance Assurance believed that state programs needed to have the ability to inspect all major dischargers annually. It cited several reasons, including:*

- *States should have minimum, quantifiable standards for procedures and resources.*
- *Major dischargers were high risk because they generate the majority of the effluent flow and toxic pollutant loadings.*

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- *Numerous noncompliance problems existed with major dischargers.*

The Office of Enforcement and Compliance Assurance also pointed out that it has issued guidance that allows minor facility inspections to be traded for major facilities at a 2:1 ratio, using risk-based rationale. The Office believed an appropriate alternative recommendation would be to ensure that any state that does not commit to inspect 100 percent of its major facilities develops and implements an inspection plan that targets an appropriate mixture of high risk dischargers (i.e., majors and minors) in priority areas such as impaired watersheds.

OIG Position: The Office of Enforcement and Compliance Assurance's response illustrates its reluctance to commit to a risk-based approach. We believe it is the impact state resources have on compliance and, ultimately, water quality, that should be used to determine the adequacy of a state's resource investment in major inspections and other activities.

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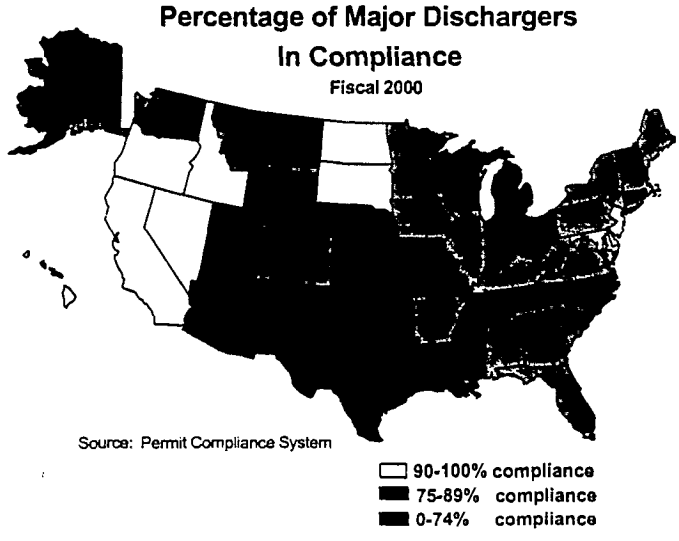
Part III
Compliance Monitoring and Enforcement Systems Deficient

The states we evaluated did not have sufficient information on dischargers to effectively implement their enforcement programs. One reason was that EPA's Permit Compliance System was incomplete, inaccurate and obsolete. The growth, variety and complexity of the regulated community had greatly outstripped the system capabilities. Compliance data for hundreds of thousands of dischargers were not monitored by the system because it was too costly to enter the data. Although many states were developing their own systems, they did not fill the information void.

States had other weaknesses in their compliance monitoring and enforcement systems, including not reporting serious, significant violations. The states we evaluated had not implemented effective storm water compliance monitoring programs to detect and correct noncompliance in higher risk areas.



Moreover, states needed to improve their enforcement response to significant violations to prevent further violations. Although EPA's goal was full compliance, only 10 states reported a compliance rate of 90 percent or better during fiscal 2000. Twenty states reported that less than 75 percent of their major dischargers were in compliance during the year. A discharger was defined as out of compliance with its permit when it had two significant, repeated violations of its permit within two consecutive quarters.

We recognize the compliance rate was not completely accurate because of deficiencies in EPA's Permit Compliance System. However, it provided an

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indicator of the states' compliance status. National compliance rates were not available for other sources such as minor facilities and storm water dischargers. As detailed later in this section, EPA and the states estimated a very large number of storm water dischargers were not in compliance because they had not obtained permits.

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Chapter 3
Permit and Other Information Systems Inadequate

The states we evaluated did not have sufficient information on regulated dischargers to determine the effectiveness of their enforcement programs.

A major barrier in state program management was the lack of information about hundreds of thousands of smaller dischargers that contributed to water quality problems. EPA's Permit Compliance System—its national permitting and enforcement system—was incomplete, inaccurate and obsolete. The system lacked data from these smaller dischargers. Although many states were developing their own systems, they did not fill the information void. As a result, states could not effectively implement the discharge program.

Without electronic reporting by dischargers, it will be virtually impossible for states to monitor compliance with permits.

One critical missing component of the Permit Compliance System was electronic transmission of self-monitoring reports. Without electronic reporting by dischargers, it will be virtually impossible for states to monitor compliance with all permits.

Further, serious toxicity violations were not classified as "significant," thereby overstating the national compliance rate. The states we evaluated had other weaknesses in their procedures for identifying significant violations.

Without sound compliance monitoring systems, significant permit violations that adversely impact water quality went uncorrected. At two of the three states, toxic discharges were released into impaired water bodies.

Permit Compliance System Had Serious Problems

EPA's Permit Compliance System Data

- Pollutant discharges
- Permit limits
- Permit violations
- Enforcement actions

EPA's permitting and enforcement information system— the Permit Compliance System—was incomplete, inaccurate and difficult to use. Compliance data from hundreds of thousands of smaller dischargers was not captured by the system and information in the system had serious limitations. Some states had created their own systems and, to some extent, duplicated the Agency's system. EPA was aware of these problems and, in 1999, identified the system as an Agency weakness. Until the system is upgraded, expanded, and reasonably accurate, its usefulness as a management and program evaluation tool will be seriously limited. As

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such, the system should continue to be reported as an Agency weakness until these problems are corrected.

EPA and state permitting and enforcement programs rely on EPA's compliance system; of the 44 states approved to issue permits, 39 states enter data into the system. EPA uses the system for program management and oversight purposes, including assisting in targeting enforcement activity to the areas experiencing compliance and environmental problems. The data are analyzed to help determine the quality of the nation's water bodies and will serve as the source of data for reporting purposes on EPA's progress in reducing pollutant loadings.

State Enforcement Program Deficiencies

- Compliance system excluded data for smaller dischargers
- Serious toxicity violations and other violations not reported
- Strategies for identifying unpermitted storm water dischargers needed development
- Many enforcement actions issued a year or more after violations
- Penalties failed to recover economic benefit of noncompliance
- Proactive strategies needed to avoid serious violations

System Capabilities Exclude Many Dischargers

The growth, variety, and complexity of the regulated community had greatly outstripped the system's capabilities. Dischargers not monitored by the system included:

- Storm water,
- Concentrated animal feeding operations, and
- Sewer overflows.

- *Permits Have Different Requirements*

The system was not designed for these type of permits, which had different permit requirements than the more traditional major and minor discharger permits. Generally, states were not entering discharge information on minor and storm water dischargers, concentrated animal feeding operations, and sewer overflows because EPA did not require it.

The lack of a sound monitoring system was particularly evident for storm water dischargers. The system was not designed to track storm water compliance data, and states did not maintain their own complete and

Number of Permits in EPA's Permit Compliance System

Type of Permit	Estimated Number of Permits	Number in System
Storm water	400,000	16,417
Concentrated animal feeding operations	15,000	5,608

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consistent data systems
for tracking and monitoring storm water compliance activities.

- *Thousands of Permits Need Data Entry*

Another reason data was excluded for smaller permits was because data entry was time-consuming. The Office of Water estimated there were about 400,000 storm water and 100,000 minor discharger permits. Compared to 7,000 major discharger permits, these permits represented a substantial workload. As such, EPA and the states had agreed that data only for major dischargers was required to be in the system.

In order for states to effectively monitor the myriad of smaller dischargers and others, electronic self-monitoring reports are critical. As noted later in this report, storm water and minor permit violations went undetected and uncorrected largely due to a lack of monitoring. Also, EPA had not yet been successful in its efforts to introduce electronic self-reporting. To effectively monitor all sources, EPA should set a high priority for implementing electronic reporting for all dischargers nationwide.

Best Practice: Electronic Reporting

California was testing electronic submission of self-monitoring reports and reported successful results. In addition to providing necessary environmental decision-making information, electronic self-reporting eliminates costs associated with preparing paper reports and repeat data entry by states and EPA. It also helps eliminate the failure of facilities and states to accurately report and categorize violations.

Best Practice: Electronic Self-Reporting

- Eliminates costs associated with preparing and reviewing paper reports
- Minimizes repeat data entry by EPA and the states
- Helps eliminate inaccurate reporting by facilities and states
- Facilitates the prompt review of discharge reports
- Allows large volumes of discharge data to be included in state and national data bases efficiently

System Inaccurate for Major Dischargers

In addition to excluding a large number of dischargers, the Permit Compliance System was inaccurate for a number of other reasons. For example:

- **California Data Not Entered** Beginning in fiscal 2000, the Office of Enforcement and Compliance Assurance had agreed to allow only about 30 percent of California's major facility compliance data to be entered into the system. These facilities represented the greatest amount of municipal flow and the industries of greatest concern.

R0013115

- **Utah's Noncompliance Rate Overstated.** A compliance system report showed that 65 percent of Utah's major facilities were in significant noncompliance for fiscal 1999. This rate was substantially overstated because the state had not entered self-monitoring reports into the system on time. The system did not have the capability to correct this error.

- **Report Unusable in Maryland.** A recent Maryland state audit report found the system generated many violations that did not represent actual violations.

- **Toxicity Violations Excluded** As detailed later in this chapter, whole effluent toxicity violations were not classified as significant violations and, in many cases, overstated the compliance rate.

As shown, it was questionable whether the compliance system fairly represented the compliance status of major facilities nationwide. It did not reflect the national compliance rate of other facilities. Without complete and accurate information, it was difficult to evaluate the effectiveness of permitting, compliance, and enforcement strategies.

System Obsolete

EPA readily acknowledged its compliance system was obsolete, resource intensive, and difficult to use. In spite of these factors, the system had not had any major redesigns in nearly 20 years.

The Permit Compliance System was first developed in 1974 and its last modernization effort was in 1982, nearly 20 years ago. Further, the system was:

- **Hard to use.** Due to the age and inflexibility of the system, it was not user friendly. The system was dependent on user coding and some users only saw the large quantity of data that was entered.

- **Resource Intensive**. The system required the manual entry of all data including facility self-monitoring reports. As a result, data entry was very labor intensive. For example, the state of Colorado estimated the cost to enter data was about $70,000 per year. Further, the system was costly for EPA to

State Data Systems

	California	North Carolina	Utah
Uses its own system	•	•	
Enters data into Permit Compliance System		•	•

• = Condition occurs

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maintain.

States Create Their Own Systems

The lack of an effective compliance system resulted in the development of unique state systems. Unique systems have created problems for EPA and the states. Some state systems did not interface with the Permit Compliance System. As a result, either states or regions had to reenter state data into the Permit Compliance System. To remedy this problem of duplicate data entry, EPA has proposed an Interim Data Exchange Format to overcome the data transfer difficulties. However, this system has not been fielded.

Further, the Office of Enforcement and Compliance Assurance had not addressed the risk that new state systems would not include the data elements required by the modernized Permit Compliance System. To illustrate, California was designing a new enforcement system to meet its own needs; however, Region 9 was not involved with the development to ensure all data elements needed for the new Permit Compliance System were included. In order to do this, the Office of Enforcement and Compliance Assurance and Office of Water need to complete the policy statement for mandatory data elements.

Compliance System Modernization Project

The Office of Enforcement and Compliance Assurance had three major initiatives underway for its Permit Compliance System which were intended to address system problems and improve its usefulness as a management tool:

1. System modernization,
2. State interim data exchange format, and
3. Electronic reporting.

In determining the status of EPA's plan to modernize its Permit Compliance System, we found that the Office of Enforcement and Compliance Assurance had not successfully collaborated with EPA's Office of Water and the states in the design of the new system requirements. This issue is discussed in more detail in Exhibit 2, *Other Matters*, found on page 69.

A wastewater treatment plant in North Carolina failed 27 out of 36 toxicity tests since 1996. None of these violations were designated as significant and, therefore, the state did not include them on quarterly non-compliance reports to EPA.

Other Aspects of Compliance Systems Need Improvement

We found other fundamental weaknesses in EPA and state compliance monitoring systems for major and minor facilities. Our review of three states, along with results from recent state audits, found:

R0013117

- Many serious toxicity violations were not classified as "significant" and thus were not subject to corrective or enforcement actions.
- Numerous other major and minor facility violations went unreported.
- State inspection procedures for major facilities needed some improvements.

Without sound compliance monitoring systems, significant permit violations that adversely impact water quality go undetected. For example, we found serious toxicity violations in two states that went uncorrected; they were not reported to EPA as significant violations. In at least one case, the toxic discharge was released into an impaired water body. Further, when violations are not identified, enforcement actions that penalize noncompliance cannot be taken.

Serious Toxicity Violations Not Identified as Significant

Serious toxicity violations, found through whole effluent toxicity tests, were not categorized as significant violations. The states we evaluated told us they were not aware toxicity test failures met EPA's criteria for a "significant" violation. Also, Office of Enforcement and Compliance Assurance guidance (a 1995 memorandum) did not clearly identify toxicity text violations as significant violations. As a result, facilities continued to discharge toxic waste water into water bodies.

"In addition, the [toxicity] test itself is intended to measure the direct potential for impairment of fish and aquatic life communities related to substances present in effluents at toxic concentrations. Thus, any failure of the effluent limitation should be considered class I [serious] and appropriate action taken."

-Wisconsin Department of Natural Resources

Whole effluent toxicity tests are one of the most important measures of assessing the impact of wastewater discharges. Toxicity tests expose aquatic organisms and fish to discharges for a specific time period, in order to predict at what levels the discharges may cause harm to the organisms. When a toxicity violation occurs, it shows the discharge is toxic enough to harm or kill fish and organisms.

Our sample of nine facilities in California and our review of North Carolina's data base identified three facilities in California and four facilities in North Carolina that had toxicity violations. The seven California and North Carolina facilities did not categorize their toxicity violations as significant. If EPA had been aware of the toxicity violations, it could have worked with state officials, obtained enforcement orders, and resolved the toxic problems.

Utah did not report any toxicity violations in the sample of facilities we reviewed. Region 8 told us that Utah had a policy in place to take actions on whole effluent toxicity test violations.

Best Practice:
Utah's Toxicity Violation Policy

- Violations must be reported within 24 hours
- Accelerated testing is required
- Investigation of the cause of toxicity is required for patterns of toxicity

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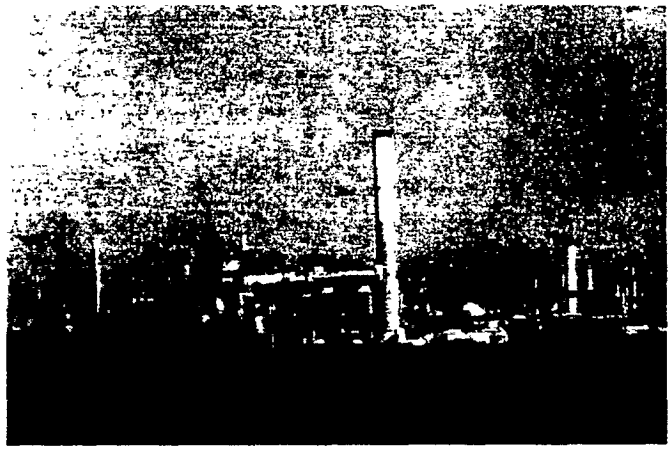
There was a large number of toxic violations nationwide that went unreported as significant violations. EPA's Permit Compliance System reported 6,552 toxicity violations nationwide between October 1, 1998 and December 31, 1999. We estimate that less than 10 percent of these violations were designated as significant and, thus, were not subject to the requirements for taking enforcement actions.

Although EPA guidance categorized effluent violations that may cause environmental harm as significant, it did not specifically designate whole effluent toxicity violations as significant. EPA officials told us this stemmed from industry opposition years earlier based on concerns over the reliability of toxicity tests. However, EPA officials confirmed that toxicity tests were very reliable. Also, they noted that toxicity tests allowed dischargers to eliminate other tests of specific chemicals. As such, EPA needs to require dischargers to categorize toxicity test failures as significant violations.

Violations by Major Dischargers Not Identified

Significant violations by major dischargers were not always identified and reported. In California, the state's manual reviews of monitoring reports missed significant violations at three of the nine facilities we reviewed. As a result, none of these violations were identified and reported. Many of these problems could be eliminated by having dischargers submit monitoring reports electronically.



Refinery in Northern California, a major discharger

A 1999 California study also found that violations were not identified and reported. The study found many self-monitoring reports were not received, and many that were received were not reviewed in sufficient detail to identify violations.

Because it did not identify daily and weekly violations, North Carolina delayed 15 months in issuing an enforcement action for mercury violations. The violator, a town's waste water treatment plant, was the cause of pollution of an environmentally-impaired stream with designated poor water quality, non-supporting of its intended uses.

R0013119

In North Carolina, permits contained daily or weekly limits which were sometimes violated but not identified or reported. In at least one case we reviewed, the violations of mercury limits were directly attributable to impairing a stream. As a result of our audit, North Carolina developed a separate software system to detect violations of daily maximum limits in permits.

State audit reports identified problems with the accurate identification of violations. For example, Arkansas's Legislative Auditor found discrepancies between the violations reported on the self-monitoring reports and those reported on in-house summary reports.

Significant Violations Not Identified for Minor Facilities

Significant violations were not identified for minor facilities. There were two main reasons for this condition:

- States were not tracking compliance at minor facilities and entering information into EPA's system.
- EPA had not explicitly defined a "significant" violation for minor dischargers.

Minor dischargers have been implicated as causes of water impairments in some water bodies. A recent Region 10 initiative to monitor compliance at minor facilities found high noncompliance rates. After the region developed an oversight system and began enforcing permit limits, pollutant discharges dropped dramatically.



Region 10 Best Practice
Minor Permit Compliance System

- Created oversight system for minor facility dischargers
- Identified violations with minimal effort
- Identified when an enforcement action should be taken

EPA's Permit Compliance System identifies violations based on data entered from permits and discharger self-monitoring reports. As discussed previously, generally states only enter data for major facilities. Even this limited data entry process is time-consuming and expensive; however, the system calculates discharge violations.

Generally, states were not reporting information on minor facility compliance to EPA. Although North Carolina was reviewing minor facility violations, we found:

- **Data Not Entered into EPA System.** None of the three states we evaluated were consistently entering minor facility data into the Agency's compliance system. Thus, minor discharger violations weren't reported to EPA.

R0013120

- **Annual Reports Missing**. Many states did not submit annual reports describing compliance and enforcement activities at minor facilities, as required by federal regulation. None of the states we reviewed submitted this report and only two of the ten states in Regions 8 and 9 submitted this report.

- **States Were Not Evaluating Compliance.** Two of the three states we evaluated did not have a state system for evaluating minor facility compliance.

- **Conditions Noted in Other Reports**. These conditions were noted in state audit reports. For example, Louisiana auditors found 21 percent of the required self-monitoring reports for minor facilities in their sample had not been submitted. Also, the state was not reviewing the monitoring reports that were submitted.

Without these annual reports on the compliance status of minor dischargers, EPA was unaware of compliance problems and was unable to take unilateral action or assist the states in helping permit-violating facilities come back into compliance.

Further, EPA had not established criteria for significant violations at minor facilities or significant minor facilities. EPA guidance stated that the inventory data for "significant minors" should be entered directly into the Permit Compliance System, but significant minors was not defined. At a minimum, minors that adversely impact impaired watersheds should be identified as significant. Also, nonsubmission of discharge monitoring reports should be identified as a significant violation. If this criteria were established, states, regions and EPA would have better data to evaluate compliance by minor facilities.

Inspections of Major Facilities Need Improvements

States needed to improve the quality of their inspections to ensure facilities were accurately reporting monitoring data. Self-monitoring reports are the backbone of the Clean Water Act's compliance monitoring system; major facilities must submit them monthly. States rely on facilities to promptly and accurately report their violations to regulators. Facilities are required to report significant violations to states within 24 hours.

Changes Needed to State Inspection Procedures

- Inspections need to be unannounced
- Inspections need to evaluate the accuracy and reliability of self-monitoring reports

R0013121

California performed cursory inspections of a sugar refinery, missing violations of chlorine limits. When the state analyzed reporting documentation in August 1999, it found several years of unreported violations of chlorine limits. The chlorine was discharged into an impaired waterway.

Two of the three states we reviewed needed to improve their inspection procedures. For the sites we reviewed, neither California nor Utah performed unannounced inspections and California did not uniformly verify the accuracy and reliability of self-monitoring reports during site visits. As a result, California missed unreported significant violations by at least one facility. This facility discharged chlorine into an impaired waterway.



Other reports found inspection quality issues in state programs. For example, the Environmental Working Group reported in July 2000 that 42 percent of all Clean Water Act inspections were a brief visual inspection of a facility. Visual inspections typically do not evaluate the accuracy of self-monitoring reports. Although most state audit reports did not evaluate the quality of inspections, a recent Oregon audit report found that the Department of Environmental Quality was not ensuring self-monitoring reports were accurate.

Oregon Department of Environmental Quality *"...was unaware of numerous instances of falsified reporting occurring over a 5-year period at one permitted facility..."*
-Oregon Audits Division

In California, inspections were not thorough because inspections were deemed lower priority than issuing permits and taking enforcement actions. The goal of inspecting all major facilities annually took precedence over a thorough inspection. States did not perform unannounced inspections because staff were concerned no one would be available at the facility and time would be wasted.

Conclusion

EPA's Permit Compliance System was obsolete and insufficient to evaluate the effectiveness of state enforcement programs. The system lacked data from thousands of smaller dischargers. Although many states were developing their own systems, these systems did not fill the information void.

One critical missing component of the Permit Compliance System was electronic transmission of self-monitoring reports. Without electronic reporting by dischargers, it will be virtually impossible for states to monitor compliance with all permits.

We also found many states were not classifying thousands of serious toxicity violations as "significant." Without this designation, states were not subject to EPA requirements for taking enforcement and corrective actions. Moreover, in some states, toxic effluent continued to be discharged into impaired waterways.

R0013122

Other aspects of discharge compliance were not being addressed by states. Two of the three states we reviewed were not evaluating compliance by minor dischargers. We also found procedures for conducting inspections and reviewing self-monitoring data was insufficient at two states. Since self-monitoring reports are the cornerstone of the discharge system, these procedural weaknesses are serious.

Recommendations

We recommend that the Assistant Administrator for Enforcement and Compliance Assurance:

3- 1. Make modernizing the Permit Compliance System a high priority. Further, ensure that future systems:
   - Require electronic submission and evaluation of self-monitoring reports for all dischargers, including minor facilities and storm water.
   - Track storm water permits, inspections, compliance rates, and enforcement actions.

3- 2. Accelerate the development of the Interim Data Exchange Format for the Permit Compliance System. Also, before proceeding further into design and development, work with the Office of Water to ensure there is an up-to-date policy statement for water system criteria.

3- 3. Have regions work with states to help ensure data elements needed for the new Permit Compliance System are included in state systems being developed.

3- 4. Continue to report the Permit Compliance System as an Agency-level weakness until the modernization project is implemented and the system data is reasonably accurate and complete.

3- 5. Revise guidance to specify that whole effluent toxicity violations are significant violations. Revise regulations to require whole effluent toxicity violations to be reported on quarterly noncompliance reports.

3- 6. Establish a definition of significant violations for minor facilities, including storm water dischargers. At a minimum, include nonsubmission of self-monitoring reports in this definition. Also, define "significant" minor facilities. Include facilities impacting impaired waterways in this definition.

Additional suggestions for modernizing the Permit Compliance System can be found at Exhibit 2, page 69.

R0013123

Agency Response and OIG Position

3-1. ***System Modernization.*** *The Office of Enforcement and Compliance Assurance stated that modernizing the Permit Compliance System was, and will continue to be, a high priority. The modernized system will allow for entry of data element fields needed to track all dischargers, including minor facilities and storm water facilities. Information tracked for those dischargers will include permit limits, inspections, compliance and enforcement action data. System modernization is scheduled for implementation by the end of 2003.*

OIG Position: While the Office asserted that the Permit Compliance System was a high priority, the system has been obsolete for over 10 years and the new system schedule has continually slipped. Further, the Office has not yet identified the data elements the system will include. These facts indicate that the system has not been a high priority.

3-2. ***State Data Transfer System.*** *The Office of Enforcement and Compliance Assurance said it and the EPA Office of Environmental Information had worked closely with their state partners in implementing the Interim Data Exchange Format over the last year.*

The EPA Office of Environmental Information is the lead for implementing the Exchange Format project, has developed the schedule for project implementation, and must address acceleration. Currently, the Exchange Format is scheduled for full implementation by March 2002.

While Office of Enforcement and Compliance Assurance agreed that there was a need to update the Policy Statement to address new data requirements, it did not agree that this must occur before design and software development. Broad capacity will be built into the system as indicated in the response to 3-1. Only a subset of that capacity is likely to be federally required. Therefore, the Policy Statement can be updated during system design and development.

OIG Position: The Agency's response does not fully address our conclusions and recommendations. According to the Office of Enforcement and Compliance Assurance's Fiscal 2000 Integrity Act Annual Assurance Letter, the Exchange Format was scheduled to be implemented in the third quarter of fiscal 2001. Thus, the Exchange Format system has been delayed nearly a year since the letter was prepared in October 2000. Further, the Office needs to work with the Office of Environmental Information to accelerate the Exchange

R0013124

Format system, since the Office of Enforcement and Compliance Assurance is responsible for the system.

The Policy Statement is obsolete and needs to be updated immediately. This critical Agency document excludes federal information requirements for storm water permits, which now compromise the largest number of permits. Further, changes to the Policy Statement should be completed before software design, so that the changes can be incorporated into the modernized system. Data entry requirements are essential for determining system requirements.

3-3. ***State Systems.*** *The Office of Enforcement and Compliance Assurance explained that it was finalizing the overall data requirements for the modernized Permit Compliance System. It stated it will continue to work closely with the states in developing detailed data requirements. Until those requirements are finalized, those states modernizing their systems should include in their modernized system the data entry requirements specified in the current Policy Statement.*

For the most part, states do not coordinate or consult with the Office of Enforcement and Compliance Assurance when modernizing their systems, as these systems are built primarily to accommodate state needs. However, the Office agreed to request of regions that they make a special effort to discuss state modernization plans during their program status meetings. Additionally, it hoped that extensive involvement of state representatives in the modernization process will have a spill over effect in getting states to include the necessary data elements in their systems.

OIG Position: We do not agree an updated policy statement is unnecessary at this time. EPA regions need an updated policy statement to engage in constructive discussions with states about which state data is needed at the national level. Existing data requirements are insufficient.

3-4. ***Agency Control Weakness.*** *The Office of Enforcement and Compliance Assurance agreed to continue to report the Permit Compliance System as an Agency-level weakness until all milestones were met. One of the milestones was the completion of modernization which is scheduled to occur by the end of 2003.*

OIG Position: The response only partially addresses our recommendation. The system should continue to be reported as an Agency weakness until the data is reasonably accurate and complete.

R0013125

3-5. ***Toxicity Violations.*** *The Office of Enforcement and Compliance Assurance pointed out that, in many ways, whole effluent toxicity is treated like any other parameter in the permit program; i.e., the permittee reports self-monitoring data on its discharge report, results are entered into the permit compliance system and tracked, and violations should be reviewed and are subject to a range of enforcement responses. The major exception is that toxicity violations are not automatically flagged as significant noncompliance. Because of the variability in permit requirements and in the frequency of compliance monitoring required, toxicity violations do not neatly fit under existing "significant noncompliance" criteria.*

However, EPA's existing regulations and guidance provide EPA regions and states with the flexibility to identify toxicity violations as significant:

- *40 CFR Part 123.45(a) provides states with the flexibility to report any violation of substantial concern on quarterly noncompliance reports.*
- *EPA's "Whole Effluent Toxicity Permitting Principles and Enforcement Strategy" prescribes review of toxicity limit violations.*
- *EPA's enforcement response guide recommends responses to toxicity violations.*

The Office of Enforcement and Compliance Assurance agreed to reconsider the applicability of significant noncompliance to whole effluent toxicity violations when it revises the definition of significant noncompliance.

OIG Position: There is no reason to delay categorizing whole effluent toxicity violations as significant violations. The current process is not working. While states have had the flexibility to identify whole effluent toxicity violations as "significant" violations, they generally have not. According to the Permit Compliance System, only 5.6 percent of the fiscal 2000 toxicity violations were identified as significant violations. Facilities nationwide had large numbers of recurring toxicity violations that were not designated as significant. For example:

- One facility in Massachusetts had 16 toxicity violations; none were categorized as significant.
- One facility in New Jersey had nine toxicity violations; none were categorized as significant.
- One facility in Florida had 19 toxicity violations; none were labeled as significant.

By not labeling toxic violations as "significant," states obfuscate EPA oversight of the appropriateness and effectiveness of state enforcement actions.

R0013126

*3-6. **Other Significant Violations**. The Office of Enforcement and Compliance Assurance noted that a state has the discretion to designate any facility with violations of concern as a "major" discharger thereby subjecting the facility to "significant" noncompliance criteria. 40 CFR Part 123.45(a) provides a state with the discretion to report any violation of "substantial concern" on a quarterly noncompliance report.*

The Office of Enforcement and Compliance Assurance committed to consider developing guidance on when a minor discharger should be designated as a major discharger and to include factors such as non-submission of discharge monitoring reports and impact of the discharge on impaired waterways.

OIG Position: The Office's response does not address our recommendation to establish a definition of significant violations for minor facilities, including storm water dischargers, and to define "significant" minor facilities. We are recommending that EPA establish a uniform definition for significant violations at all minor dischargers, including storm water. Designating minor dischargers as major dischargers does not address our recommendation or the problems that exist.

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R0013128

Chapter 4
Storm Water Compliance Systems Have Deficiencies

"Urban runoff from seven south Orange County [California] cities is so noxious that it exceeds safe-swimming water standards at all but three of 35 sites–and by 100-fold at four..."
-Orange County Register

Storm water pollution posed significant water quality problems and health risks—in 1999, more than 6,000 beaches were closed or had health advisories issued due to polluted waters caused mainly by storm water runoff.

The states we evaluated were not effectively monitoring compliance by storm water dischargers, resulting in violations going undetected and unaddressed. We found:

California estimated there could be as many as 19,000 facilities operating without proper storm water permits.

- **State strategies were needed for identifying storm water non-filers**. States estimated thousands of facilities had not obtained storm water permits.
- **Risk-based inspection programs were lacking**. The thousands of relatively small dischargers in this program dictated a risk-based approach that had not been well developed.
- **Processes were needed to monitor discharge reports**. States did not maintain adequate processes or systems for reviewing self-monitoring reports, identifying major violations, and taking appropriate action.
- **Tracking systems for citizen complaints were insufficient**. Although citizen complaints were a primary means of identifying violations, complaint tracking systems were not implemented.

The main impediments to effective storm water monitoring systems were a lack of resources and information. Although the storm water program involved nearly 400,000 dischargers nationwide, state resources were not significantly increased to implement this program. Further, EPA's Permit Compliance System and state systems did not track storm water permit compliance data, resulting in significant data gaps. As a result, the states we reviewed did not have effective storm water compliance monitoring programs to detect and correct noncompliance in higher risk areas.

Numerous Storm Water Non-filers

The states we evaluated did not have adequate strategies for identifying storm water dischargers that had failed to file for a proper permit. Although some "non-filers" were identified through citizen complaints, states did not have systematic processes to search for and identify non-filers because of inadequate resources and data.

R0013129

The number of unpermitted dischargers was substantial. For example, Utah estimated it had about 500 unpermitted facilities subject to storm water regulations. California estimated that at least 19,000 facilities might be subject to storm water regulations, but had yet to apply for a permit. Because the identification of non-filers continued to be a challenge in the state, the state was investigating the feasibility of accessing other state agency databases to assist in identifying non-filers.

Inadequate Inspection Programs

The states we evaluated were not employing sound, risk-based inspection programs of storm water dischargers:

Storm Water Inspection Programs

	California (Los Angeles)	Utah	North Carolina
Number of permitted facilities	16,641 (3,304)	690	6,227
Estimated annual rate of facilities inspected	12 %	2 % *	Construction-100%; others unknown
Risk-based inspection schedule developed	No	No	No
Inspections documented	Yes	Sometimes	Yes
Inspection results tracked and violations followed up	No	No	No, except construction sites

** Number of inspections performed could not be substantiated.*

Inspection Statistics Unreliable

State-reported inspection statistics were generally overstated or unsubstantiated at the states we reviewed. For example, California's Los Angeles region included searches for non-filers in its tally. Fortunately, the Los Angeles region had recently increased its inspection field presence from previous years. Utah's reported inspections could not be fully substantiated; the state did not consistently document or track inspection results.

Although most state audit reports did not evaluate storm water inspections, the Louisiana Legislative Auditor reported in January 2001 that most of the uninspected facilities were storm water dischargers.

States Need Strategies

We recognize that it is not realistic to inspect hundreds or thousands of storm water dischargers every year with limited resources. Therefore, states should develop risk-based strategies to target inspections that provide maximum benefit to improving total water quality.

R0013130

Best Practice: Risk-Based Inspection Strategy

California was developing a risk-based inspection plan: the Los Angeles region's work plan for fiscal year 2000/2001 showed that it intended to start targeting industrial and construction inspections at the highest risk dischargers using specific criteria, such as administrative or technical non-compliance, high-risk industries, large construction sites, and complaints. Other criteria states could use to focus inspection resources are impaired waters or high priority watersheds, and repeat violators.

California Best Practice: Risk-Based Inspection Plan

- Focuses limited resources on highest risk dischargers
- Uses criteria to identify highest risk dischargers

States Need to Follow Up on Inspection Results

The states we evaluated were not consistently tracking or following up on inspection results. Four of eleven inspection reports reviewed in California and Utah detected violations that were not tracked or acted upon. Therefore, facilities with major violations, such as failure to prepare a storm water pollution prevention plan or implement storm water best management practices, did not come into compliance promptly, if at all. And there was no evidence to determine if or when compliance was achieved.

"The heart of a general permit is the pollution prevention plan..."
- EPA Region 9

Self-Monitoring System Not Identifying Major Violations

The states we evaluated were not reviewing self-monitoring reports for compliance with permits and regulations. In California, one of four monitoring reports we reviewed did not meet regulatory requirements. The Los Angeles region acknowledged that in the past they have had to focus limited resources on requiring dischargers to submit reports, as opposed to addressing noncompliance items in reports.

Utah did not track which facilities were required to submit self-monitoring reports; thus, the state could not ensure all required reports were received.

Significant Storm Water Violations Found: California

- Missing sampling analysis during the required test period
- Missing descriptions of best management practices implemented at the facility
- Reporting results which were not based on storm events
- Not submitting monitoring reports

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EPA and state systems did not facilitate a review of self-monitoring reports. The Permit Compliance System was not designed to track storm water compliance data. State data systems did not fill this gap, either. However, storm water data was critical, not only for determining compliance, but for evaluating the effectiveness of the storm water program.



Control of sediment into storm drain

Due to the large volume of storm water self-monitoring reports, states need an electronic scoring process that cost-effectively identifies significant violations and other important information. Several low-cost viable options need to be seriously considered including scan sheets (commonly used for electronic scoring of tests) and web-based reporting. This would make efficient use of limited resources, as well as provide assurance that required reports are submitted and noncompliance is detected.

Complaint Tracking Systems Lacking

The states we reviewed did not maintain adequate or consistent tracking systems for citizen complaints. Complaints were an important source of violation information. Without consistently tracking when and how citizen complaints were resolved, there was no evidence that the states addressed the complaints or provided a formal or informal response addressing citizen concerns.

Barriers

Deficiencies in the state storm water programs occurred primarily because of incomplete and inconsistent data systems for tracking storm water activities and inadequate resources. Also, states were reluctant to place additional burdens on small and economically vital business.



Fed by urban runoff, Munger Creek in Orange County, California, had an increased fecal-coliform count. (Photo by Orange County Register.)

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Inadequate Data Systems

As previously discussed in Chapter 3, one major impediment to storm water self-monitoring systems was data systems. Storm water data was critical, not only for determining compliance, but for evaluating the effectiveness of the storm water program. We found EPA's Permit Compliance System:

- Included only about 16,500 of an estimated 400,000 storm water permits.
- Did not require states to enter storm water permit data. This was due to concerns over the increased state and federal data entry workload.
- Was not designed to track storm water compliance data.

State data systems did not fill this gap, either. The states we evaluated did not maintain their own complete and consistent data systems for tracking and monitoring storm water compliance activities. All three state data systems were not tracking one or more pieces of critical storm water data.

For example, Utah did not track critical compliance data and could not support an internal report citing 100 percent compliance. Utah also did not maintain an information system on its current construction site permits. Our sample included an instance where a construction facility was operating with an expired permit until a complaint was lodged.

Inadequate Resources

The promulgation of the Phase I storm water regulations in November 1990 substantially increased the universe of permit holders under the Clean Water Act. Implementation of the Phase II regulations beginning in 2000 further increases the universe. However, minimum resources have been dedicated to carry out storm water activities. In addition, permit fees were generally inadequate to help fund storm water programs.

Staff Years Dedicated to Storm Water
Fiscal 1999

State	Storm Water Permits	Staff Years
California (Los Angeles Region)	3,304	2.5
North Carolina	6,227	7
Utah	690	1+

For example, at the time of our audit, California's Los Angeles region only had 2.5 staff years to monitor more than 3,300 storm water permit holders and conduct searches for as many as 10,000 unpermitted facilities that were subject to regulation. The program was grossly underfunded and as a result, was identified as not meeting federal standards for controlling pollution caused by storm water runoff. This was a serious concern because storm water runoff was the largest single source

> "...the Los Angeles Regional Board inexplicably devotes the least amount of resources to its worst water quality problem: polluted runoff."
> - Natural Resources Defense Council

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of water pollution in this region. To help address this concern, the Los Angeles region requested and received a substantial increase in its 2000/2001 storm water budget, which enabled it to hire additional storm water staff.

Risk-Based Strategies

Because of limited resources and the large number of storm water dischargers, states should engage in risk-based strategies to focus their resources on the most significant water quality issues. Urban runoff, including storm sewers, is one of the top three sources of pollutants in rivers, lakes, and estuaries. Storm water dischargers now make up about 75 percent of the number of discharge permits. However, as further discussed in Chapter 2, state water programs have generally given higher priority to major "point source" dischargers, such as municipal waste water treatment plants and industrial facilities.

States Taking Enforcement Actions

The three states in our review took some substantial storm water enforcement actions. The three states assessed penalties of over $500,000. North Carolina took one enforcement action for $50,975.

Storm Water Enforcement Actions
Fiscal Year 1999

	Number of Enforcement Actions	Penalties
California (Los Angeles Region)	28	$256,100
North Carolina	12	$248,741
Utah	2	$ 86,609

Recommendations

We recommend that the Assistant Administrator for Enforcement and Compliance Assurance:

4-1. Work with EPA regions in assisting states to:
- Develop mechanisms to better balance their limited resources between all categories of dischargers, as indicated by the states' analysis of risks to water quality.
- Create effective strategies for identifying storm water non-filers.
- Develop sound storm water inspection programs which include risk-based inspection schedules and tracking and follow-up of inspection results.
- Establish tracking systems for citizen complaints.

4-2. Facilitate the development of a system which allows self-monitoring reports to be electronically scored for compliance. Consider low-cost options such as scan sheets (commonly used for electronic scoring of tests) and web-based reporting.

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Agency Response and OIG Position

*4-1. **State Strategies and Systems.** The Office of Enforcement and Compliance Assurance agreed to continue to work with the EPA regions and states to implement risk-based approaches to water enforcement. It noted that the Office's Memorandum guidance and national strategies provide flexibility to address majors as well as minors. The 2000 Storm Water Enforcement Strategy outlines a recommended "sweep" approach of targeting a priority watershed or geographic area, then focusing storm water inspections and enforcement actions on a category of non-filers (e.g., a priority industrial sector or large construction sites) in that area.*

The Office noted that while EPA can assist the states by providing direction, guidance, training, and work-sharing, states must take responsibility to develop appropriate planning mechanisms to develop and implement risk-based strategies (which should include a sound inspection program and a system to track citizen complaints), and balance their limited resources.

OIG Position: The Office's Memorandum Guidance does not address our recommendation. While the guidance allowed "trading" major inspections for minor inspections at a 2:1 ratio, the guidance did not address trading major inspections for storm water inspections. Nor did it address the other aspects of our recommendation. Moreover the storm water enforcement strategy was developed for EPA regions, not states.

We agree that states are responsible for their enforcement strategies. However, we do not agree there is sufficient flexibility in the existing system. EPA-driven requirements for major facility inspections, oversight, and enforcement actions focus state programs on major dischargers. Instead of setting rules for divesting in major facility oversight, it would be more useful if EPA used its national perspective and expertise to help states develop and fine-tune risk-based enforcement strategies, including those for monitoring storm water permits.

*4-2. **Electronic Submission of Storm Water Reports.** The current Permit Compliance System already determines compliance based on electronic review of the discharge monitoring reports, though some improvements are needed in the system. The modernized system will certainly have this capability. Additionally, the modernized system will provide the capability for facilities and states to electronically report information using the Agency's Central Data Exchange portal and the National Environmental Information Exchange Network for the transfer of permit data.*

OIG Position: The Permit Compliance System does not determine compliance for storm water permits because it does not have the capability to accept storm

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water compliance data. Further, for various reasons, the system does not accept compliance data electronically. As a result, states must enter compliance data manually. Manual data entry is a huge obstacle, especially for the hundreds of thousands of storm water and minor permits.

One obvious solution to the data entry problem is to have permit holders submit their reports electronically. Low-cost, common platform options are electronic score sheets (used for testing) and web-based reporting. We have no evidence the new system will address these issues; however, in meetings with the Office, it indicated it would explore these options.

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Chapter 5

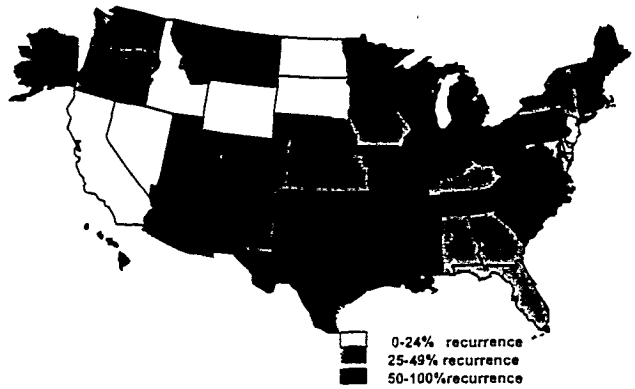
Enforcement Actions Late and Penalties Insufficient

"Regulations are not self-implementing; they have impact only when regulated parties decide to comply or agencies force them to do so."
-National Academy of Public Administration

Although the states we evaluated generally took enforcement actions on significant violations, we found these actions were often taken a year or more after the violation occurred. Further, penalties were sometimes insufficient to prevent further violations and were not always collected. This may have contributed to a large number of recurring violations. Over one-third of the states reported that over half of their major facilities with significant violations in 1999 also had recurring significant violations in fiscal 2000. (Data was not available for non-major facilities.)

Major Facilities with Recurring Violations

Facilities With Significant Violations Recurring in 2000



Source: Permit Compliance System

Some states were taking actions to improve the effectiveness of their enforcement programs by:

- Requiring penalties to include recovery of the economic benefit of noncompliance.
- Using minimum penalties.
- Publicizing violations and responses.

States could further improve the effectiveness of enforcement actions by taking actions promptly and improving proactive strategies that help avoid violations.

Delayed Enforcement Actions

The three states we evaluated were oftentimes taking a year or more to respond to significant violations at major facilities:

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Enforcement Actions Delayed Over 1 Year

State	Percentage of Late Actions	Months Late (Violation to Action)
California (San Francisco Region)	50%	15
North Carolina	100%	26 to 41
Utah	100%	12 to 41

[We evaluated 15% and 67% of the formal enforcement actions taken on major dischargers in North Carolina and Utah, respectively. In California, we evaluated 67% of the actions on major dischargers taken by the San Francisco Region.]

There was evidence this problem extended to other states. For example, the Louisiana Legislative Auditor found the state took over a year to issue nearly 40 percent of its actions.



Discharge from a Northern California facility

Not taking prompt enforcement action increases water pollution as violations go unchecked. States must take swift action not only to bring violators into compliance quickly, but also to establish credible enforcement programs. For example, a California municipality failed to meet its deadline to replace its obsolete treatment plant by 1997. Although the state issued a cease and desist order in 1993, at the time of our audit, no penalties were assessed. Delays continued and the plant continued to pollute the Pacific coast until the new plant demonstrated full compliance in January 2001.

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There were a number of reasons states enforcement actions were delayed:

- **Enforcement Process**. Enforcement actions generally had to be approved by higher management levels and, in California, Governor-appointed boards. These approval processes delayed actions. Also, states negotiated enforcement orders or penalty amounts with dischargers, which was a time-consuming process. Further, in order to compute penalties, states needed to obtain cost data from the discharger, further delaying actions.

- **Reluctance.** States were reluctant to take immediate action on violations, especially when violators were making efforts to comply. Staff tended to work closely with the discharger, developing a working relationship they believed would be threatened by a formal enforcement action. Also, North Carolina and Utah negotiated formal orders or penalty amounts due to concerns over litigation; negotiations caused further time delays.

- **Consequences**. There were limited adverse consequences associated with delayed enforcement actions. The Office of Enforcement and Compliance Assurance told us that states not taking actions on repeat violators received phone calls from EPA; generally, EPA took no other actions. The most obvious adverse consequence of delay enforcement was the continued discharge of pollutants in excess of permit limits. However, this consequence usually had no immediate impact on a state.

Another factor may have been the lack of time standards for taking enforcement actions. The states we evaluated had not set standards for taking enforcement actions. EPA's standard was variable and not embraced by the states we evaluated.

> *"The Enforcement Response Guide... addresses timely responses to... violations...Even though some of the language can be seen as ambiguous..."*
>
> - EPA Office of Enforcement and Compliance Assurance

EPA's Enforcement Response Guide set a variable time standard for taking enforcement actions. It required a formal enforcement action when there was a repeated, significant violation in the same or a consecutive quarter. A state was expected to complete a formal action before the end of the quarter following the second violation. Thus, the timing of the second violation determined how long a state had to take a "timely response." For example, if the repeat violation occurred April 1, the state had

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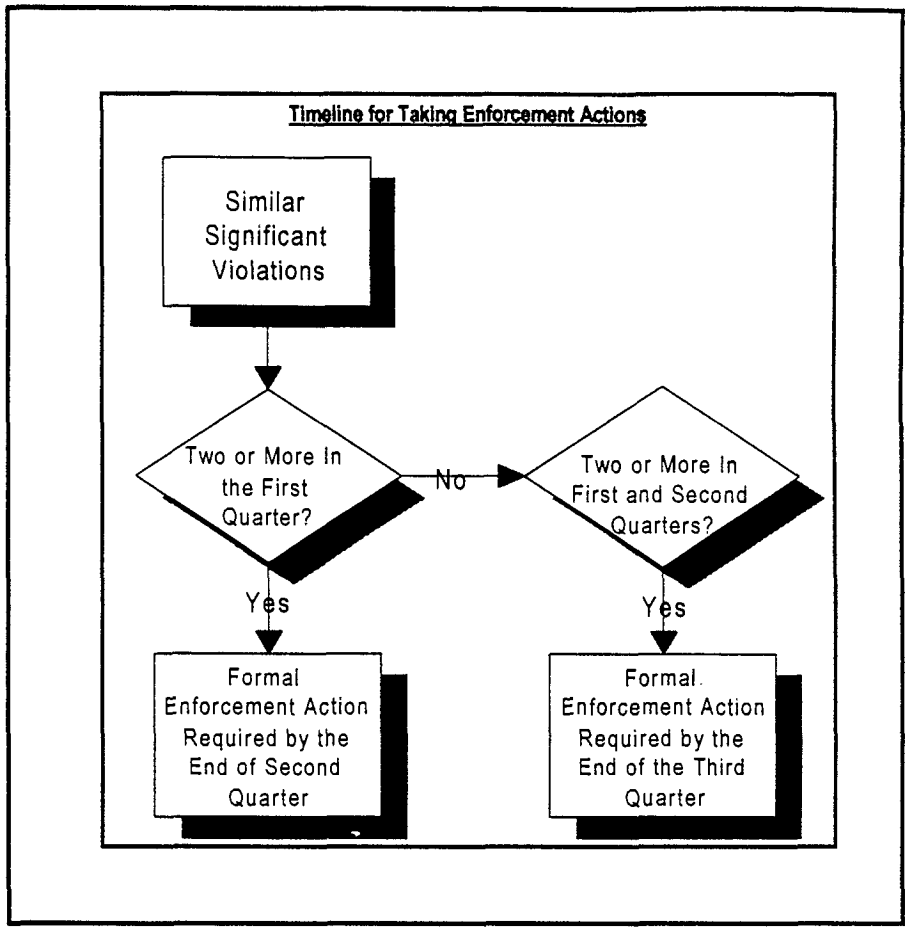
6 months to complete the action; if it occurred on June 30, the state had only 3 months to complete the action. Three months may not be enough time to issue an enforcement action. We recommend that EPA set a clear and consistent time standard for taking enforcement actions.



Penalties Did Not Recover Economic Benefit

Two of the three states were not calculating or recovering the economic benefit of noncompliance, although both states had recently instituted changes to do so. The failure of states (and EPA) to recover the economic benefit of noncompliance has been a long-standing problem. EPA oversight should continue to evaluate the effectiveness of penalties, including the recovery of economic benefit.

Adverse Impacts of Insufficient Penalties

- Financial gain realized when economic benefit of violation not recovered
- Violator implicitly rewarded for each violation
- Violator gains an economic advantage over compliers

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"EPA expects states to make a reasonable effort to calculate economic benefit and encourages states to recover this amount in negotiations and litigation."

-EPA's 1986 Oversight Framework

Frequently, violators have economic gains from postponing compliance actions. These savings can come from:

- Delaying or avoiding purchase of equipment.
- Delaying the construction of new facilities.
- Avoiding annually recurring costs of operating and maintaining equipment over the period of noncompliance.

To ensure everyone is thus treated fairly and consistently, economic benefit should be recovered for all significant violations.

At the time of our review, neither California nor North Carolina required or prescribed the recovery of economic benefit. Also, they had not developed procedures for calculating economic benefit:



Recovery of Economic Benefit

	California	North Carolina	Utah
State law requires recovery of economic benefit?	No*	No	No
Policy requires recovery of economic benefit?	Yes	Yes	Yes
Policy prescribes methods to compute economic benefit?	No	No	Yes
Economic benefit recovered?	No	No	Yes

**California passed a law effective January 1, 2000 requiring the recovery of economic benefit. It did not impact the actions we reviewed.*

Although recent state audit reports did not address recovery of economic benefit, EPA Region 9's evaluation of Nevada's program and a 1997 Virginia audit found that these states were not recovering economic benefit.

When states did not recover economic benefit, violators could realize substantial financial gains and be implicitly rewarded for noncompliance. To illustrate, a California municipality's waste water treatment plant was not completed by the deadline required by the state's cease-and-desist order. However, a penalty was not assessed. The municipality saved at least $1.5 million by delaying construction of the $50 million plant.

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Besides the lack of a requirement and methodology, there were other reasons states did not recover economic benefit. One of the main reasons economic benefit was not calculated was because obtaining necessary cost data was cumbersome and time consuming. Minimum penalties also sometimes prevented the recovery of economic benefit. For example, a North Carolina treatment plant was fined repeatedly for failing to meet its permit limits. The state's environmental specialist concluded paying minimum penalties was less costly than complying with permit requirements.

Reasons States Did Not Recover Economic Benefit in Penalties

- Lack of methodology
- Difficult and time-consuming to obtain cost data
- Time-consuming to compute penalties
- Penalties generally higher; states reluctant to assess higher penalties
- Not required to by state law or policy
- Minimum penalties used instead

Economic Benefit Recognized As Deterrent

Recently, both California and North Carolina had recognized the importance of recovering economic benefit in improving compliance. California passed a law requiring the recovery of economic benefit. North Carolina issued its *Principles of Enforcement* which call for the cost of noncompliance to be greater than the cost of compliance. North Carolina stated that it was committed to incorporate economic benefit into penalties for serious violations and chronic repeat violations.

Lack of Consistent Penalties

Penalties were not consistent nationwide or within states. In order to maintain a level playing field, penalties should recoup the economic benefit the violator gained through noncompliance. As GAO concluded, a key difference among state enforcement authorities is the recovery of economic benefit. Economic benefit tends to be a large portion of computed penalties. When it is not computed, it can lead to smaller penalties and an unfair economic advantage to the violator. To make enforcement consistent nationally, economic benefit should be recovered in state penalties.

Internal studies by California and Arkansas had found problems with the consistency of penalties. In 1999, California reported that there were inconsistencies in enforcement actions amongst its regional boards. In 2000, Arkansas reported that "the current formal enforcement structure allows for inconsistencies in the initiation of formal enforcement actions and the levying of fines."

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To ensure the regulated community is treated fairly, states should have uniform penalty structures that have specific guidelines and equitable formulas.

Uncollected Penalties

Penalties must be collected to establish credibility. We found some penalties for storm water permit violations were not collected in California. There was evidence penalty collection was problematic in other states. Louisiana's Legislative Audit report showed the state had not collected $441,188 in penalties for the years 1998 and 1999. A Maryland audit found the state did not assess or collect penalties of $100 per day for not meeting consent order milestones. In this last case, the discharger continued to violate its permit 13 times between October 1997 and March 2000 without paying assessed penalties.

Proactive Actions Could Prevent Significant Violations

The states we evaluated needed to improve strategies to prevent violations from occurring at overused facilities. Many significant violations occurred because waste water treatment facilities were obsolete, worn out, or exceeding capacity. Further, an expanding population taxed existing systems beyond capacity.

> *"If you ignore the (sewage) systems for 20 or 30 years, it's going to come back and haunt you."*
>
> -Orange County CoastKeeper, environmental advocate

We found states had vehicles available to address future discharges that would violate permits. For example, California could issue a time schedule order for threatened discharges of waste in violation of requirements.

We found numerous violations due to plant obsolescence and capacity limits. For example:

- In North Carolina, one small city's waste water treatment plant capacity had not kept pace with population growth, leading to pollution violations. The treatment plant discharged pollutants into a stream which ran through a residential area.

- In Northern California, one small city's population growth outstripped the capacity of its sewage collection system. Sewage spills occurred because the collection system lacked necessary capacity. Some of these spills ended up in drinking water sources.

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Many of these violations could not be prevented without major capital investments, including new plants, that required months or years to finance and construct.

EPA should continue to work with states to establish proactive strategies, such as time schedule orders, to hold dischargers accountable for compliance. As one North Carolina official observed, when discharge rates reach 80 percent of the limit, consideration should be given to expanding the plant. When discharges approach 90 percent, plant expansion should have begun.

Best Practices: Deterring Noncompliance



Best Practices: Deterrence

- Minimum penalties
- Publicity of enforcement actions
- Compliance report card

States had several best management practices that were effective in improving compliance. These practices included:

- **Minimum Penalties.** Both California and North Carolina had instituted minimum penalties for certain violations. They followed the lead of New Jersey, which reported improvements in water quality by using minimum penalties for large sewage spills and other water quality violations. However, as found by North Carolina, minimum penalties may not be effective for more severe violations if they are too low.

Minimum Penalties: Pros and Cons

+ Penalties assessed for normally unaddressed minor violations

+Relatively quick consequence to violations

+Ensures consistent, dependable response from regulators

-Serious violations may receive the same penalties as minor violations

-Minimum penalty may be substantially less than recovering economic benefit

- **Publicity of Enforcement Actions.** EPA's sector facility indexing project and North Carolina's website provided some measure of public accountability over violators and regulator responses. By accessing these Internet sites, the public can identify violators, locations, and penalties assessed. States can gain an additional deterrent effect by publicizing their enforcement responses widely, using vehicles such as state websites and press releases.

- **Compliance Report Card.** California planned to publicize the results of its enforcement program to keep managers, policy makers, and the public informed about violations and actions taken. Its planned compliance report card would be produced annually, showing compliance rates, enforcement actions taken, the use of penalty funds and supplemental

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environmental projects. Ongoing compliance rates of dischargers and the report card would be placed on the Internet.

Recommendations

We recommend that the Assistant Administrator for Enforcement and Compliance Assurance:

5- 1. Establish a clear and consistent standard for measuring the promptness of enforcement actions.

5- 2. Continue to work with the regions to assist states in establishing proactive enforcement strategies to help facilities avoid long-term serious violations due to plant or system obsolescence or capacity limits.

Chapter 6 also contains a recommendation for setting standards for enforcement actions. See page 60.

Agency Response and OIG Position

*5-1. **Time Standard.** The Office of Enforcement and Compliance Assurance explained that the permit program already had a "timely and appropriate" standard described in the Enforcement Management System. It believed that a more appropriate recommendation would be for the Office to review the consistency of its standard and ensure that the regions and states are aware of it.*

OIG Position: We agree with the Office's alternative recommendation and ask it to address the recommendation's implementation.

*5-2. **Proactive Strategies.** The Office of Enforcement and Compliance Assurance stated that it, in conjunction with the EPA Office of Water, had developed guidance documents and training workshops to assist the regulated community in avoiding noncompliance due to plant or system obsolescence or capacity problems. Some specific examples were guidance for implementation of nine minimum controls and a long-term control plan for combined sewer overflows, as well as guidance documents and training workshops for municipal officials, system operators, and consultants on procedures to eliminate and prevent combined and sanitary sewer overflows.*

The Office of Enforcement and Compliance Assurance said it was involved in the development of the Guide for Evaluating Capacity Management, Operation and Maintenance Programs at Sanitary Sewer Collection Systems which describes management practices and operation and maintenance techniques that have served municipalities best in the

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reduction and elimination of sanitary sewer overflows from their systems. The audience for this guidance is state and EPA personnel who are assisting municipalities to comply with sanitary sewer overflow requirements. The guidance will also help municipalities make decisions on the rehabilitation and repair of their collection systems and ways to better operate those systems. The guidance was scheduled for release as an interim-final document early in fiscal 2002, and was planned to be finalized following the final publication of the Sanitary Sewer Overflow Rule.

The Guide for Evaluating Capacity Management, Operation and Maintenance Programs at Wastewater Treatment Plants will assist inspectors in determining whether a capacity management, operation and maintenance program was adequate for a particular wastewater treatment plant. The guidance will also be useful to municipalities for determining whether their plants were following accepted practices and for addressing any discrepancies as needed in order to improve or maintain compliance. The guidance was scheduled for release as an interim-final document early in fiscal 2002.

OIG Position: The Office's reply partially addresses the issue and recommendation. The guides are excellent references and will provide some measure of compliance assistance to EPA regions and states. However, the guides in and of themselves are not proactive enforcement strategies.

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Chapter 6

Improved Performance Evaluation and Measurement Needed

To ensure fair and effective enforcement of the Clean Water Act, EPA regions need to continue performing both periodic, in-depth program evaluations and annual performance evaluations of states' performance. These evaluations need to be consistent, continue toward a goal of measuring the effectiveness of performance, and be made easily accessible to the public.

> *"EPA must balance the new expectations raised by the Government Performance and Results Act, the [National Environmental Performance] partnership approach suggesting more flexibility in state oversight, and the more traditional measures used to assess performance of state enforcement programs."*
>
> -EPA Office of Regulatory Enforcement

Oversight Tools

EPA had developed several tools to evaluate state enforcement performance:

- **Quarterly Non-Compliance Reports.** States are required to report on major facilities that have significant violations of their permits on a quarterly basis, along with the enforcement actions the state has taken. Further, the Office of Enforcement and Compliance Assurance has developed an automated system called "SNC [Significant Noncompliance] Tracker" which allows both states and regions to evaluate compliance records of major facilities at any time.

- **Policy Framework.** In 1986, EPA established a framework for evaluating enforcement programs. In addition, Clean Water Act-specific guidance provides additional criteria.

- **Core Performance Measures.** Under the National Environmental Performance Partnership System, EPA and the Environmental Council

EPA's Oversight Criteria and Measures

- Clear identification of and priorities for the regulated community
- Clear and enforceable requirements
- Accurate and reliable compliance monitoring
- High or improving rates of continuing compliance
- Timely and appropriate enforcement response
- Appropriate use of civil, judicial, and administrative penalty authorities

-EPA 1986 Policy Framework

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of the States have agreed upon seven "core" performance measures for evaluating state enforcement and compliance performance.

Regions Performed Valuable Evaluations

"While states and local government have primary responsibility for compliance and enforcement actions... EPA retains the responsibility for ensuring fair and effective enforcement of federal requirements, and a credible national deterrence to noncompliance."

-EPA's 1986 Policy Framework for EPA-State Enforcement Agreements

We found that at least eight regions were performing in-depth evaluations of state programs. (We were unable to obtain information from two regions.) The three regions we audited were performing in-depth evaluations that had important findings that were used, or should have been used, to improve state programs. To illustrate:

- In February 2000, Region 9 presented its findings on California's Clean Water Act discharge program to a California joint legislative committee hearing on water quality issues. Its findings included the lack of storm water inspections and inadequate recovery of economic benefit in penalties. Both of these issues were being addressed by revisions in California's enforcement strategy and policy.

- In June 1999, Region 4's issued its findings from a review of North Carolina's Clean Water Act discharge program. These findings included the lack of an effective storm water program and weaknesses in the state's enforcement policy concerning identifying toxicity test failures as permit violations.

Although regional evaluations found significant weaknesses with state programs, they were inconsistent. The regions that responded to our survey had developed their own evaluation programs; these programs evaluated many of the same program elements but did not evaluate others.

The frequency of in-depth evaluations also varied substantially. Region 4 performed in-depth evaluations every 8 years or so because of the large number of states in the region. Region 6 told us it performed a detailed program review on a semiannual basis.

EPA should develop and use consistent criteria and measures for in-depth program evaluations. At a minimum, all of the oversight criteria and measures in EPA's 1986 Policy Framework should be included along with additional elements



Best Practice: Region 8's Scoring System

- Performance measured objectively and consistently
- Clear expectations set for performance
- States challenged to improve scores
- Areas needing improvement specifically identified
- Region could focus resources on areas where state needed assistance

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included in the Clean Water Act discharge guidance, such as the adequacy of pretreatment programs.

Further, to ensure consistent oversight, there should be a uniform, objective scoring mechanism. In this regard, Region 8 used an objective scoring system in 1999 for measuring state performance.

We also believe regional evaluations should be made easily accessible to the public. Publicity apparently caused North Carolina to improve its storm water program. Although EPA Region 4's evaluation of North Carolina's enforcement program in 1999 found serious deficiencies in management of the storm water program, the state did not agree to make investments in the program until we reported these same problems a year later.

Performance Measures Need Focus on Effectiveness

EPA regions needed to use core performance measures to consistently measure the effectiveness of state enforcement programs. Under the National Environmental Performance Partnership System, EPA and the Environmental Council of the States had agreed upon seven "core" performance measures for evaluating enforcement programs.

Core Performance Measures

- Number of major inspections and percentage in priority areas
- Number of enforcement actions
- Number of facilities reached through compliance assistance*
- Rates of significant noncompliance*
- Percentage of significant noncompliers returned to compliance
- Environmental or health benefits achieved by enforcement activities*
- Results of using alternative compliance approaches*

**Optional*

While there was state resistence to collecting and reporting state data, EPA should continue to press its state partners, including the Environmental Council of the States, to use core performance measures that address the effectiveness of enforcement programs. Further, these measures should be reported annually and be easily accessible to the public.

Core performance measures were not consistently used by regions or states to evaluate performance. Core performance measures are a limited set of measures designed to help gauge progress toward protection of the environment and public health. Only part of one core measure, the number of major facility inspections, was used to evaluate state performance by all seven regions that responded to our survey.

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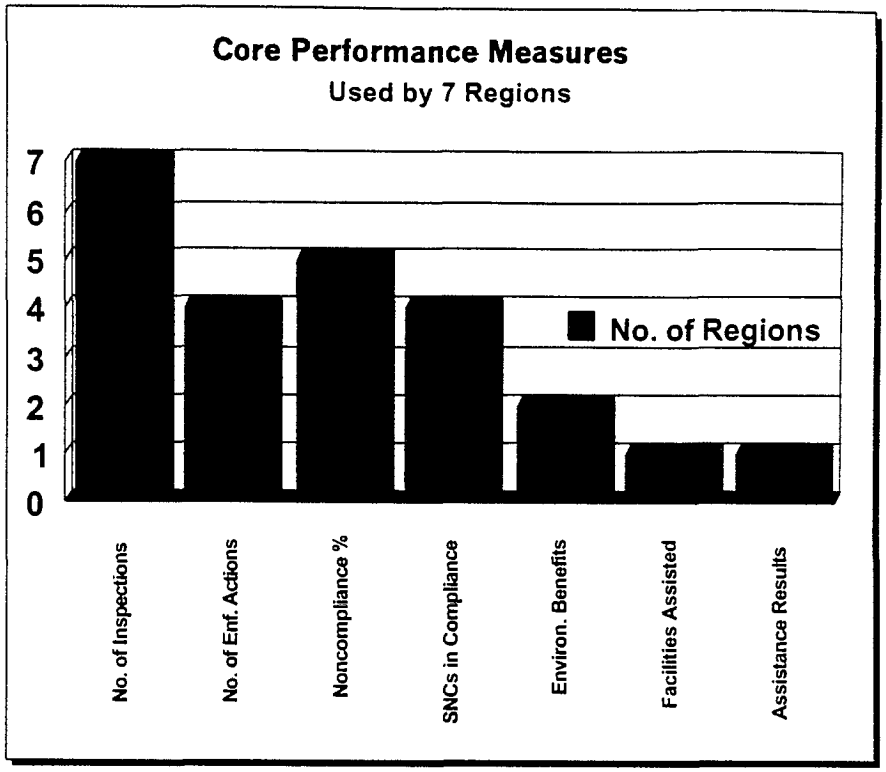

SNC=Major Facilities in Significant Noncompliance

We believe the core performance measures needed further evolution in order to achieve their national objective of "managing for environmental results" for a number of reasons:

- **Bean Counts.** Three of the measures counted activities, such as the number of major facilities inspected. These "bean counts" would be more meaningful if they were converted into rates, such as the percentage of the targeted universe inspected.

- **Measuring Success.** Rates, such as compliance rates, were not evaluated against benchmarks, standards, industry averages or geographic norms. It was unclear what a successful, average, or unsuccessful rate was.

- **Environmental Outcomes.** The states we reviewed were not measuring environmental outcomes from enforcement activities or assistance activities.

- **Correlation Analysis.** Except for North Carolina, the states we evaluated had not attempted to analyze correlations between monitoring activities, enforcement actions and compliance rates. Analyzing such correlations

"What is the relationship between enforcement and compliance, and how can we use this information to improve compliance and meet other [North Carolina] objectives?"

-North Carolina's Enforcement Assessment 2000

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would be useful in evaluating the effectiveness of inspections, monitoring, notices of violations, and penalties.

> *"Many [states] were not enthusiastic about the prospect of an EPA report with comparable performance measures for all 50 states...."*
>
> -National Academy of Public Administration, November 2000

As found by the National Academy of Public Administration, there were several reasons that the core performance measures did not fully shift the focus from "bean counting" to environmental results. Four of the most important core performance measures were optional, such as environmental benefits achieved through concluded enforcement activities. Further, states refused to collect and report on many measures. They claimed the measures did not always address their problems and added to their reporting burden.

EPA had its problems with core performance measures as well, the Academy reported. EPA was unwilling to abandon its traditional practice of negotiating agreements on activities states will conduct. Further, the core measures were developed separately from the Agency's own goals and measures under the Government Performance and Results Act. States believed there was a significant disconnect between the Agency's own goals and core performance measures.

> *"All states should compile core performance measures; EPA should gather them and make them publicly available."*
>
> -National Academy of Public Administration, November 2000

In spite of these weaknesses, core performance measures can provide an important measure of success and public accountability. By reporting on compliance rates and environmental benefits, the core performance measures provide indicators of state program accomplishments and success. The National Academy of Public Administration has recommended that all states compile core performance measures and EPA consolidate them and make them publicly available. We agree. As California observed, state officials "must be regularly informed as to how their actions, policies, and staff are affecting the rate of compliance." States (and EPA) should be held accountable for their results.

Developing core outcome performance measures will be more difficult. GAO recently concluded that enforcement outcome measures have been difficult to create because of:

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- The frequent absence of baseline data needed to determine whether compliance rates or environmental quality have improved under new strategies.
- The inherent greater difficulty and expense in quantifying outcomes as compared to counting and reporting enforcement activities.
- Difficulty in establishing causal links between enforcement strategies and compliance rates or environmental quality.

States' Efforts to Develop Performance Measures

While core performance measures may not have addressed each state's problems, the states we evaluated had not made much progress in developing more appropriate measures.



Best Practice: Using Outcome Measures

"Florida was one of the few states to have attempted to quantify outcomes, noting that calculating accurate industrywide compliance rates was an important part of the state's effort to focus programs on results."

-GAO Testimony, June 1998

Utah and North Carolina were tracking their compliance rates, although there were some serious limitations. California was not routinely evaluating its compliance rates state wide. However, states were making efforts to develop better measures.

North Carolina had formed a work group to develop performance measures to assess the effectiveness of its enforcement programs, including water quality. The three performance measures developed for enforcement were the (1) number of repeat violators, (2) compliance rate per number of regulated facilities, and (3) compliance rate per inspections.

Utah and Region 8 had also partnered in an attempt to develop better enforcement performance measures, including environmental improvement measures. After much effort, the project came to a halt. The Region and state decided not to proceed because the effort would not reduce reporting; instead, it would increase data gathering.

California was in the midst of a major initiative to improve its compliance rates for water dischargers. It recognized the serious limits of its monitoring and data systems and was in the process of implementing new systems.

"... The attractiveness of performance measures is exceeded only by the difficulty of their design and implementation."

-National Academy of Public Administration

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Only one of the seven regions that responded to our survey was aware of a state that used outcome-based performance measures. As previously noted, developing outcome-based measures was inherently difficult. The Office of Enforcement and Compliance Assurance had issued grants to states to develop better performance measures. The results of these studies should be used to further refine the core performance measures.

Lack of Goals and Standards

Although it was EPA's goal to increase compliance, this goal had not been articulated into specific measures of success by EPA or the states we reviewed. Both Utah and California had set some compliance goals; however, there were not specific goals or standards for most aspects of the program. For example, compliance goals were not established for watersheds, priority programs, high-risk sources, or priority industrial sectors. None of the states we reviewed had specific goals or objectives for increasing compliance, reducing recidivism, or improving water quality by specific amounts or percentages.

The lack of standards and goals made it difficult for decision-makers to make decisions on whether to invest or divest in certain strategies, target areas, sectors, watersheds, or sources. Also, without goals or standards, it was difficult to evaluate the relative success of programs.

Recommendations

We recommend that the Assistant Administrator for Enforcement and Compliance Assurance routinely determine whether states are fulfilling their obligations to monitor and enforce discharge programs. Specifically:

6- 1. Develop consistent criteria and measures for in-depth program evaluations of state programs:
   a. At a minimum, all of the oversight criteria and measures in the 1986 Policy Framework should be included along with additional elements included in the Clean Water Act discharge guidance. Include the accuracy and completeness of data systems, the quality of inspections, and the reliability of self-monitoring reports.
   b. Evaluate all significant discharge programs including storm water, minor dischargers, and concentrated animal feeding operations.
   c. Use a uniform, objective scoring mechanism.

6- 2. Have regions perform in-depth evaluations of state enforcement programs every two to three years. Make these evaluations available to the public through publicity releases or the EPA website.

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6- 3. Continue to remind state partners, including the Environmental Council of the States, of their obligation to use core performance measures that address the effectiveness of enforcement programs.

6- 4. Have regions collect and use all core performance measures to consistently measure the effectiveness of state enforcement programs on an annual basis. Consolidate these measures nationwide and make them public.

6- 5. Work with regions to assist states in setting specific goals and standards for compliance, recidivism, the timeliness of enforcement actions and other important measures.

Agency Response and OIG Position

*6-1. **Consistent Criteria and Measures**. The Office of Enforcement and Compliance Assurance agreed that a process for periodic evaluation of the Clean Water Act discharge program in each state would be useful. It stated that most regions conducted assessments of state water enforcement programs, either annually or bi-annually, though the nature of the assessment varied. Some variability in the assessment process was necessary since priorities varied by state, as did work sharing with EPA regions. The Office asserted that the review content of state performance for any program, not just the Clean Water Act discharge program, must be governed principally by the authorization agreements, grant work plans and agreements and the performance partnership agreement between a region and a state. Those policies and agreements should define priorities, describe work sharing arrangements between a region and a state, and define the evaluation process to be used, among other things.*

The Office of Enforcement and Compliance Assurance stated it had a national evaluation process which focused on "program element reviews" among programs. These reviews examine policy and implementation of a particular program element in all EPA regions and a sample of states. The Office noted it was responsible for working with EPA regions and states to evaluate a wide scope of statutory programs, and while resources did not permit a commitment to ensure a top to bottom evaluation of the enforcement of the discharge program in every state, the Office agreed to consider how best to concentrate on key concerns of the program.

The Office of Enforcement and Compliance Assurance noted that since the program element reviews will each address a different program or problem, there will not be a standing uniform scoring mechanism. However, within each review, the questions used and the weight assigned

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to the answers will be the same. The Office agreed to continue to develop a consistent set of criteria and measures as part of its design for each program element review. All applicable policy is considered in designing each review. For discharge permits, this will include criteria from the 1986 Policy Framework. However, the Office was not yet in a position to identify what reviews will be undertaken in the future.

OIG Position: We laud the Office of Enforcement and Compliance Assurance's efforts to develop a consistent set of criteria and measures for "key concerns" of state enforcement programs. However, the plan to evaluate a single element of a state enforcement program is less than optimal and merits serious reconsideration. EPA should be aware of significant weaknesses in the state programs it has authorized. A single program element review will not evaluate all of the state's significant discharge programs. Morever, single program element reviews fail to consider how resource constraints drive program management.

As the Office noted, it has uniform criteria to evaluate state enforcement programs: (1) EPA 1986 Policy Framework, and (2) core performance measures developed by EPA and the Environmental Council of the States. These criteria provide a sound foundation for consistently evaluating state performance nationally.

Further, as detailed in this report, all of the regions that responded to our survey indicated they were performing comprehensive state evaluations. Thus, lack of resources does not seem to be a major issue.

6-2. ***In-Depth Evaluations.*** *The Office of Enforcement and Compliance Assurance pointed out that many regions performed in-depth evaluations of state enforcement programs on a rotating basis, using the Performance Partnership Agreement, grant agreement, and existing policy as a basis. The Office agreed that it would be ideal to have these evaluations of enforcement programs in all states every 2 or 3 years; however, resources simply would not allow that in some EPA regions. The Office also agreed that publicity can be an effective factor to ensure competent program operations; however, active publication of all evaluations on a website may exacerbate federal-state tensions and inhibit a frank, open review process. The Office reserved to use the website as conditions dictate.*

OIG Position: It appears EPA regions have adequate resources for evaluating state programs; all of the regions that responded to our survey indicated they were performing comprehensive evaluations of state programs. Further, the Office of Enforcement and Compliance Assurance could team with the Office

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of Water to better leverage federal resources directed at evaluating state performance.

One weakness in the existing state evaluation process was the lack of consistent criteria and measures. For evaluations to be equitable, comparable, and valuable, they need to be consistent, objective, continue toward a goal of measuring the effectiveness of performance, and easily accessible to the public.

The public should be aware of serious deficiencies in a state's ability to protect human health and the environment. While public information about state performance may exacerbate federal-state tensions, it would provide an important means for holding states accountable for their environmental performance.

6-3. ***State Use of Core Performance Measures.*** *The Office of Enforcement and Compliance Assurance agreed to continue to remind states of their obligation to use core performance measures, and suggested that OIG encourage the states directly where possible to do so as well. In fiscal 1999, $1.8 million was awarded to 11 states to develop outcome measures, and, in fiscal 2000, another $1.2 million was awarded to 10 states to develop outcome measures specifically for compliance assistance. The Office was also discussing with states possibilities for funding performance measurement work within the National Environmental Performance Partnership System framework.*

6-4. ***EPA Use of Core Performance Measures.*** *The Office of Enforcement and Compliance Assurance advised that states report on the required core measures through national data systems. It is the optional measures which the states have opted not to use. The Office agreed to continue to promote the use of the optional measures through all means available, including grants. The Office consolidates information on required core measures of outputs nationally, and this information is used by EPA regions in their performance discussions with their states and is available to the public on request.*

6-5. ***Compliance Measures.*** *The Office of Enforcement and Compliance Assurance noted that while measures for compliance, recidivism, and the timeliness of enforcement actions were not "core measures" for states, it had established performance standards for the timeliness of enforcement actions which, for the most part, were derived directly from the 1986 Policy Framework. Regions have worked with states to have them adopt these standards. In fact, the Office included state performance on this standard in some of its program management reports.*

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Since the measure for recidivism is new, the Office of Enforcement and Compliance Assurance wanted to get some experience with the measure before establishing performance goals. Likewise, it has not set performance goals for compliance rates, recognizing that compliance rates are the product of many factors, not just EPA activities. The Office planned to work with the states through a grant to the Environmental Council of the States to assist in developing a consistent approach to determining compliance rates.

The Office of Enforcement and Compliance Assurance stated it monitored and reported on recidivism and timeliness on a national basis. It was considering setting a national target for recidivism for all programs, as well as a national target for improving compliance.

OIG Position: The Office's response partially addressed recommendation 6-5. The Office's efforts to set goals and standards for compliance, recidivism, and timeliness are critical to evaluating the effectiveness of state (and EPA) performance and should be continued. We are recommending, however, that regions work with states to establish specific performance goals in these areas. We look forward to the Agency's response to this recommendation in its reply to this report.

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Exhibit 1

Details on Scope and Methodology

Scope

This audit resulted from concerns over the effectiveness of state enforcement programs. We focused on the Clean Water Act discharge program because of a lack of recent audit coverage in this area.

Forty-four states have EPA approval to issue, monitor, and enforce permits under the Clean Water Act's National Pollutant Discharge Elimination System program. EPA regions issue permits in the remaining states. The purpose of the discharge program is to protect human health and the environment by preventing the discharge of pollutants.

In addition to evaluating national data, we evaluated three EPA regions: 4, 8, and 9. In each region, we evaluated one state authorized to issue discharge permits. We selected states with a range of population, economy and sources of water pollution: California, North Carolina, and Utah. These states represent about 16 percent of the U.S. population.

We issued a separate report on North Carolina entitled *"North Carolina's NPDES Enforcement and EPA Region 4 Oversight"* in September 2000. This report addressed matters not included in this report, such as water testing methodology. Issues pertaining to this audit are included in this report. Additional details on the scope and methodology of our North Carolina evaluation are discussed in the North Carolina report.

We considered the results from a National State Auditors' Association-coordinated audit that included enforcement of the Clean Water Act. As of April 1, 2001, five state audit reports had been issued that addressed Clean Water Act enforcement to some degree: Arkansas, Colorado, Louisiana, Oregon, and Maryland. We considered the results of these audits in this report.

We performed our audit according to Government Auditing Standards issued by the Comptroller General. Our field work was conducted from February 2000 to October 2000. The audit included management procedures in effect as of fiscal 1999. We evaluated strategies, compliance monitoring systems, and enforcement actions taken from October 1, 1998 to December 31, 1999.

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Methodology

As part of our evaluation of management controls, we performed a risk assessment. This risk assessment identified the potential threats to state water enforcement and the management controls to address these threats. Based on this risk assessment and interviews with EPA officials, we identified critical management controls.

Management Controls

In assessing management controls, we also considered the Agency's own assessment. EPA's Permit Compliance System was identified in 1999 as an Agency weakness during EPA's annual self-assessment process. In EPA's fiscal 2000 Integrity Act Report to the Office of Management and Budget, EPA reported it had three major initiatives underway, in conjunction with the states, which were intended to address the issues involved with the Permit Compliance System and improve the usefulness of the system as a management tool: (1) system modernization; (2) interim data exchange format; and (3) electronic reporting. The status of these initiatives is discussed in Exhibit 2, page 69.

The management control weaknesses we found are described in this report, along with recommendations for corrective action. These weaknesses were a significant contributing cause to enforcement effectiveness problems.

Management Controls Over State Water Enforcement Programs

- Clean Water Act and amendments
- EPA approval process for state programs
- 40 CFR 122 and 123
- State laws, policies and guidance
- EPA's Permit Compliance System and state data systems
- 1986 Policy Framework for State/EPA enforcement agreements
- EPA Memorandum Of Agreement Guidance
- EPA's Enforcement Management System, Enforcement Response Guide, and enforcement policies
- Regional performance partnership grant agreements, work plans, and evaluations
- Regional audits and evaluations of state programs
- Regional memorandum of agreements
- EPA Inspection Manual
- Inspections
- Self-monitoring reports
- Quarterly noncompliance reports

Analysis Techniques

In evaluating state strategies, we considered compliance monitoring activities performed in high-risk areas.

To evaluate compliance monitoring and enforcement systems, we evaluated a judgmental sample of facilities to see if violations were properly identified and enforcement actions were appropriately taken. In California, we selected a judgmental sample of nine major facilities in the San Francisco Bay Regional

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Water Quality Control Board. We also evaluated the storm water compliance monitoring systems of the Los Angeles Regional Water Quality Control Board. Both boards are part of California's State Water Resources Control Board. Moreover, we considered Region 9's audits of Clean Water programs that had been performed in California's three other regional water boards. In evaluating compliance monitoring and enforcement systems in Utah, we selected a judgmental sample of six major facilities.

We also evaluated a sample of 34 major facility inspections in California and Utah; California's were selected from the San Francisco region. We evaluated four storm water inspections in the Los Angeles region and seven from Utah. These were judgmental samples; however, we believe they were representative.

To evaluate regional oversight of state programs and performance measures, we conducted a survey of 10 regions; seven regions responded. We also obtained information on oversight procedures for another region. In evaluating oversight, we compared annual and in-depth state evaluation criteria to EPA's 1986 Policy Framework and the National Environmental Performance Partnership System's core performance measures.

Evidence Considered

In analyzing state strategies, we considered the National Water Quality Inventory; EPA's Strategic Plan and annual plans; state plans, strategies, and grant agreements; EPA's 2000/2001 Memorandum of Agreement Guidance; Office of Water's report, *"Liquid Assets 2000";* regional memoranda of agreement, strategies and plans; and GAO reports. We interviewed responsible EPA headquarters, regional, and state personnel.

We considered the following evidence in evaluating compliance monitoring and enforcement:

- State compliance monitoring activities, including receipt and review of discharge monitoring reports, discharger inspections, and handling of complaints.
- State enforcement actions, including timeliness and appropriateness of the response, appropriateness of the penalty, and penalty collection.

We reviewed inspection procedures and examined state inspection reports. We also considered state and regional board policies and practices, management reports and interviews with responsible officials.

For the three regions we reviewed, we obtained regional evaluations of state performance.

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Data Limitations

There were serious limitations in the scope of the management information available to evaluate state enforcement programs. EPA's permit compliance system was inaccurate and incomplete. (This problem is described in Chapter 3, page 19.) Thousands of smaller discharge permits were not required to be included in the system. Further, state systems were limited, especially for storm water program compliance status and activities. These issues are also further discussed in Chapter 3, page 19 and Chapter 4, page 35.

Prior Audit Coverage

Neither EPA Office of Inspector General nor GAO have conducted any recent national audits of state enforcement of Clean Water Act dischargers.

The National Academy of Public Administration issued a report in November 2000 which included evaluations of EPA's water and enforcement programs.

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Exhibit 2: Other Matters

Key Management Decisions Needed for the Permit Compliance System

During the audit we attempted to determine if the plans for the modernized Permit Compliance System would remedy data gaps in EPA and state water enforcement information. These data gaps are discussed in Chapter 3 of this report (page 19). We were unable to ascertain whether the modernized system and its components would remedy these data gaps. We also identified management decisions the Office of Enforcement and Compliance Assurance should address promptly to ensure the system will meet both EPA and state needs.

Permit Compliance System Modernization Projects

EPA is redesigning the Permit Compliance System to better address current requirements of discharge permitting and enforcement programs and to meet new Office of Water initiatives, such as tracking reduced pollutant loadings, capturing information on storm water sources, and assessing the health of individual watersheds. EPA estimates that the cost for modernizing the system is between $12 and $14 million.

The Office of Enforcement and Compliance Assurance has three major initiatives currently underway for its Permit Compliance System, in conjunction with the states, which are intended to address system problems and improve its usefulness as a management tool:

- System modernization,
- State interim data exchange format, and
- Electronic reporting.



Permit Compliance System Initiatives

Initiative	Target Date (Fiscal)	New Functions
System Modernization	2003	Tracks reduced pollutant loadings, captures information on storm water sources, assesses health of watersheds
Interim Data Exchange Format	2001	Eases entry of state data into system; simplifies transition to modernized system
Electronic Self Reporting	2002	Discharger self-monitoring reports submitted electronically

Efforts to modernize the system have been frustrated over the years by a lack of funding and other Agency priorities. In addition, there have been regulatory hurdles to overcome. For example, to enable electronic reporting, the Agency had to modify federal discharge regulations to allow the regulated community to use electronic reporting to submit discharge information to EPA.

Concerns

In evaluating whether the modernized system would remedy problems with data gaps, we identified several concerns that we believe should be promptly addressed:

- **Data Entry Requirements Were Not Updated**. The Agency policy that identifies data that EPA and states are required to enter into the national information system had not been updated for over a decade and excluded storm water data. Meanwhile, the functional requirements documents for the new system had been completed and the project had started the detailed design phase. Data entry requirements are critical for determining system requirements, identifying system costs and benefits, and developing electronic reporting regulations.

- **Requirements Documents Were Incomplete**. The requirements documents for the new system were incomplete. We were told that new data elements had been established for storm water and concentrated animal feeding operation permits and, potentially, new data elements will be needed for certain minor facility operation permits. However, this will not be fully known until the data entry policy is updated. Also, the Office of Enforcement and Compliance Assurance had not determined how the compliance status would be determined for storm water, concentrated animal feeding operations, and other new permits.

- **Formal Consensus Was Not Reached**. The Office had not successfully collaborated with the Office of Water in the design of the system requirements. Further, the states had not formally bought into system requirements. Although the Office of Water and states had been included in workshops to determine system requirements, they had not reached a formal consensus on the modernized system requirements to ensure the new system will meet the users' needs.

- **Cost-Benefit Analysis Was Incomplete**. System modernization for the Permit Compliance System had begun the detailed design phase without completing the required life cycle cost-benefit analysis. Office of Management and Budget Circular No. A-11, Part 3 - *Planning, Budgeting, and Acquisition of Capital Assets* (July 2000), and OMB

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Circular No. A-130, *Management of Federal Information Resources* (November 2000), require agencies to prepare and update cost benefit analyses for information systems. An accurate cost-benefit analysis is necessary to identify the most cost-effective solution for the new system. Also, the expected benefits of the new system need to be quantified for evaluating the return on investment.

- **Key Decision Documents Were Needed.** Although the modernized system was estimated to cost more than $10 million in life cycle costs, the required system charter and system management plan decision papers had not been prepared or approved by appropriate levels of management. According to EPA's Information Resources Management Policy, the system charter should have been developed during project initiation, included an estimate of life cycle costs, and identified appropriate management levels for approval of decision papers. Further, the decision paper for the system management plan should have been produced at the conclusion of the analysis stage and updated as the project progressed.

Suggestions

We suggest that the Office of Enforcement and Compliance Assurance collaborate with the Office of Water to create an updated data entry policy. Upon completion of this policy, we suggest that the Assistant Administrator for Enforcement and Compliance Assurance:

- Complete the system requirements document.
- Execute memoranda of agreements with the Office of Water and state participants to help ensure (1) that the baseline requirements for the new system design are formally agreed to and (2) that both federal and state needs are addressed in the design of the new system.
- Perform a cost-benefit analysis of the new system that addresses the electronic reporting and data entry requirements, the system development costs, and the projected operational and maintenance costs over the life of the system.
- Establish and approve a system charter and system management plan.

Agency Response and OIG Position

The Office of Enforcement and Compliance Assurance agreed with the suggestions, except for the suggestion to execute memoranda of agreements with the Office of Water and the states on the system requirements and design. It explained that the schedule below addresses the tasks it will perform, with the involvement of EPA regions and states:

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Update system management plan	*5/01-12/01*
Complete system design specification document	*7/01-3/02*
Update federally required data element list	*4/02-9/02*
Update system policy statement	*Ongoing-9/02*

- ***System Requirements Document.*** *The Office of Enforcement and Compliance Assurance informed us that data requirements were collected from EPA (the Office of Water and the Office of Enforcement and Compliance Assurance) and states to determine the scope of the modernized Permit Compliance System. The next phase of system modernization is the design phase. One of the major products from that phase will be a design specification document. This document will be developed with very intense participation by EPA and states (both direct users and interface states). The design specification includes data elements to be collected in the system, data entry screens, report formats, and specific functionality to be supported, including electronic reporting efforts being managed elsewhere in the Agency. This effort will begin in July 2001 with the national Permit Compliance System meeting and will be completed by March of 2002.*

OIG Position: The finalization of the data requirements has the potential to affect the design phase and the cost benefits of system modernization. Accordingly, we suggest that extensive work on the design phase not be initiated until after the finalization of the data and functional requirements.

- ***Memoranda of agreements with the Office of Water and state participants.*** *The Office of Enforcement and Compliance Assurance agreed that full consultation and coordination with the Office of Water and the states was necessary; however it did not agree that the development of agreements with these parties was necessary or desirable. The Office believed that such a process would be extremely time consuming and resource intensive, and the goals of such a process can be achieved in other ways. Coordination had already occurred (and will continue) with Association of State and Interstate Water Pollution Control Administrators and the Environmental Council of the States.*

  Decisions on policy and system issues will be handled at a senior level between the Office of Water and the Office of Enforcement and Compliance Assurance with recommendations coming from the Permit Compliance System Steering Committee (representing EPA headquarters, regions, and states). One of the tasks before the Steering Committee and senior water managers is the updating of the

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system Policy Statement and the identification of federally-required data elements.

The Office of Enforcement and Compliance Assurance stated it had worked extensively with the Office of Water to identify data requirements. It intended to continue to work with the Office of Water and the states to finalize data requirements, both for existing programs and for new regulatory activities which were not well handled in the Permit Compliance System. In the next several months, system modernization managers will be working with the Office of Water to verify that requirements are still accurate and complete. Additionally, a data requirements team with representatives from the Office of Enforcement and Compliance Assurance, Office of Water, and state will be established at the Permit Compliance System national users meeting in July to review, validate, and finalize the identified requirements.

Once the data requirements are established, a workgroup, including EPA headquarters and regional representatives, as well as states, will be formed to identify the subset of data requirements which will be federally mandated for entry into the Permit Compliance System. The Policy Statement will then be modified to incorporate the data elements which states and regions are required to enter into the system as well as the universe to which those requirements will apply.

OIG Position: We believe it is critically important that the data and functional requirements for the modernized system be formally agreed to by the Office of Water and states to help ensure the system contains the agreed upon data, data definitions, data formats, and pertinent technical information needed to foster data quality and data integration. Without such agreements, there is an increased risk that the modernized system will not (1) meet the users' needs and (2) lower the costs to exchange data.

Formal agreements are also called for by the Exchange Network, an EPA project to improve environmental decision-making, improve data-quality and accuracy, and reduce data redundancy. The Exchange Network's Blueprint calls for EPA and the states to have "trading partner agreements" that contain the agreed upon data, formats, and related technical information. The Blueprint specifically cites Permit Compliance System data as an exchange of data to be governed by trading partner agreements.

- ***Cost-Benefit Analysis.*** *The Office of Enforcement and Compliance Assurance agreed to complete a cost-benefit analysis by September 2001.*

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OIG Position: Because the finalization of the data requirements has the potential to affect the design phase and the costs and benefits of the Permit Compliance System modernization, we suggest that the cost-benefit analysis be completed after the finalization of the data and functional requirements.

- ***System charter and system management plan.*** *The Office of Enforcement and Compliance Assurance agreed to establish and approve a system charter and management plan by December 2001. However, the Office stated that a system management plan was done early in the planning phases of system modernization. It was replaced with the Information Technology Management Reform Act submission, which contained all of the information required in the system management plan and was approved by Deputy Assistant Administrator. This submission was provided to the Office of Management and Budget. As this document was updated each year, the Office believed that it served the purpose of the system management plan; however, it agreed to update the plan by December 2001.*

OIG Position: We concur with the decision to update the system management plan by December 2001. However, we were unable to substantiate that a system management plan was previously prepared. Further, a system management plan must be approved by the Assistant Administrator, rather than the Deputy Assistant Administrator. Also, a system management plan also must be linked with Agency and organizational information resource management strategic and multi-year implementation plans, and be updated to reflect actual and planned changes as new system decision papers are approved.

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Exhibit 3

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Exhibit 4

Report Distribution

U.S. Environmental Protection Agency

- Administrator
- Deputy Administrator
- Chief Financial Officer
- Assistant Administrator for Water
- Assistant Administrator for Environmental Information
- Associate Administrator for Congressional and Intergovernmental Relations
- Agency Followup Official (2710)
- Agency Followup Coordinator (2724)
- Regional Administrators

State of California

- Environmental Protection Agency
- State Water Resources Control Board
- State Auditor

State of North Carolina

- Department of Environment and Natural Resources
- Division of Water Quality
- State Auditor

State of Utah

- Department of Environmental Quality
- Division of Water Quality
- State Auditor

Association of State and Interstate Water Pollution Control Administrators

Environmental Council of the States

General Accounting Office

National Academy of Public Administration

National State Auditors' Association

Natural Resources Defense Council

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

JUN 29 2001

OFFICE OF
ENFORCEMENT AND
COMPLIANCE ASSURANCE

MEMORANDUM

SUBJECT: OECA Comments on the Draft Audit Report, "State Enforcement of Clean Water Act Dischargers Can Be More Effective"

FROM: Sylvia K. Lowrance
Acting Assistant Administrator

TO: Charles McCollum
Divisional Inspector General for Audit
Western Audit Division
Office of the Inspector General

Thank you for the opportunity to review and comment on the April 25, 2001 version of the Draft Audit Report, "State Enforcement of Clean Water Act Dischargers Can Be More Effective." We agree with several of the conclusions in the report, including that States need to implement risk-based approaches to water enforcement and that it would be useful to have a process for periodic evaluation of the Clean Water Act program in each State. We also agree that modernization of the Permit Compliance System (PCS) should be a high priority; in fact, the modernization of the Permit Compliance System (PCS) has been an OECA priority for the last four years. As we have informed you on at least two previous occasions, part of the justification for this work was to improve the quality of information in PCS. OECA has funded modernization efforts during this 4 year period and Agency funds have been provided since FY 2000. OECA's commitment to modernizing PCS is further demonstrated through our recommendations as early as 1999 that PCS be added as an Agency-level FMFIA weakness.

However, we remain very concerned about the way some of the issues, as well as EPA's role, are characterized in the report and that many of the findings are based on anecdotal information. In brief, the draft report does not recognize that: 1) the Office of Enforcement and Compliance Assurance (OECA) has an exhaustive process for setting national enforcement priorities, including stakeholder meetings and a Federal Register notice and comment period (p. ii), 2) States should be responsible for setting "watershed-specific enforcement priorities"(p. 13), and 3) flexibility in NPDES program requirements

(e.g., tradeoffs of major and minor inspections are allowed) supports State enforcement strategies (p. 7). We are also concerned that the issues related to PCS have been oversimplified in the report.

OECA's national enforcement priority setting process includes consultation with the Regions, States, Tribes, and the national program managers. In addition, the views of the public are solicited through the publication of a Federal Register notice identifying proposed priorities. Public health and environmental risk is a major criterion used in identifying possible priorities, and documents coming from States, such as the 305(b) report, are used in determining which environmental problems pose the greatest risks. Wet weather issues, such as sewer overflows and contaminated urban and agricultural runoff, were identified as major sources of water quality impairment in the 305(b) reports and were identified as an OECA priority for FY 2000-2001. Storm water was added at the request of EPA's Office of Water. A stakeholder meeting held in the fall of 2000, which included State representation, verified that "wet weather" should be a priority again for FY 2002-2003. The audit report fails to recognize the involvement of States in the OECA national priority setting process, as well as the significance given to environmental issues identified by the States. A chronology of OECA's stakeholder process is included in response 2-1 of the attachment.

OECA believes it has been sending a consistent and strong message to the Regions and the States that enforcement resources should be concentrated on the most significant pollution sources. OECA has developed national risk-based strategies for addressing sewer overflows, concentrated animal feedlot operations, and storm water; each of these emphasize the importance of focusing on impaired watersheds. We agree more needs to be done, but we question whether additional guidance documents and further rounds of consultation would help, or whether they would drain scarce resources in redundant and time consuming bureaucratic processes with little environmental result. We believe that the real issue is not OECA's priority setting process but whether risk-based strategies are being implemented in the field by the States. The draft report reveals that several States have no risk-based planning at all. States need to assume a greater share of responsibility in addressing significant pollution problems. For example, they are often in the best position to identify watershed-specific priorities and develop field level implementation plans. A constructive recommendation would be that EPA should place more emphasis on program reviews and improve its efforts to share information (e.g., on "best practices") with the States.

OECA disagrees with the finding that the core NPDES program inhibits the development of State strategies. In its FY 2000/2001 OECA Memorandum of Agreement (MOA) Guidance ("the MOA Guidance"), OECA's focus was not on major point sources, but on the same "wet weather" risks to water quality cited by OIG in its report, including CAFOs and storm water. The MOA Guidance does state that it is an Agency goal to inspect 100% of all major point sources annually because major point sources generate the majority of effluent flow and toxic pollutant loadings which can significantly affect water quality in receiving waters. OECA believes that implementing a risk-based approach means evaluating all dischargers contributing to water quality impairment and an important component of that is maintaining a field presence at major facilities. Consistently inspecting major facilities in the past may be responsible for the relatively high levels of compliance among majors. We need to recognize that we would lose significant environmental benefits associated with higher levels of compliance among majors if we were to allow a total shift to minors. OECA's MOA Guidance allows Regions/States flexibility in shifting a portion of their total inspection resources from major to minor facilities, particularly in priority watersheds, where those minor facilities represent a significant risk. OECA's guidance makes clear that minor inspections can be traded for major inspections at a 2:1 ratio, using a risk-based rationale, if the Region/State is willing to

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cc: Eric Schaeffer, ORE
Michael Stahl, OC
Mary Kay Lynch, OPPA-C
Michael Cook, OW/OWM

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ATTACHMENT

OECA Responses to Recommendations in Draft OIG Report,
"State Enforcement of Clean Water Act Dischargers Can Be More Effective"

I. Executive Summary

OIG is recommending that the Office of Enforcement and Compliance Assurance, in partnership with the Office of Water and EPA regions, collaborate with states to develop risk-based enforcement priorities. EPA also should make modernization of its Permit Compliance System a high priority. Teaming with the Office of Water and the states, the Office of Enforcement and Compliance Assurance should ensure that the new system will meet both federal and state needs.

OIG is also recommending that the Office of Enforcement and Compliance Assurance revise its enforcement guidance to better define significant violations for toxicity test failures, minor facilities, and storm water dischargers.

Lastly, the Office of Enforcement and Compliance Assurance should routinely determine whether states are fulfilling their obligations to monitor and enforce discharge programs. To do so, it should develop consistent criteria for in-depth program evaluations of state programs. These evaluations, along with state performance measures, should be accessible to the public.

EPA Response: The Office of Enforcement and Compliance Assurance (OECA) has an exhaustive stakeholder process in place to determine what the national enforcement priorities are; it includes consultation with the Regions, States, and the Office of Water (OW). OECA has developed national risk-based strategies for the wet weather priorities and will continue to assist the Regions in working with the States to implement them. Modernization of the Permit Compliance System (PCS) is and will continue to be a high priority for OECA. OW and the States have been involved in workshops to help identify the data requirements needed for management of the NPDES program. Additionally, an OECA/OW/State data requirements team will be established at the PCS national users meeting in July 2001 to review, validate, and finalize the identified requirements. The final data requirements as identified by OECA, OW, and the States will be incorporated in the modernized PCS system.

Existing national enforcement guidance has flexibility to address toxicity, minors, and storm water violations. OECA will work with the Regions to ensure that the States are aware of the guidance and will consider OIG's specific recommendations when guidance is updated in the future.

OECA agrees that State compliance and enforcement programs need to be periodically evaluated. EPA Regions do assess State programs on a rotating basis and OECA now has a national evaluation process which focuses on "program element reviews."

Chapter 2: State Enforcement Strategies Need to Be Modified

OIG recommends that the Acting Assistant Administrator for Enforcement and Compliance Assurance:

*3- 1. **In partnership with the Office of Water and EPA regions, collaborate with states to develop risk-based enforcement priorities. Encourage states to develop mechanisms to evaluate tradeoffs in enforcement investments.***

EPA Response: OECA already has a consultation process in place, in which Regions, States, EPA's Office of Water, and other stakeholders are extensively consulted in determining what the national water enforcement priorities should be for each 2-year cycle. A major factor in identifying the candidates for priorities is the element of risk. To start the FY 2002/2003 process, in the Spring of 2000, Regions were asked to begin by engaging States and Tribes in a discussion of national priorities. We received comments, suggested changes for existing priorities, and recommendations for new

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priorities from 16 individual States and their environmental agencies, as well as receiving collective State comments from 3 EPA Regional offices. Based on feedback received and combined with an analysis conducted at Headquarters, a Federal Register (FR) notice was published on September 28, 2000 soliciting public comment on a list of 15 potential priorities and encouraging suggestions for additional nominations. The comments received from the FR notice helped set the stage for OECA's "National Priorities Meeting" held on November 14, 2000. State, Tribal, Regional and Headquarters managers attended the meeting. Fifteen priority candidates were described and discussed and attendees were then requested to recommend their top choices for OECA's FY 2002/2003 MOA priorities. Six State representatives and 12 representatives from State associations attended the meeting and they all contributed to the outcome. The 6 recommended priorities are all current priorities, sending a clear signal that stakeholders and our regulatory partners want OECA to continue working on those national priorities in FY 2002/2003.

While Regions can and do recommend that States participate in national water priorities, suggest where States might focus their resources, and meet with States to conduct joint work planning, ultimately it is the State's decision as to the priorities it will set. We believe OIG should recognize State involvement in identifying national priorities and that a more appropriate recommendation would be for OECA to develop a process to ensure States are implementing the risk-based strategies we have.

*3- 2. **Initiate action to eliminate the regulatory requirement to inspect all major dischargers annually.***

EPA Response: Our regulations at 40 CFR Part 123.26(e)(5) require that State programs have the "procedures and ability" to inspect all majors annually. We believe that it is important to retain this regulatory requirement because not all States are authorized to implement the NPDES program yet and this requirement sets a minimum, quantifiable standard for States to be held to (i.e., a State applying for approval to implement the NPDES program must have procedures and resources in place to at least inspect all of its largest dischargers annually). Major facilities are considered high risk facilities because they generate the majority of effluent flow and toxic pollutant loadings. As shown in the maps included in this audit report (p. 17 and 39), there still are numerous noncompliance problems with major dischargers indicating that it is important that we maintain a field presence at these facilities.

OECA recognizes that a risk-based approach, such as addressing impaired watersheds, requires addressing majors *and* minors which is why we issued the September 11, 1995 memorandum to the Regions entitled "Revision to Inspection Coverage and Frequency Criteria of Clean Water Act Permittees." This memorandum, as well as OECA's Memorandum of Agreement (MOA) Guidance, provides EPA Regions and States flexibility in shifting some inspection resources from lower risk majors to higher risk minors. OECA's guidance makes clear that minor inspections can be traded for major inspections at a 2:1 ratio, using a risk-based rationale, if the Region/State is willing to report the minor inspection results in PCS. Resistance sometimes arises from a lack of rationale (e.g., no risk-based strategy), unwillingness to commit to the tradeoff ratio, and/or unwillingness to report minor data in PCS. Reporting and tracking outcomes from these inspections is critical to addressing OIG's concerns regarding the lack of data on minors and for EPA to document results under the Government Performance and Results Act (GPRA).

We believe an appropriate alternative recommendation would be for OECA to ensure that any State that does not commit to inspect 100% of its majors develops and implements an inspection plan that targets an appropriate mixture of high risk dischargers (i.e., majors and minors) in priority areas such as impaired watersheds.

Chapter 3: Permit and Other Information Systems Inadequate

OIG recommends that the Acting Assistant Administrator for the Office of Enforcement and Compliance Assurance:

*3-1. **Make modernization of the Permit Compliance System a high priority. Further, ensure that future systems:***
- ***Allows for submission and evaluation of self-monitoring reports for all dischargers, including minor facilities and storm water.***
- ***Tracks storm water permits, inspections, compliance rates, and enforcement actions.***

EPA Response: Modernization of PCS is, and will continue to be, a high priority for OECA. The modernized system will build in the capacity to allow for entry of all data element fields needed to track all dischargers, including minor facilities and storm water facilities. Information tracked for those dischargers will include permit limits, inspections, compliance and enforcement action data. PCS modernization is scheduled for implementation by the end of 2003.

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3-2. Accelerate the development of the state data transfer system for the Permit Compliance System. Also, before proceeding further into design and development, work with the Office of Water to ensure there is an up-to-date policy statement for water system criteria.

EPA Response: Over the last year, OECA and the Office of Environmental Information (OEI) have been working closely with our State partners in implementing the PCS Interim Data Exchange Format (IDEF). IDEF will ease the States' entry of required information from their modernized State systems into legacy PCS, and will simplify the transition of that information entry into the modernized PCS. OEI is the lead for implementing the IDEF project and has developed the schedule for implementation of the project. Acceleration of that implementation schedule needs to be addressed by OEI. Currently IDEF is scheduled for full implementation in February/March 2002.

While OECA agrees that there is a need to update the PCS Policy Statement to address new data requirements, we do not agree that this must occur before design and software development. Broad capacity will be built into the system as indicated in the response to 3-1. Only a subset of that capacity is likely to be Federally required. Therefore, the Policy Statement can be updated during system design and development.

3-3. Have regions work with states to help ensure data elements needed for the new Permit Compliance System are included in state systems being developed.

EPA Response: OECA is in the process of finalizing the overall data requirements for the modernized PCS system. We will continue to work closely with the States in developing those detailed data requirements. Until those requirements are finalized, those States modernizing their systems should include in their modernized system the current PCS data entry requirements as referenced in the current PCS Policy Statement.

For the most part, States do not coordinate or consult with OECA when modernizing their State systems as they are built primarily to accommodate State needs. We will, however, request of Regions that they make a special effort to discuss State modernization plans during their EPA/State program status meetings. Additionally, we hope that extensive involvement of State representatives in the PCS modernization process will have a spill over effect in getting States to include the necessary data elements in their systems.

3-4. Continue to report the Permit Compliance System as an Agency-level weakness until the modernization project is implemented and the system data is reasonably accurate and complete.

EPA Response: OECA will continue to report PCS as an Agency-level weakness until all milestones have been met. One of the milestones is the completion of PCS modernization which is scheduled to occur by the end of 2003.

3-5. Revise guidance to specify that whole effluent toxicity violations are significant violations. Revise regulations to require whole effluent toxicity violations to be reported on quarterly noncompliance reports.

EPA Response: In many ways, whole effluent toxicity (WET) is treated like any other parameter in the NPDES program, i.e., the permittee reports self-monitoring data on its discharge monitoring report, WET results are entered into PCS and tracked, and violations should be reviewed and are subject to a range of enforcement responses. The major exception is that WET violations are not automatically flagged as significant noncompliance or "SNC." Because of the variability in permit requirements (e.g., many permits just require monitoring with a trigger for follow-up study instead of a numeric limit) and the variation in frequency of compliance monitoring required (e.g., quarterly or annually),WET violations do not neatly fit under our existing SNC criteria. However, EPA's existing regulations and guidance provide Regions and States flexibility to identify WET violations as significant. The regulations at 40 CFR Part 123.45(a)(2)(G) currently provide the Director with flexibility to report any violation of "substantial concern" on the QNCR. EPA's 1989 "Whole Effluent Toxicity Permitting Principles and Enforcement Strategy" states that any violation of a WET limit is of concern and should be reviewed. EPA's "Enforcement Management System" enforcement response guide was last revised in 1989 and recommended responses to WET violations were added.

When OECA revises the NPDES definition of SNC, we will re-consider the applicability of SNC criteria to WET.

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3-6. Establish a definition of significant violations for minor facilities, including storm water dischargers. At a minimum, include nonsubmission of self-monitoring reports in this definition. Also, define "significant" minor facilities. Include facilities impacting impaired waterways in this definition.

EPA Response: The Director has discretion to designate any facility with violations of concern as a "major" thereby subjecting the facility to SNC criteria, and 40 CFR Part 123.45(a)(2)(G) currently provides the Director with discretion to report any violation of "substantial concern" on the QNCR. OECA will commit to consider developing guidance on when a minor should be designated as a major and to include factors such as non-submission of discharge monitoring reports and impact of the discharge on impaired waterways.

Chapter 4: Storm Water Compliance Systems Have Deficiencies

OIG recommends that the Acting Assistant Administrator for Enforcement and Compliance Assurance:

4-1. Work with EPA regions in assisting states to:

- *Develop mechanisms to better balance their limited resources between all categories of dischargers, as is indicated by the states' analysis of risks to water quality.*
- *Create effective strategies for identifying storm water nonfilers.*
- *Develop sound storm water inspection programs which include risk-based inspection schedules and tracking and follow-up of inspection results.*
- *Establish tracking systems for citizen complaints.*

EPA Response: OECA will continue to work with the Regions and States to implement risk-based approaches to water enforcement; OECA's MOA guidance and national strategies provide flexibility to address majors as well as minors. OECA's 2000 Storm Water Enforcement Strategy outlines a recommended "sweep" approach of targeting a priority watershed/geographic area, then focusing storm water inspections and enforcement actions on a category of non-filers (e.g., a priority industrial sector or large construction sites) in that area. While EPA can assist the States by providing direction, guidance, training, and work-sharing, States must take responsibility to develop appropriate planning mechanisms to develop and implement risk-based strategies (which should include a sound inspection program and a system to track citizen complaints), and balance their limited resources.

4-2. Facilitate the development of a system which allows self-monitoring reports to be electronically scored for compliance. Consider low- cost options such as scan sheets (commonly used for electronic scoring of tests) and web-based reporting.

EPA Response: The current PCS system already determines compliance based on the electronic review of the discharge monitoring reports, though some improvements are needed in the system. Modernized PCS will certainly have this capability. Additionally, modernized PCS will provide the capability for facilities and States to electronically report information utilizing the Agency's Central Data Exchange portal and the National Environmental Information Exchange Network for the transfer of NPDES data.

Chapter 5: Enforcement Actions Late and Penalties Insufficient

OIG recommends that the Acting Assistant Administrator for Enforcement and Compliance Assurance:

5-1. Establish a clear and consistent standard for measuring the promptness of enforcement actions.

EPA Response: The NPDES program already has a "timely and appropriate" standard described in the NPDES "Enforcement Management System." We believe that a more appropriate recommendation would be for OECA to review the consistency of its standard and ensure that the Regions and States are aware of it.

5-2. Continue to work with the regions to assist states in establishing proactive enforcement strategies to help facilities avoid long-term serious violations due to plant or system obsolescence or capacity limits.

EPA Response: OECA, in conjunction with OW, has developed guidance documents and training workshops to assist the regulated community in avoiding noncompliance due to plant or system obsolescence or capacity problems. Some

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specific examples are guidance with regard to implementation of nine minimum controls and a long-term control plan for combined sewer overflows (CSOs) as well as guidance documents and training workshops for municipal officials and their system operators and consultants on procedures to eliminate and prevent sanitary sewer overflows (SSOs) and CSOs.

OECA is involved in the development of a *Guide for Evaluating Capacity Management, Operation and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems* which describes the management practices and operation and maintenance techniques that have served municipalities best in the reduction and elimination of SSOs from their systems. The audience for this guidance is State and EPA personnel who are assisting municipalities to comply with SSO requirements. The guidance will also help municipalities make decisions on the rehabilitation and repair of their collection systems and ways to better operate those systems. The guidance is scheduled for release as an interim-final document early in fiscal 2002, and is planned to be finalized following the final publication of the SSO Rule.

Guide for Evaluating Capacity Management, Operation and Maintenance Programs (CMOM) at Wastewater Treatment Plants will provide guidance to assist compliance monitoring inspectors in determining whether a CMOM program is adequate for a particular wastewater treatment plant. The guidance will also be useful to municipalities for determining whether their plants are following accepted practices and for addressing any discrepancies as needed in order to improve or maintain compliance. The guidance is scheduled for release as an interim-final document early in FY 2002, and is planned to be finalized following the final publication of the SSO Rule.

Chapter 6: Improved Performance Evaluation and Measurement Needed

OIG recommends that the Acting Assistant Administrator for Enforcement and Compliance Assurance routinely determine whether states are fulfilling their obligations to monitor and enforce discharge programs. Specifically:

6- 1. Develop consistent criteria and measures for in-depth program evaluation of state programs:

- *a. At a minimum, all of the oversight criteria and measures in the 1986 Policy Framework should be included along with additional elements included in the Clean Water Act discharge guidance. Include the accuracy and completeness of data systems, the quality of inspections, and the reliability of self-monitoring reports.*
- *b. Evaluate all significant discharge programs including storm water, minor dischargers, and concentrated animal feeding operations.*
- *c. Use a uniform, objective scoring mechanism.*

EPA Response: OECA agrees that a process for periodic evaluation of the Clean Water Act (CWA) discharge program in each State would be useful. In fact, most Regions do conduct an assessment of State water enforcement programs, either annually or bi-annually, though the nature of the assessment varies. Some variability in the assessment process is necessary since priorities vary by State, as does work sharing with the Region. For your information, the content of the review of State performance for any program, not just the CWA discharge program, must be governed principally by the authorization agreements, grant work plans and agreements and the Performance Partnership agreement between the Region and State. Those policies and agreements should define priorities, describe work sharing arrangements between the Region and State, and define the evaluation process to be used, among other things.

OECA now has a national evaluation process which focuses on "program element reviews" among programs. These reviews focus on examining policy and implementation of a particular program element in all Regions and a sample of States. OECA is responsible for working with the Regions and States to evaluate a wide scope of statutory programs, and while resources do not permit a commitment to ensure a top to bottom evaluation of the enforcement of the CWA discharge program in every State, OECA will consider how best to concentrate on key concerns of the program.

Since the OECA program element reviews will each address a different program or problem, there will not be a standing uniform scoring mechanism. However, within each review, the questions used and the weight assigned to the answers will be the same. OECA agrees to continue to develop for each of its program element

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reviews a consistent set of criteria and measures as part of its design for each review. All applicable policy is considered in designing each review. For NPDES, this will include criteria from the 1986 Policy Framework. However, we are not yet in a position to identify what reviews will be undertaken in the future.

6- 2. ***Have regions perform in-depth evaluations of state enforcement programs every two to three years. Make these evaluations available to the public through publicity releases or the EPA website.***

EPA Response: Many Regions do perform in-depth evaluations of State enforcement programs on a rotating basis, using the Performance Partnership Agreement, grant agreements, and existing policy as a basis for those evaluations. Again, OECA agrees that it would be ideal to have these evaluations of enforcement programs in all States every 2 or 3 years; however, resources simply would not allow that in some Regions. OECA also agrees that publicity can be an effective factor to ensure competent program operations; however, active publication of all evaluations on a website may exacerbate Federal/State tensions and inhibit a frank, open review process. OECA reserves use of the website as conditions dictate.

6- 3. ***Continue to remind state partners, including the Environmental Council of the States, of their obligation to use core performance measures that address the effectiveness of enforcement programs.***

EPA Response: OECA agrees to continue to do so, and suggests that OIG encourage the States directly where possible to do so as well. In FY 1999, $1.8 million was awarded to eleven States to develop outcome measures, and in FY 2000, another $1.2 million was awarded to 10 States to develop outcome measures specifically for compliance assistance. OECA is also discussing with States possibilities for funding performance measurement work within the NEPPS framework.

6- 4. ***Have regions collect and use all core performance measures to consistently measure the effectiveness of state enforcement programs on an annual basis. Consolidate these measures nationwide and make them public.***

EPA Response: States currently report on the required core measures through national data systems. It is the optional measures which the States have opted not to use. OECA will continue to promote the use of the optional measures through all means available to us, including grants. OECA does consolidate information on required core measures of outputs nationally, and this information is used by the Regions in their performance discussions with their States and is available to the public on request.

6- 5. ***Work with regions to assist states in setting specific goals and standards for compliance, recidivism, the timeliness of enforcement actions and other important measures.***

EPA Response: While the above measures are not "core measures" for States, OECA has established performance standards for the timeliness of enforcement actions which, for the most part, derive directly from the 1986 Policy Framework. Regions have worked with States to have them adopt these standards. In fact, OECA includes State performance on this standard in some of its program management reports. Since the measure for recidivism is new, OECA has wanted to get some experience with the measure before establishing performance goals. Likewise, we have not set performance goals for compliance rates, recognizing that compliance rates are the product of many factors, not just our OECA activities. OECA does plan to work with the States through an ECOS grant to assist in developing a consistent approach to determining compliance rates. OECA does monitor and report on recidivism and timeliness on a national basis and is considering setting a national target for recidivism for all programs as well as a national target for improving compliance.

Exhibit 2: Other Matters, Key Management Decisions Needed for PCS

In evaluating whether the modernized system and components would remedy problems with data gaps, OIG identified several concerns that they believe should be promptly addressed:

- ***Data Entry Requirements Not Updated.***
- ***Incomplete Requirements Document.***

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EPA's Response: OECA has already worked extensively with OW, particularly the Permits Division, to identify data requirements. A number of special sessions were held with OW personnel when they were unable to attend the established sessions. We intend to continue to work with OW and the states to finalize data requirements, both for existing programs and for new regulatory activities which are not currently well handled in PCS. In the next several months, PCS modernization managers will be working with OW to verify that requirements provided previously by them are still accurate and complete. Additionally, an OECA/OW/State data requirements team will be established at the PCS national users meeting in July to review, validate, and finalize the identified requirements.

Once the data requirements are finally established, a workgroup, including EPA Headquarters and Regional representatives, as well as States, will be formed to identify the subset of data requirements which will be federally mandated for entry into PCS and, which currently required data elements can be eliminated. The PCS Policy Statement will then be modified to incorporate the data elements which States/Regions are required to enter into PCS as well as the universe to which those requirements will apply.

- ***Key Decision Documents Are Needed.***

EPA Response: The System Management Plan (SMP) is a document which contains information on why the system is needed, what contract will be used, who is the project manager, what is the estimated cost, etc. While such a plan was done very early in the planning phases of PCS modernization, it was replaced with the OECA ITMRA submission. This submission contains all of the information required in the SMP, is reviewed by all management levels and is approved by OECA's Deputy Assistant Administrator. It is then reviewed by peer review teams within the Agency and annually provided to OMB as part of the Agency's overall response to IT investment reporting requirements of the Clinger-Cohen Act. As this document is updated each year, we believe that it serves the purpose of the SMP; however, we will update the SMP by December 2001.

OIG suggests that the Office of Enforcement and Compliance Assurance collaborate with the Office of Water to create an updated data entry policy. Upon completion of this policy, OIG suggests that the Acting Assistant Administrator for Enforcement and Compliance Assurance:

- ***Complete the systems requirements document.***

EPA Response: Data requirements were collected from EPA (OW and OECA) and States to determine the scope of the modernized PCS system. The next phase of PCS modernization is the design phase. One of the major products from that phase is a design specification document. This document will be developed with very intense participation by EPA and States (both direct users and interface States). The design specification includes data elements to be collected in PCS, data entry screens, report formats, and specific functionality to be supported, including electronic reporting efforts being managed elsewhere in the Agency. This effort will begin in July of this year with the National PCS meeting and will be completed by March of 2002.

- ***Execute memoranda of agreements with the Office of Water and state participants to help ensure (1) that the baseline requirements for the new system design are formally agreed to and (2) that both federal and state needs are addressed in the design of the new system.***

EPA Response: While we agree that full consultation and coordination with the Office of Water and the States is necessary, we do not agree that the development of MOAs with these parties is necessary or desirable. Such a process would be extremely time consuming and resource intensive, and the goals of such a process can be achieved in other ways. Coordination has already occurred (and will continue) with ASWIPCA and the Water Subcommittee of ECOS. Decisions on policy and system issues will be handled at a senior level between OW and OECA with recommendations coming from the PCS Steering Committee (representing EPA Headquarters, Regions, and States). One of the tasks before the PCS Steering Committee and senior water managers is the updating of the PCS Policy Statement and the identification of Federally required data elements. The schedule below addresses this task. Again, Regions and States will be involved in regular formulation and decision on these issues.

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Update System Management Plan	05/01-12/01
System Design Specification Document	07/01-03/02
Update Federally Required Data Element List	04/02-09/02
Update PCS Policy Statement	Ongoing-09/02

- ***Perform a cost-benefit analysis of the new system that addresses the electronic reporting and data entry requirements, the system development costs, and the projected operational and maintenance costs over the life of the system.***

EPA Response: This analysis is underway and should be completed by September 2001.

- ***Establish and approve a system charter and system management plan.***

EPA Response: We agree and will complete them by December 2001.

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(Slip Opinion)

NOTICE: This opinion is subject to formal revision before publication in the Environmental Administrative Decisions (E.A.D.). Readers are requested to notify the Environmental Appeals Board, U.S. Environmental Protection Agency, Washington, D.C. 20460, of any typographical or other formal errors, in order that corrections may be made before publication.

BEFORE THE ENVIRONMENTAL APPEALS BOARD
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C.

In re:	)	
City of Irving, Texas Municipal Separate Storm Sewer System	)	NPDES Appeal No. 00-18
Permit No. TXS001301	)	

[Decided July 16, 2001]

ORDER DENYING REVIEW

Before Environmental Appeals Judges Scott C. Fulton, Ronald L. McCallum, and Kathie A. Stein.

CITY OF IRVING, TEXAS
MUNICIPAL SEPARATE STORM
SEWER SYSTEM

NPDES Appeal No. 00-18

ORDER DENYING REVIEW OF PETITION

Decided July 16, 2001

Syllabus

Petitioner, City of Irving ("Irving"), filed a Petition for Review of a National Pollutant Discharge Elimination System ("NPDES") permit issued to it by U.S. Environmental Protection Agency, Region VI ("Region"), for operation of Irving's municipal separate storm sewer system ("MS4"). Irving's appeal seeks review of several permit conditions on the basis that they require Irving to regulate, legislate, and use its enforcement powers in violation of the principles of federalism contained in the Tenth Amendment, which Irving contends prohibits Congress or federal agencies from compelling states to enact or enforce a federal regulatory program. Irving also objects to permit conditions requiring it to develop training and education programs targeted to reduce storm water pollution, on the basis that such provisions compel it to speak to its citizens and to deliver a message chosen by the Region in violation of its First Amendment right to free speech.

In addition to its constitutional objections to the permit, Irving contends that other permit conditions evidence error, abuse of discretion, or other unlawful action by the Region that warrants review by the Board, including: (1) the permit's failure to authorize all forms of discharge from its MS4; (2) inclusion of permit language requiring Irving to develop a storm water management plan ("SWMP"); (3) inclusion of provisions making Irving jointly liable for failure of co-permittees to fulfill their permit obligations; (4) the establishment of a permit compliance certification date that precedes the effective date of the permit; (5) the requirement that Irving submit annual reports; and (6) the requirement that Irving seek approval prior to implementing certain changes to its SWMP, in that it places no time limit on the Region when processing such a request.

Held: The Board finds that while Irving attempts to present its constitutional arguments as a challenge to specific permit conditions established by the Region, the permit provisions in question fall within the immediate contemplation of both the Clean Water Act ("CWA") and its implementing regulations at 40 C.F.R. § 122.26(d). Thus, Irving is in reality challenging the validity of the statutory and regulatory provisions themselves, rather than the manner in which they were applied by the Region when it

wrote Irving's permit. The Board denies review of Irving's constitutional arguments on the basis that the proper forum for Irving's challenge lies with the federal courts, finding, *inter alia*, that nothing in Irving's Petition or in the administrative record in this case presents circumstances sufficiently compelling to overcome the presumption of non-reviewability of Agency rules in the context of Board proceedings.

With regard to the balance of Irving's objections, we find nothing clearly erroneous in the Region's approach nor any other circumstances warranting review. Accordingly, the Petition for Review is denied in its entirety.

Before Environmental Appeals Judges Scott C. Fulton, Ronald L. McCallum, and Kathie A. Stein.

Opinion of the Board by Judge Fulton:

The City of Irving ("Irving") has filed a Petition for Review ("Petition") dated August 14, 2000, seeking review of several conditions set forth in a National Pollutant Discharge Elimination System ("NPDES")[1] permit issued to Irving, Dallas County Utility and Reclamation District, Dallas County Flood Control District No. 1, and Irving Flood Control Districts Sections I and III by the U.S. Environmental Protection Agency, Region VI ("Region") on February 8, 1997. The permit would authorize storm water discharges from Irving's municipal separate storm sewer system ("MS4").[2] The Petition argues that several conditions violate Irving's constitutional rights under

[1]Under the Clean Water Act ("CWA"), persons who discharge pollutants from point sources (discrete conveyances, such as pipes) into waters of the United States must have a permit in order for the discharge to be lawful. CWA § 301, 33 U.S.C. § 1311. The National Pollutant Discharge Elimination System is the principal permitting program under the CWA. CWA § 402, 33 U.S.C. § 1342.

[2]Under CWA § 402(p) and 40 C.F.R. § 122.26, an NPDES permit is required for MS4s serving populations of 250,000 or more (large systems), and those serving populations of more than 100,000 but less than 250,000 (medium systems). It is undisputed that Irving satisfies the requirement of a medium system.

the First and Tenth Amendments and that the Region clearly erred or abused its discretion in setting several other permit conditions.

In its Response to Petition for Review ("Response"), the Region contends that its actions were a lawful exercise of its discretion and that the conditions objected to by Irving are required under the Clean Water Act ("CWA") and in no way violate Irving's constitutional rights. Response at 8-13. The Region further argues that, as a general matter, the Board does not review arguments challenging the constitutionality of statutes administered by EPA. *Id.* at 6.

Because we decline to assume jurisdiction over Irving's constitutional claims and Irving has failed otherwise to explain why the Board should review such a challenge or demonstrate how the Region's findings were clearly erroneous, an abuse of discretion, or otherwise unlawful, review is denied.

I. BACKGROUND

A. *Factual Background*

Irving owns and operates an MS4 that discharges storm water into a system of rivers and creeks in Texas. Administrative Record Exhibit ("AR Ex.") 1 at 4-4. Pursuant to the requirements for system-wide MS4 permitting set forth in CWA § 402(p)(4) ("Permit application requirements") and the implementing regulations at 40 C.F.R. § 122.26(d) ("Application requirements for large and medium municipal separate storm sewer discharges"), Irving joined with its co-permittees to submit Part 1 of the required NPDES permit application in 1992 and the Part 2 application in 1993.[3] AR Exs. 1, 3. From 1993 through 1997,

[3]As explained more fully *infra*, section I.B, the permitting process for an MS4 consists of a two-part application. Part 1 of the application requires an applicant to provide general owner information, describe its legal authority to implement permit (continued...)

Irving, its co-permittees, and the Region worked to revise the Part 2 application, resulting in the Region's issuance of a draft permit on February 8, 1997. Irving filed its Comments on Draft NPDES Permit No. TXS001301 ("Comments") on March 20, 1997, during an extension of the public comment period. Petitioner's Exhibit ("P Ex") 2. The Region continued negotiations with Irving and its co-permittees and, after having received certification from the Texas Natural Resource Conservation Commission,[4] issued its Response to Comments on Draft Permit ("RTC") (AR Ex. 33) and the final permit at issue here on September 11, 1998. R Ex 34 (NPDES Permit No. TXS001301, hereinafter "Permit"). On November 2, 1998, Irving filed a Request for Evidentiary Hearing pursuant to regulations governing the NPDES program at that time. P Ex 4. On July 14, 2000, the Region returned Irving's Request for Evidentiary Hearing without prejudice to Irving's filing an appeal with the Board under changes made to the NPDES

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[3](...continued)
requirements, identify sources of discharge to the MS4 and characterize the water quality of such discharges, describe existing pollutant management programs, commence identification of sources of illicit discharges that contribute to storm water pollution, and describe financial resources available for storm water programs. 40 C.F.R. § 122.26(d)(1). Part 2 of the application expands on the requirements of Part 1, and also requires permittees to develop a storm water management program that must include:

> a comprehensive planning process which involves public participation and where necessary intergovernmental coordination, to reduce the discharge of pollutants to the maximum extent practicable using management practices, control techniques and system, design and engineering methods, and such other provisions which are appropriate.

Id. § 122.26(d)(2)(iv).

[4]Under CWA § 401(a)(1), 33 U.S.C. § 1341(a)(1), the Region may not issue a permit until the state in which a facility is located (in this case Texas) either certifies that the permit complies with the state's water quality standards or waives certification. *See* 40 C.F.R. § 124.53.

permit appeals process effective June 14, 2000.[5] Respondent's Exhibit ("R Ex") 3. Irving filed its Petition with the Board on August 14, 2000. Irving's co-permittees have not challenged the permit.

In its Petition, Irving makes several challenges to the permit on constitutional grounds. The first is that several provisions of the permit[6] violate the constitutional principles cited in cases such as *Koog v. United States*, 79 F.3d 452 (5th Cir. 1996), *New York v. United States*, 505 U.S. 144 (1992), and *Printz v. United States*, 521 U.S. 898 (1997), that Congress (and thus federal agencies by association) cannot, under the principles of federalism contained in the Tenth Amendment, compel states to enact or enforce a federal regulatory program. *See* Petition at 2-5, 15. Irving argues that the permit is structured in a way that requires Irving to regulate, legislate, and use its enforcement powers according to requirements set by EPA rather than in a manner chosen by Irving itself. *Id.* at 4. Irving suggests that the Region could have avoided these constitutional violations had it accepted Irving's proposed language to structure the permit so that permit compliance would be based on

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[5]Procedures for issuing, modifying, revoking, or terminating permits are governed generally by 40 C.F.R. pt. 124. Prior to June 14, 2000, subpart E of part 124 established an evidentiary hearing process for NPDES permits. Section 124.74 required that any person challenging a final NPDES permit decision submit a request to the Regional Administrator for an evidentiary hearing within 30 days of service of the notice. 40 C.F.R. § 124.74(a) (1998). Only a decision after an evidentiary hearing or a denial of the request for an evidentiary hearing could be appealed to the Board. *Id.* § 124.91. On May 15, 2000, EPA promulgated substantial changes to the permit review process. *See* Amendments to Streamline the National Pollutant Discharge Elimination System Program Regulations, 65 Fed. Reg. 30,886 (May 15, 2000) (codified at 40 C.F.R. § 124.19). Included in these changes was the elimination of the evidentiary hearing procedures for NPDES permits. *Id.* at 30,896. Under current procedures, persons appealing an NPDES permit condition may now file a petition directly with the Board within 30 days after the issuance of a final NPDES permit decision. 40 C.F.R. § 124.19(a).

[6]Irving's Petition cites Pts. I.B, II (Introductory Provisions), II.A, II.E-G, and V.C. Petition at 4-5, 10, 16-17, 20.

compliance with Irving's storm water management program ("SWMP") as outlined in Part 2 of its NPDES permit application. *Id.* at 9, 17; *see also* Comments at 5; P Ex 5 (Letter from M. Walter of Irving, to J. Ferguson of EPA Region 6 (Apr. 17, 1998)). For the same reasons, Irving argues that permit conditions requiring it to ensure legal authority to control discharges to and from its MS4 also go beyond the constitutional restrictions mentioned above.[7] Petition at 12. It is also Irving's contention that because, in its view, EPA does not have the constitutional authority to set many of the requirements of the SWMP, Irving should be able to make changes to the SWMP at any time without prior approval by the Region.[8] Petition at 20.

Irving's second set of constitutional arguments challenges permit conditions[9] that require it to develop training and education programs designed to help reduce various sources of storm water pollution. Petition at 10-12. Irving argues that these provisions infringe upon its First Amendment right to free speech "by compelling Irving to 'speak' to its citizens and by compelling Irving to deliver a message chosen by EPA." *Id.* at 10.

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[7]Irving also objects to this provision on the basis of its First Amendment right to petition the government. While Irving asserts that the permit requires that Irving work with higher sovereign powers to ensure legal authority is maintained, it makes no argument as to why or how this violates Irving's First Amendment rights, nor cites any authority to support its claim. Petition at 12-13. Given Irving's failure to substantiate its First Amendment objection, we will not entertain it further. *See* 40 C.F.R. § 124.19(a) (petition shall include a statement of the reasons supporting that review); *City of Port St. Joe & Fla. Coast Paper Co.*, 7 E.A.D. 275, 283 n.17 (EAB 1997) (legal arguments presented in summary fashion without arguments or documentation do not meet regulatory requirements that petition shall include a statement of reasons supporting review).

[8]Irving acknowledges, however, that if changes made by it to the SWMP so decrease the effectiveness of the MS4 program that it no longer attains the goals of the permit, the Region would then have the authority to modify the permit. Petition at 20.

[9]These include Pts. II.A.9.c, II.A.10, and III of the permit.

Besides its constitutional claims, Irving argues that other permit conditions set by the Region evidence error or abuse of discretion, or are otherwise unlawful. First, Irving alleges that the Region violated CWA § 402(p) and its supporting regulations by failing to authorize all forms of discharges from Irving's MS4, and limiting its lawful discharge under the permit to municipal storm water discharges only. *Id.* at 13-16. Irving maintains that accidental spills, sanitary sewer overflow discharges, and storm water associated with industrial activity that enter the MS4 despite Irving's efforts to prevent their entry should be legally authorized under its NPDES permit. *Id.* at 13-14. It argues that the current structure of the permit would make Irving liable for every form of discharge that passes through the MS4 regardless of whether Irving has control over it. This structure, according to Irving, is contrary to EPA's stated approach to regulating storm water discharges from MS4s. *Id.* at 15-16.

Irving also argues that permit language requiring it to develop an SWMP is unnecessary and ambiguous.[10] *Id.* at 16-17. In particular, it argues that the language in the permit requiring development of an SWMP strongly suggests that the Region did not determine whether the SWMP incorporated in the permit already satisfies the statutory standards for MS4s under the CWA. *Id.* at 17. Irving argues that the inclusion of language that anticipates development of an SWMP thus creates a conflict in the operative provisions of the permit and is arbitrary and capricious.[11] *Id.*

Irving further alleges that the Region erred when it included permit provisions in Part I.C holding Irving jointly responsible for permit compliance where MS4 operational authority is shared. *Id.* at 18. Irving argues that such a provision would make it liable for failures of co-

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[10]Irving specifically references the introductory paragraphs in Pt. II and all of Pts. II.A, D-F.

[11]Irving also states that such language "could raise constitutional issues if wrongly interpreted" but fails to explain how this is so. Petition at 16.

permittees to perform their obligations under the permit, the SWMP, or under agreements between the co-permittees on management and operation of the MS4 system, and that Irving has never consented to such liability. *Id.*

Irving also states that the Region erred by setting a compliance certification date that is prior to the effective date of the permit. *Id.* at 19. In addition, Irving argues that the requirement that Irving submit annual reports instead of adhering to the biannual reporting provision of its SWMP, is an abuse of the Region's discretion. *Id.* at 19-20. Finally, apart from its constitutional objection to the permit's requirement that Irving seek approval from the Region prior to implementing certain changes to its SWMP, Irving argues that such a provision is unreasonable because it places no time limit on the Region when processing such a request. *Id.* at 20.

The Region argues in response that Irving fails to meet its burden of showing that the Region committed any clear error of law or fact or abuse of discretion when it set the permit conditions. Response at 5-6. The Region cites CWA § 402(p)(3)(B)(ii) and (iii), 33 U.S.C. § 1342(p)(B)(ii) and (iii), as requiring NPDES permits for MS4s to "effectively prohibit" non-storm water discharges into storm sewers and to require controls to reduce discharges of pollutants from an MS4 to the "maximum extent practicable." *Id.* at 2. The Region states that the storm water program is incidental to the general prohibition of all unpermitted discharges under CWA § 301(a), 33 U.S.C. § 1311(a). *Id.* at 9. The Region also points to the permitting process for MS4s set forth in 40 C.F.R. § 122.26(d) as allowing EPA to work with municipalities in designing site-specific permits containing SWMPs and emphasizing the use of best management practices to meet the CWA § 402(p)(3)(B)(ii) and (iii) requirements. *Id.* at 2. The Region maintains that it properly issued Irving's permit in accordance with the CWA, implementing regulations, and EPA guidance, and that the permit provisions were supported by the administrative record in this case. *Id.* at 8, 12-13.

The Region argues that while the constitutional principles raised by Irving may involve an important policy decision, the Board, as a general matter, does not adjudicate arguments challenging the constitutionality of a statute, and "a permit appeal proceeding is not the appropriate forum in which to challenge either the validity of Agency regulations or the policy judgments that underlie them." *Id.* at 6-7. Furthermore, the Region argues that the MS4 program does not violate the Constitution as asserted by Irving, because the Supreme Court has held that federal statutes of general applicability, such as the CWA, can be applied to states and municipalities so long as their application "does not excessively interfere with the functioning of those separate sovereign governments." *Id.* at 10 (citing *Reno v. Condon*, 120 S. Ct. 666, 672 (2000); *South Carolina v. Baker*, 485 U.S. 505, 514-15 (1988); *Printz v. United States*, 521 U.S. 898, 932 (1997)). The Region concludes that since Irving's objections do not allege such an interference, the Board should deny review of Irving's Petition. *Id.*

B. *Statutory and Regulatory Background*[12]

In 1972, Congress amended the Federal Water Pollution Control Act (what is now commonly referred to as the CWA) to prohibit the discharge of any pollutant to waters of the United States from a point source unless authorized by an NPDES permit. 33 U.S.C. §§ 301, 402. As originally structured, the NPDES program focused its attention primarily upon the reduction of pollutants coming from the discharge of industrial processing wastewater and municipal sewage by requiring pollution control mechanisms and tracking point sources primarily on an "end-of-pipe" basis. *See, e.g.,* National Pollutant Discharge Elimination System – Regulations for Revision of the Water Pollution Control Program Addressing Storm Water Discharges, 64 Fed. Reg. 68,722,

[12]For additional discussion of the background of the storm water program, see *In re Arizona Municipal Storm Water NPDES Permits*, 7 E.A.D., 646, 654-57 (EAB 1998), *petition for review denied sub nom Defenders of Wildlife v. EPA*, 191 F.3d 1159 (9th Cir. 1999).

68,723 (Dec. 8, 1999). Although covered under the definition of a point source, storm water from conveyances such as separate storm sewers was not specifically addressed by the CWA and EPA initially attempted to provide exemptions for MS4s until the U.S. Court of Appeals for the District of Columbia ruled that EPA could not exempt such discharges under the CWA. *Id.; NRDC v. Costle*, 568 F.2d 1369, 1377 (D.C. Cir. 1977); *see also* 132 Cong. Rec. S16,424 (Oct. 16, 1986), *reprinted in* 2 Environment and Natural Resources Policy Division, Library of Congress, *A Legislative History of the Water Quality Act of 1987* 646 (1988) (hereinafter "*Leg. Hist.*").

Moreover, in the wake of several major studies indicating that the leading cause of water quality impairment was pollution from diffuse sources such as storm water drainage from urban areas and construction sites, Congress passed the Water Quality Act of 1987 ("WQA"), which amended the CWA to specifically cover storm water discharges. *See* National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges, 55 Fed. Reg. 47,990, 47,991-92 (Nov. 16, 1990); *Legis. Hist.* at 646. Among other amendments, the WQA added § 402(p) to the CWA, which required permits to be obtained by October 1992 for four types of storm water discharges, namely: discharges associated with industrial activity; discharges from municipal storm sewer systems serving populations over 100,000; discharges with respect to which a permit had been issued prior to 1987; and any discharge determined by the permitting authority to be contributing to a violation of water quality standards or a significant source of pollutants to waters of the United States. 55 Fed. Reg. at 48,992. The WQA also required EPA to conduct studies on storm water discharges not already covered by CWA § 402, the purpose of which was to identify any other sources contributing to the degradation of water quality and to provide a basis for establishing a comprehensive program to regulate such sources. *Id.* at 47,993. Thus, the WQA set up a schedule for the gradual regulation of all storm water discharges deemed harmful to water quality, as currently embodied in CWA § 402(p). *See* 33 U.S.C. § 402(p).

Under CWA § 402(p), the requirements for an MS4 permit differ considerably from the technology-based treatment standards and numeric effluent criteria required of other end-of-pipe dischargers. CWA § 403(p)(3)(B) states that permits for MS4 discharges:

> (i) may be issued on a system- or jurisdiction-wide basis;
> (ii) shall include a requirement to effectively prohibit non-stormwater discharges into the storm sewers; and
> (iii) shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants.

33 U.S.C. § 1342(p)(3)(B)(i)-(iii). The rationale for the difference in treatment standards can be found in the legislative history to the WQA, which stresses Congress' concern that the variability of MS4 discharges - due to the fact that the type and extent of the pollutants in such discharges will depend on the activities occurring in the drainage area - would make regulation of MS4s based solely on the technical and numeric effluent standards under CWA § 301 inappropriate.[13] *Legis. Hist.* at 617. Congress therefore created the "maximum extent practicable" ("MEP") standard and the requirement to "effectively prohibit non-storm water discharges" into the MS4 in an effort to allow

[13]As explained by EPA in its 1996 guidance on storm water regulations, the difficulty of applying numeric effluent limits to storm water discharge stems from the fact that such limits are derived from methodologies designed primarily to calculate water quality impacts from "process wastewater discharges which occur at predictable rates with predictable pollutant loadings under low flow conditions in receiving waters." Questions and Answers Regarding Implementation of an Interim Permitting Approach for Water Quality-Based Effluent Limitations in Storm Water Permits, 61 Fed. Reg. 57,425, 57,426 (Nov. 6, 1996). By contrast, storm water discharge is highly variable both as to flow and pollutant type and concentration, and storm water permits are issued on a system-wide basis, thus rendering it largely incompatible with numeric effluent calculation methodologies. *Id.*

permit writers the flexibility necessary to tailor permits to the site-specific nature of MS4 discharges. *Legis. Hist.* at 646; House Committee on Public Works and Transportation, Section-by-Section Analysis (100th Sess. 1987), *reprinted in* 1987 U.S.C.C.A.N. (101 Stat. 7) 5, 38-39; *see also* 55 Fed. Reg. at 48,038. Included in that flexibility was the capacity to direct permit requirements at the *sources* of pollution in the MS4 rather than solely at the end of the pipe. 55 Fed. Reg. at 48,038. Thus, the MS4 permit requirements set forth under CWA § 402(p)(3)(iii) were designed to allow permit writers to use a combination of pollution controls that, as Congress noted, "may be different in different permits;" not all of the types of controls listed in § 402(p)(3)(iii) are required to be incorporated into each MS4 permit. 1987 U.S.C.C.A.N. at 39.

In 1990, EPA promulgated its first set of regulations implementing CWA § 402(p) as it pertained to permit requirements for storm water discharges associated with industrial activity and discharges from large and medium municipal separate storm sewer systems (commonly referred to as "Phase I" regulations). 55 Fed. Reg. at 47,990; 40 C.F.R. pt. 122. In the preamble to the final rule, EPA noted that while the MS4 program required a substantial amount of flexibility, it should not be "to such an extent that all municipalities do not face essentially the same responsibilities and commitment for achieving the goals of the CWA" and that the regulations being promulgated would "build in substantial flexibility in designing programs that meet particular needs, without abandoning a nationally consistent structure * * *." 55 Fed. Reg. at 48,038. To achieve these ends, the permit application requirements established in 40 C.F.R. Part 122 centered on the development of site-specific SWMPs to be issued primarily on a system-wide basis. *Id.* at 48,043. Such an approach would, as appropriate, allow several municipal entities responsible for different parts of a single MS4 system to be co-permittees on a single permit. This would in turn facilitate coordination and consolidation of MS4 activities, as well as spread the resource burden for monitoring, analysis, and development

and implementation of water pollution controls.[14] *Id.* Additionally, EPA established a two-part permit application for the development of MS4 permits that would assist permittees in developing SWMPs capable of meeting statutory and regulatory requirements. *Id.* This application process also provides information to the permit-writers for use in setting permit conditions; it was anticipated that if a municipality submitted a satisfactory application all or part of its proposed SWMP would likely become an integrated part of its final permit. Office of Water, U.S. EPA, EPA 833-B-92-002, *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems* 1-9 (1992) (hereinafter "*Part 2 Guidance Manual*"). The two parts of the permit application cover the six general elements necessary for an MS4 permit: adequate legal authority, source identification, discharge characterization, proposed SWMP, assessment of controls, and fiscal analysis. *Id.* at 2-1 to 2-4. Details of these elements of the permit application process for medium and large MS4s are set forth at 40 C.F.R. § 122.26(d). Because, as discussed below, several of the issues presented depend on an understanding of the regulatory framework for MS4 permits, we will briefly review several of the key elements of that framework.

1. *Adequate Legal Authority*

Municipalities applying for an MS4 permit must demonstrate adequate legal authority to control and prohibit certain discharges to the MS4; to carry out all inspection, surveillance, and monitoring procedures necessary to determine compliance and noncompliance with permit conditions; and to require dischargers to the MS4 to comply with permit or other conditions. 40 C.F.R. § 122.26(d)(2)(i). This is because the municipality, as the permittee, "is responsible for compliance with its permit and must have the authority to implement the conditions in its

[14]Where a permit has more than one legal entity as permittee, applications require a description of the roles and responsibilities of each legal entity and procedures in place to ensure effective coordination. 40 C.F.R. § 122.26(d)(2)(vii).

permit." *Part 2 Guidance Manual* at 3-1. Compliance with the MEP and "effective prohibition" standards set forth in CWA § 402(p)(3) requires a permittee to do more than plan for pollution controls during the term of its permit; it must also make a "strong effort to have the necessary police powers and controls" necessary to meet statutory standards prior to issuance of the permit. 55 Fed. Reg. at 48,044. In order to meet this requirement, applicants must cite to and describe how specific state and/or local ordinances currently in effect meet the federal requirements set forth in 40 C.F.R. § 122.36(d)(2)(i). *Part 2 Guidance Manual* at 3-4. Should existing authority be insufficient to meet such requirements, applicants must describe what changes are needed and provide a schedule for implementation of such changes. *Id.*

2. *Proposed Storm Water Management Program*

The proposed SWMP is generally considered to be the most important part of the permit application and the lynchpin of the program. *Part 2 Guidance Manual* at 6-1. Part 1 of the application requires submission of a description of existing management programs to control pollutants from the MS4 and a description of existing programs to identify and prevent illicit discharges to the system. 40 C.F.R. § 122.26(d)(1)(v). Part 2 requires the permittee to propose control measures meeting the MEP standard for the most expected types of discharge to an MS4, namely: (1) runoff from commercial and residential areas; (2) storm water runoff associated with industrial activity; (3) storm water runoff from construction sites; and (4) non-storm water discharges (e.g., illicit discharges and improper disposal). 55 Fed. Reg. at 48,052. While the SWMP provisions are designed to allow for flexibility and tailoring to the needs of each particular MS4, all SWMPs must meet certain minimum requirements, including establishing a comprehensive planning process that provides for public participation and any necessary intergovernmental coordination concerning management practices, control techniques, system design, and engineering or other methods to reduce the discharge of the above-listed types of pollutants to the maximum extent practicable, as well as a

description of staff and equipment available to implement the SWMP. 40 C.F.R. § 122.26(d)(2)(iv). Other specific SWMP provisions require the municipality to submit a description of programs for public education and outreach, implementation and enforcement of ordinances preventing illicit discharges to the MS4, investigation and monitoring of discharge sources to the MS4, and implementation and maintenance of site planning and best management practices ("BMPs") for construction sites. *Id.* § 122.26(d)(2)(iv)(B)-(D). Because a permitting authority is likely to incorporate all or part of an SWMP meeting regulatory requirements into the NPDES permit and utilize the SWMP to develop effluent limits, these provisions provide a municipality with an opportunity to have substantial input into permit conditions. *Part 2 Guidance Manual* at 6-1.

3. *Assessment of Controls*

In order for an SWMP to be successful, assessing its effectiveness is imperative; in this way, successful parts of the program may be enhanced and unsuccessful control measures can be changed. As the first step of this process, Part 2 applications require MS4s to submit an estimate of anticipated pollutant reduction once the SWMP is in place. 40 C.F.R. § 122.26(d)(2)(v). Subsequently, in order to determine whether an SWMP is achieving its anticipated effectiveness, MS4 permittees are required to provide annual reports on the progress of their SWMPs covering, among other things, the status of SWMP implementation, any proposed SWMP revisions, a summary of any monitoring data, projected annual expenditures, a summary of any enforcement actions, inspections, or educational programs, and any changes to water quality. 40 C.F.R. § 122.42(c). EPA guidance encourages permittees to provide both direct evidence of SWMP effectiveness (such as reductions in pollutant loads) as well as indirect evidence (such as measurements demonstrating increased public awareness of storm water issues) to assist the permittee and permit-writer in:

> [d]etermining whether the most cost-effective best management practices (BMPs) are included in the [SWMP]; [e]nsuring that the [SWMP] includes adequate public participation programs and intergovernmental coordination; [e]stablishing on-going monitoring inspection and surveillance programs that help refine estimates of program effectiveness; and [d]eveloping a strategy to evaluate progress toward achieving water quality goals.

Part 2 Guidance Manual at 7-1.

II. *DISCUSSION*

A. *Standard of Review*

In appeals under 40 C.F.R. § 124.19(a), the Board will not grant review unless it appears from the petition that the condition in question is based on a clearly erroneous finding of fact or conclusion of law, or involves an exercise of discretion or an important policy consideration that warrants review.[15] 40 C.F.R. § 124.19(a). The Board exercises its authority to review permits sparingly, in recognition of Agency policy favoring resolution of most permit disputes at the Regional level. *In re New England Plating Co.*, NPDES Appeal No. 00-7, slip op. at 7 (EAB, Mar. 29, 2001), 9 E.A.D. __; *In re Town of Ashland Wastewater Treatment Facility*, NPDES Appeal No. 00-15, slip op. at 9-10 (EAB,

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[15]As noted *supra*, note 5, prior to the Amendments to Streamline the NPDES Program Regulations, 65 Fed. Reg. 30,886 (May 15, 2000), the rules governing petitions for review of NPDES permitting decisions were set out in 40 C.F.R. § 124.91 (1998). Even though these amendments have eliminated the evidentiary hearing requirement in favor of direct appeal to the Board, the standard of review under 40 C.F.R. § 124.91 is essentially identical to that of 40 C.F.R. § 124.19. *See, e.g., In re New England Plating Co.*, NPDES Appeal No. 00-7, slip op. at 6 n.10 (EAB, Mar. 29, 2001), 9 E.A.D. __; *In re Town of Ashland Wastewater Treatment Facility*, NPDES Appeal No. 00-15, slip op. at 9 n.11 (EAB, Feb. 26, 2001), 9 E.A.D. __.

Feb. 26, 2001), 9 E.A.D. __; *In re Town of Hopedale, Bd. of Water & Sewer Comm'rs*, NPDES Appeal No. 00-4, slip op. at 8-9 n.13 (EAB, Feb. 13, 2001). The burden of establishing grounds for review rests upon the petitioner. 40 C.F.R. § 124.19(a)(1)-(2).

Irving's arguments are considered in light of this framework. For the reasons set forth below, the petition for review is denied.

B. *Issues Pertaining to Irving's Constitutional Rights*

Irving argues that several permit conditions require it to legislate and regulate in a manner that violates its constitutional rights under the Tenth Amendment, and sets forth a list of specific provisions Irving finds to be beyond EPA's constitutional power to impose. Petition at 4-5. Upon closer scrutiny, however, the provisions cited by Irving in its Petition come directly from provisions set forth in the CWA and EPA's implementing regulations.[16] When viewed in this light, it

[16]For example, Irving objects to Part I.B, Part H (Introductory Provisions) and Part II.E of the permit which requires it to effectively prohibit discharge of non-storm water into the MS4, but this requirement comes verbatim from CWA § 402(p)(3)(B)(ii). Furthermore, the implementing regulations at 40 C.F.R. § 122.26(d)(2)(iv) require an MS4 permit applicant to provide an SWMP that "reduce[s] the discharge of pollutants to the maximum extent practicable * * *." Under § 122.43, the Region is required to establish permit conditions that "provide for and assure compliance with all applicable requirements of CWA and regulations." 40 C.F.R. § 122.43(a).

Irving also argues that Parts II.A.9 and 10 and Part III of the permit, which require it to develop public education programs, compels Irving to speak in violation of its First Amendment rights. Petition at 10-12. As discussed in section I.B above, these requirements come directly from the statutory scheme established by Congress and detailed by EPA in the implementing regulations at 40 C.F.R. § 122.26(d)(2)(iv)(B)(*5*) and (*6*).

Similarly, Irving objects to Part II.A.2 and III.A, which require Irving to "implement changes to its ordinances to minimize the discharge of pollutants from areas of new development and significant redevelopment," including revisions to its (continued...)

appears that Irving's real complaint is with the statute itself and its implementing regulations.

To the extent that Irving objects to the substance of the storm water regulations, CWA § 509(b)(1) contemplates that challenges to administrative regulations be brought in a federal circuit court of appeals within 120 days from the date of promulgation of such regulations.

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[16](...continued)
landscaping ordinance. Petition at 4. As the Region correctly points out, these requirements are taken directly from the permit application requirements at 40 C.F.R. § 122.26(d)(2)(iv)(A)(*2*).

Irving objects to Part II.A.5 of its permit, which requires reduction of the discharge of pollutants related to the application and distribution of pesticides, herbicides, and fertilizers. Petition at 4. Again, this requirement comes directly from 40 C.F.R. § 122.26(d)(2)(iv)(*6*). Irving also objects to provisions in Part II.A.6 requiring it to effectively prohibit certain sources of illicit discharge and improper disposal to the MS4, but again, such requirements are found at 40 C.F.R. § 122.26(d)(2)(iv)(B)(*1*)-(*7*). Part II.A.8 of the permit, which requires implementation of an industrial and high risk inspection program, and is also objectionable to Irving, is a nearly-verbatim copy of language found at 40 C.F.R. § 122.26(d)(2)(iv)(C). Likewise with Part II.A.8 of the permit, which requires implementation and maintenance of BMPs to reduce pollution from construction sites to the MS4; this provision also comes nearly verbatim from 40 C.F.R. § 122.26(d)(2)(iv)(C). Part II.A.10, requiring Irving to implement a public education program targeting illicit discharges, improper disposal, and the proper use, application, and disposal of pesticides, herbicides, and fertilizers - also on Irving's list - comes from language found at 40 C.F.R. § 122.26(d)(2)(iv)(A)(*6*) and (B)(*5*), (*6*). The Part II.E requirements for ensuring legal authority to control discharges to and from the MS4 to which Irving objects can be found in nearly identical form at 40 C.F.R. § 122.26(d)(1)(ii) and (2)(i). The objected-to SWMP resource requirements set forth in Part II.F are reflected in and driven by 40 C.F.R. § 122.26(d)(1)(vi) and (2)(vi). Finally, Irving objects to the requirement that it provide evidence that its governing body has reviewed or been appraised of its annual report, but the provisions to which it cites make no such reference. Assuming Irving intended to refer to Part V.D, it appears that the Region is following the signatory requirements for all NPDES permit applications and reports as required by 40 C.F.R. § 122.22(a)(3). While those provisions do not specifically require a statement or resolution that the permittees' governing body has been appraised of a report, we do not see how this is any different in essence from the signatory requirement, nor how inclusion of it can be said to violate Irving's Tenth Amendment rights.

CWA § 509(b)(1), 33 U.S.C. § 1369(b)(1). As a consequence, the Board does not ordinarily allow a permit appeal to be used as a vehicle for collateral challenge of regulatory provisions when the time for such challenge has long since passed. *See In re Woodkiln, Inc.*, 7 E.A.D. 254, 269-70 (EAB 1997) (refusing to review final Agency regulations attacked on substantive content or alleged invalidity, either in exercise of Board's permit review authority and in an enforcement context); *In re City of Hollywood*, 5 E.A.D. 157, 176 (EAB 1994). Indeed, we have observed that the presumption of nonreviewability in the administrative arena is a rule of practicality and is especially appropriate in the context of a provision like CWA § 509(b), which sets limits on the availability of a judicial forum for challenging particular kinds of regulations:

> [O]rdinarily, the only way for a regulation that is subject to a preclusive review provision to be invalidated is by a court in accordance with the terms of the preclusive review provision. * * * Once the rule is no longer subject to court challenge by reason of the statutory preclusive review provision, the Agency is entitled to close the book on the rule insofar as its validity is concerned.

In re Echevarria, 5 E.A.D. 626, 634-35 (EAB 1994).[17]

Moreover, we have repeatedly recognized that the regulations authorizing appeals to the Board contemplate review of *conditions* of permits, not review of the statutes and regulations which are predicates

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[17]The Board will review the vitality of an Agency regulation only in "an exceptional case," such as where a challenged regulation has been effectively invalidated by a court but has yet to be formally repealed by the Agency. *Echevarria*, 5 E.A.D. at 635 n.13; *see also In re B.J. Carney Indus.*, 7 E.A.D. 171, 194 (EAB 1997) (holding that the Board will entertain a challenge to an Agency regulation only in "the most compelling circumstances"). Nothing in Irving's brief or in the administrative record persuades us that this case presents any compelling circumstances warranting a departure from our practice of not reviewing final Agency regulations in the context of Board cases.

for such conditions. *See, e.g., In re City of Port St. Joe & Fla. Coast Paper Co.*, 7 E.A.D. 275, 286-87 (EAB 1997) (rejecting challenge to validity of regulations or policy judgments underlying them in permit appeal proceeding); *In re Suckla Farms, Inc.*, 4 E.A.D. 686, 696 (EAB 1993); *In re Ford Motor Co.*, 3 E.A.D. 677, 682 n.2 (Adm'r 1991).

In any case, as a general rule, constitutional questions of the kind argued by Irving here are reserved to the federal courts. *In re Britton Constr. Co.*, CWA Appeal Nos. 97-5 & 97-8, slip op. at 24 n.6 (EAB, Mar. 30, 1999), 9 E.A.D. __ (citing *Johnson v. Robinson*, 415 U.S. 361, 368 (1974)). While the Board has entertained matters that question whether a statute or regulation is being *applied* in a manner which passes constitutional muster (*see, e.g., In re Ocean State Asbestos Removal, Inc.* 7 E.A.D. 522, 558 (EAB 1998); *In re Gen. Elec. Co.*, 4 E.A.D. 615, 627-36 (EAB 1993)), we have also repeatedly refused to entertain challenges to the constitutionality of statutes and Agency regulations themselves. *See Britton*, slip op. at 24 n.6; *City of Port St. Joe*, 7 E.A.D. at 317 n.58 (EAB 1997); *In re Echevarria*, 5 E.A.D. 626, 634 (EAB 1994). *See also In re Pontiki Coal Corp.*, 3 E.A.D. 572, 578 (Adm'r, 1991) (holding that the scope of review under 40 C.F.R. § 124.19 only contemplates challenges to specific permit decisions, not to constitutional validity of regulations themselves).

As we have discussed, while Irving attempts to present its constitutional arguments as a challenge to specific permit decisions made by the Region, it is fairly plain that the permit provisions in question fall within the immediate contemplation of both the CWA and the implementing regulations at 40 C.F.R. § 122.26(d). Thus, Irving's "as applied" challenge is, as we see it, in actuality a challenge to the constitutionality of the CWA and EPA's implementing regulations.

For all of the foregoing reasons, we decline to review Irving's constitutional claims.

C. *Whether the Region Erred in Failing to Authorize All Discharges from Irving's MS4*

Irving objects to the Region's failure to permit all discharges from its MS4, arguing that CWA § 402(p) and its implementing regulations require the Region to permit all discharges from its MS4, including non-storm water discharges and storm water associated with industrial activities. Petition at 13-16. Irving argues that by refusing to authorize such discharges under its permit, liability for them transfers to Irving, a position which forces it to use its police powers to stop such discharges and violates the scheme established by the storm water regulations, which places responsibility for controlling and obtaining legal authorization for storm water discharges on the discharger rather than the municipality. *Id.* This, according to Irving, runs counter to the thrust of EPA's regulations and constitutional principles.

Upon review, Irving's regulatory arguments misrepresent the structure of the storm water program. While Irving is correct that the "storm water permitting rules expressly require permits for '*all discharges* from large and medium municipal separate storm sewer systems,'" *id.* at 14, neither this phrase nor any other regulatory text supports Irving's conclusion that a single permit must address all such discharges. Indeed, the opposite appears to be contemplated. With respect to non-storm water discharges that find their way into the MS4, the statute itself requires storm water permits issued to an MS4 to effectively *prohibit all such discharges*. CWA § 402(p)(3)(B), 33 U.S.C. § 1342(p)(3)(B). Thus, the Region would appear to lack the authority to authorize within the context of a storm water permit non-storm water discharges such as those listed by Irving in its Petition.

Similarly, with respect to storm water associated with industrial activity, the permit appears to comport both with the regulations and the Federal Register preamble cited by Irving in its Petition. *See* Petition at 16; National Pollutant Discharge Elimination System Permit

Application Regulations for Storm Water Discharges, 55 Fed. Reg. 47,990, 47,997-98 (Nov. 16, 1990). The regulations contemplate that storm water associated with industrial activity is to be permitted separately from municipal storm water.[18] 40 C.F.R. § 122.26(c). Because, as the Region points out, Irving did not apply for a permit for storm water associated with industrial activity, this particular permit does not authorize such discharges. Rather, such discharges will, consistent with the preambular discussion of the program, be addressed in permits to be subsequently issued, presumably to sources of such storm water. The language of the final permit expressly stating that liability for unauthorized discharges through the MS4 does not transfer from the discharger to the permittee would appear to ameliorate Irving's concern about incurring liability for such discharges. Permit, Pt. I.B.2.

As touched on earlier in section I.B, the language of Part I.B.2 of the permit was taken directly from CWA § 402(p)(3)(B) as well as implementing regulations at 40 C.F.R. § 122.26(d)(2)(iv) requiring MS4s to eliminate the type of discharges Irving argues should be permitted. Irving's constitutional objection to this permit provision, because it takes issue with the substance of the regulation itself, is, for the reasons we have already stated, an argument the Board will not entertain. In sum, we do not see any clear error by the Region on this point and therefore deny review.

D. *Whether Language Requiring Irving to Submit an SWMP is Arbitrary and Capricious.*

Irving objects to language in its permit it states requires it "to develop, prospectively, an SWMP that will be assessed, also prospectively, for compliance with the 'effective prohibition' and 'MEP' standards." Petition at 17. Irving argues that this language either raises

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[18]Additionally, all industrial storm water permittees are required to provide information regarding such discharges to the MS4 owner/operator under 40 C.F.R. § 122.26(a)(4).

questions regarding whether the Region in fact accepted Irving's SWMP. If the SWMP has been accepted by the Region, then, according to Irving, the language creates a conflict within the operative provisions within the permit. *Id.*

We do not see the ambiguity or the conflict alleged by Irving. The SWMP is intended to be a dynamic document, changing over time to reflect changing conditions and improved practices. 55 Fed. Reg. at 48,052-54. The permit, in boilerplate fashion, sets out the general requirements of an SWMP, including a requirement that it be updated, as necessary; provision for how modifications are to be made; and a statement that compliance with Irving's SWMP and any approved updates "shall be deemed compliance with Parts II.A,B, and F" and that all approved updates made in accordance with the permit "are hereby incorporated by reference." Permit, Pt. II. Accordingly, by its terms, the permit serves as the rule by which the SWMP, over time, will be measured. The prospective language is thus not without purpose - it anticipates likely changes to a dynamic document. For these reasons, we deny review of this issue.

E. *Whether EPA Erred in Making Irving Jointly Liable for Compliance by Other Co-permittees*

Irving argues that Part I.C.1.e and Part I.C.2 of its permit might together be read to hold Irving responsible for, or force it to assume, permit obligations of one or more co-permittees should a co-permittee fail to meet its permit obligations, creating liabilities beyond those contemplated by the operative regulations and Irving's intra-system agreements. Petition at 18. In particular, Irving appears to be concerned that it would incur liabilities for parts of the broader system beyond Irving's operational control. For its part, the Region argues that Irving is overstating the impact of these provisions and that they were added to ensure that, "regardless of any private contractual or inter-governmental agreements the co-permittees may enter into to perform their responsibilities," Response at 33, Irving continues to "comply with the

terms of the final Permit for which [it is] responsible." *Id.* In terms of the scope of that responsibility, the Region states that "Petitioner is responsible only for permit compliance and SWMP implementation for those portions of the MS4 that the Petitioner operates." *Id.* at 32. Although not as clear as the Region's Response, the RTC appears to be consistent with the idea that these provisions were intended not to enlarge Irving's liability but rather to ensure that Irving could not transfer away its responsibilities under its permit. RTC at 3. In particular, the RTC observes, "It is not EPA's intent or purpose to redistribute the roles and responsibilities of the permittees." *Id.*

In examining the issue, our starting point is, of course, the text of the permit itself. The provisions of the permit with which Irving is concerned read as follows:

> 1. Each permittee is responsible for:
>
> * * * *
>
> e. A plan of action to assume responsibility for implementation of storm water management and monitoring programs on their portions of the Municipal Separate Storm Sewer System should interjurisdictional agreements allocating responsibility between permittees be dissolved or in default.
>
> * * * *
>
> 2. Permittees are jointly responsible for permit compliance on portions of the Municipal Separate Storm Sewer System where operational or Storm Water Management Program implementation authority over portions of the Municipal Separate Storm Sewer System is shared or has been transferred from one permittee to another in accordance with legally binding instruments.

Permit, Pt. I.C.1.e and 2.

We agree with the Region that, as to Part I.C.1.e, Irving's concern is overstated. First, the only liability produced by this provision is liability for preparing a contingency plan. Second, and more importantly, the fact that the provision contemplates ultimate responsibility only for each participant's *portion* of the MS4 belies any notion that Irving would ultimately be subject to liability under the plan for matters beyond its operational control.

Part I.C.2 presents a more difficult question, as the language of the provision is not tightly drafted and is open to more than one interpretation. We are not without assistance on this question, however, as the regulations upon which these provisions were predicated provide additional grist for consideration. In anticipation of intra-system, multiple-permit approaches to storm water management, the rules provide:

> Co-permittees need only comply with permit conditions relating to discharges from the muncipal separate storm sewers *for which they are operators.*

40 C.F.R. § 122.26(a)(iv) (emphasis added). We conclude that the better interpretation here is one that reconciles the text of the permit with the rule upon which it is based, and thus interpret Part I.C.2 to mean that, irrespective of any agreements into which Irving might enter related to storm water management, Irving remains ultimately responsible for those portions - and only those portions - of the MS4 within its operational

control.[19] Interpreting the provision thusly, we deny review of the issue.[20]

F. *The Permit's Compliance Certification Date*

Irving has objected to the date in its permit for certification of its compliance with the floatable monitoring program as being incorrect. Petition at 19. In its Response, the Region recognizes that the date is incorrect and states that it will make all necessary schedule adjustments pending final disposition of this appeal. Based on this representation, we deny review of this issue, and direct the Region to make the necessary changes.

G. *Whether the Region Erred in its Inclusion of Annual Reporting and Prior Approval Requirements*

Irving objects that the annual reporting requirements set forth in Part V.D of its permit represent an abuse of discretion because they conflict with the biannual reporting requirements set forth in Irving's SWMP. Petition at 19-20. Irving stated in its Petition that it knew of no requirements calling an annual report. *Id.* at 19. However, as pointed out *supra* in section I.B, 40 C.F.R. § 122.42(c) requires an MS4

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[19]This does not mean that Irving cannot enter into legally binding agreements which themselves enlarge Irving's liability beyond its operational control. If Irving chooses to assume additional liabilities by virtue of intra-system agreements, it of course may do so, but the resulting liabilities would arise from those agreements and not from Part I.C.1.e and 2 of Irving's permit.

[20]While it appears that the Region's interpretation of this permit condition is similar or identical to ours, we note that because we serve as the final decision maker for the Agency in this matter, our interpretation will be binding on the Region in its implementation of the permit. *See, e.g., In re Ocean State Asbestos Removal, Inc.*, 7 E.A.D. 522, 542-43 n. 22 (EAB 1998); *In re Austin Powder Co.*, 6 E.A.D. 713, 717 (EAB 1997); *In re Mobil Oil Corp.*, 5 E.A.D. 490, 590 n.30 (EAB 1994). It should thus address Irving's concern in appealing this issue.

permittee to submit annual reports. Accordingly, the Region's decision to include this condition was not erroneous.[21]

Irving also argues that permit conditions requiring Regional approval before certain changes to its SWMP may be implemented is unreasonable because it places no time limit on the Region's response to the request. Petition at 20. This is not entirely true, however. Under Parts II.G.2.b and c of the permit, which cover most possible changes to the SWMP, changes to the SWMP covered by the provision are deemed approved and may be implemented unless the Region denies the proposed change within 60 days. The only changes to the SWMP which are not subject to this sixty-day default and which must receive formal approval by the Region prior to inclusion into the SWMP are those which propose deletion of a BMP without substitution of another BMP. *See* Response at 36.

As pointed out by the Region in its RTC, Part II.G was modified in response to Irving's comments to clarify what changes to its SWMP would not be considered to be minor modifications to its permit. RTC at 13. In its Petition, Irving merely reiterates the comments that gave rise to these changes. As we have observed in the past, something more is required to sustain a petition for review - namely, a petitioner must demonstrate with specificity why the Region's response to the petitioner's comments was clearly erroneous. *See, e.g., In re Town of Ashland Wastewater Treatment Plant*, NPDES Appeal No. 00-15, slip op. at 11 (EAB, Feb. 26, 2001), 9 E.A.D.__ (A petitioner in an NPDES appeal must demonstrate with specificity why the Region's response to its comments is clearly erroneous or otherwise merits review). Moreover, in view of the fact that Irving's SWMP was an important part of Irving's application for an MS4 permit and a predicate for the Region's granting the permit, it does not strike us as unreasonable that the Region reserve a review and approval function with respect to

[21]As we have already observed, to the extent that Irving is challenging the underlying rule, this is the wrong forum for such a challenge.

significant changes to the SWMP as a means of ensuring that the SWMP continues over time to comport with the SWMP framework set forth in the permit. Furthermore, because deletion of a BMP may raise particular concerns regarding the integrity of the SWMP, it is not obvious to us that the decision by the Region not to limit itself to a sixty-day review period for review of BMP deletions is erroneous. Any failure by the Region to act is remediable through an unreasonable delay suit under section 706 of the Administrative Procedures Act, 5 U.S.C. § 706(1).

III. *CONCLUSION*

For the foregoing reasons, review of NPDES Permit No. TXS001301 is denied in all respects. Consistent with the discussion in section II.F, *supra*, we direct the Region to make all necessary corrections to erroneous compliance dates listed in the permit.

So ordered.

Xavier

HARTCROWSER

Earth and Environmental Technologies

SERVICE STATION
STORM WATER RUNOFF STUDY
CONTRACT NO. DT 308-02

Prepared for

Western States Petroleum Association

October 5, 1993
J-6565

R0013213

SERVICE STATION STORM WATER RUNOFF STUDY

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LOS ANGELES REGION

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1.0 SUMMARY OF FINDINGS

This Retail Gasoline Outlet Storm Water Runoff Study identifies and quantifies chemical constituents detected in simulated storm water runoff from concrete and asphalt pavement at five preselected retail gasoline outlets (RGOs). The RGOs were selected to represent geographical areas, varying population densities, and different types of RGOs operating in California. Rainfall typical for California was simulated at each of the five RGOs. Runoff generated during the tests was collected and analyzed to identify and quantify chemical constituents that may have been present.

Metals.

The study analyzed metals in the first 15-minute sample (first flush) of runoff from the RGO pump island area. The concentrations reported in the data are below minimum analytical detection limits with the exceptions of barium, copper, and zinc. The GTEL Environmental Laboratory, Inc. (GTEL) analytical data sheets indicate that the maximum detection limit was increased for some samples due to a foaming effect noted in these samples.

The analytical results for metals demonstrate that the maximum concentrations of most constituents detected in the runoff water samples are lower than current United States Environmental Protection Agency (EPA) primary and secondary drinking water maximum contaminant levels (MCLs). The exceptions are antimony, arsenic, beryllium, cadmium, and lead, where the concentration cannot be compared to the drinking water MCLs because the minimum analytical detection limits are higher than the drinking water MCLs.

Volatile Organic Compounds.

The data collected during this study indicate that all VOC concentrations found in the storm water runoff from the pavement at RGOs are below the EPA MCLs. The concentrations of metals and VOCs detected during this study represent normal conditions at RGOs where the RGOs maintain effective housekeeping practices and cleanup of incidental spills.

At each RGO, nine samples of runoff water were obtained to be analyzed for the volatile organic compounds benzene, toluene, ethylbenzene and total xylenes (BTEX). Forty-five samples were collected from the five RGOs for analysis of volatile organic compound (VOC) content. Of 45 samples, 27 of the samples were below analytical detection limits (reported as ND, not detected). In the remaining 18 samples, VOCs were detected in the

runoff water at concentrations below the respective EPA MCLs. Out of the 45 samples, all were below the EPA MCLs.

2.0 PROJECT PROCEDURES

The simulated storm water runoff tests were conducted to identify and quantify chemical constituents in runoff at the five selected RGOs. The findings presented in this report identify the levels of chemicals commonly present in the runoff from typical RGOs in California. The data are presented as a comparison between each RGO and EPA primary and secondary drinking water MCLs.

Representatives of the Western States Petroleum Association (WSPA) selected RGO categories to represent the various geographical areas, varying population densities and types of RGOs located in California. The storm water runoff sampling was conducted at the five Southern California RGOs selected by the WSPA representatives.

Rainfall was simulated in the same manner at both the pump island (automotive refueling areas) and the driveway approach areas at each RGO (See Figure 1); samples were collected in the same manner at each RGO; sampling equipment was properly cleaned between each round of sampling. The only notable difference in the testing methodologies at the five RGOs occurred at the Category 5 RGO. One quart of gasoline was "spilled" at the pump island of the Category 5 RGO and cleaned up with absorbent material prior to the rainfall simulation. The "spill" was simulated at the pump island area only.

Tables 1 through 5 identify the sample source, collection time, date, weather conditions, and the specified analyses for each of the samples collected at the five RGOs.

The rainfall simulation was designed to represent the light, medium, and heavy rainfall regions of California. This report compares and documents the analytical data obtained from these tests. The test data quantify the concentrations of storm water constituents in runoff at the RGO pump islands and in driveway approaches to the RGO and pump islands. The analytical data for the samples collected at the five selected RGOs are summarized in Tables 6 through 9. The GTEL analytical data sheets are presented in Appendix A.

A comparison of average RGO runoff concentrations with water quality criteria and typical urban runoff are presented in Tables 10 through 14.

3.0 LITERATURE SEARCH

Initially a computerized literature file search was conducted to assess whether other similar studies had been performed which contained scientific information that may contribute to this storm water runoff project. The computerized literature file search did not disclose a previous RGO storm water study. Key literature abstracts relating to storm water runoff or other related information is included in Appendix B.

The computerized literature file search was conducted using the Dialog Information Database. The search was conducted of the following files:

NTIS (National Technical Information) - File 6;
COMPENDEX (Engineering Information Inc., NY, NY) - File 8;
APILIT (American Petroleum Institute) - File 354;
Pollution Abstracts/Cambridge Scientific Abstracts - File 41;
Water Resources Abstracts - File 117;
WATERNET (American Water Works Association,) - File 245; and
CA SEARCH (Chemical Abstracts , Columbus, OH) - File 399.

4.0 TECHNICAL APPROACH

The technical approach for this project included:

Developing site selection criteria and selecting representative RGOs;
Conducting preliminary field testing to establish test procedures; and
Determining sampling and analytical procedures.

These topics are described in detail in the following sections.

4.1 Selection of Retail Gasoline Outlets

The selection of the RGOs for this study was based on a cross section of the various populated and geographic areas in California and used the following criteria:

Anticipated refueling frequencies and anticipated ages of vehicles expected to frequent the RGOs.

Anticipated commercial use, based on the RGO's location.

The RGO's age and general appearance.

The construction class of the RGO including fuel islands, mechanics' bays, car washes and convenience stores.

The topography around the RGO including the drainage pattern and adjacent property use.

The WSPA members provided RGOs to represent differing examples of the above-listed categories. The RGOs selected for each category are located in the following cities in California:

Trabuco Canyon
Apple Valley
San Diego
Rancho Cucamonga
Los Angeles

Using the criteria previously mentioned, the RGOs which were selected had the following characteristics:

Category 1

Throughput greater than 250,000 gallons per month
Urban location, little or no commercial use
New facility, clean appearance
Covered fuel islands; carwash; no mechanics' bays
Hilly area, runoff to the east and west; facility is bermed[1]; shopping center adjacent to RGO

The Category One RGO was observed to have minimal staining on the ground surface around the pump islands. The pump island and driveway approach areas are concrete. The driveway approach area was observed to be relatively clean and free of oil and grease stains.

Category 2

Throughput greater than 250,000 gallons per month
Urban location, little or no commercial use
New facility, clean appearance
Covered fuel islands; carwash; convenience store; no mechanic's bays
Flat area, runoff to the west; facility is bermed; fast food adjacent to RGO

The Category Two RGO was observed to have minimal staining on the ground surface around the pump islands. The pump island and driveway approach areas are concrete. The driveway approach area is concrete and was observed to have oil and grease stains.

(1) - refers to concrete curbs (present at the category 1 and 2 RGOs) which direct the flow of storm water to on-site surface storm drains. At the RGOs without berming, rainfall on the RGO lot flows into surface storm drains on-site or off of the RGO into the street adjacent the RGO.

Category 3

Throughput of 150,000 to 250,000 gallons per month
Inner city, light commercial use
Older facility, stained and degraded concrete and asphalt
Covered fuel islands; mechanic's bays
Flat area, runoff to the south; facility is not bermed; residential and retail adjacent to RGO

The Category Three RGO was observed to have dark oil and grease stains on the ground surface around the pump islands and in the driveway approach areas. The pump island areas are concrete. The asphalt in the driveway approach areas was observed to be in poor condition, or degraded.

Category 4

Throughput of 150,000 to 250,000 gallons per month
Urban location, light commercial use
Older facility, stained and degraded concrete and asphalt
Covered fuel islands; mechanic's bays
Area sloped to the south; runoff to the south; facility is not bermed; shopping center adjacent to RGO

The Category Four RGO was observed to have oil and grease stains on the ground surface around the pump islands. The pump island areas are concrete. The asphalt in the driveway approach areas was observed to be in good condition.



Category 5

Throughput less than 150,000 gallons per month
Inner city, high commercial use
Older facility, stained and degraded concrete and asphalt
Covered fuel islands with mechanic's bays
Flat area, runoff to the north and south; facility is not bermed; industrial and retail adjacent to RGO

The Category Five RGO was observed to have oil and grease stains on the ground surface around the pump islands. The pump island areas are concrete. The asphalt in the driveway approach areas was observed to be degraded.

4.2 Preliminary Field Testing

Two days of preliminary field testing were conducted prior to initiating the on-site RGO storm water evaluation (discussed in further detail in Appendix C - Preliminary Field Testing). The preliminary field testing was performed at an abandoned RGO in Westminster, California.

The preliminary field testing was conducted to achieve the following objectives:

Develop the simulated rainfall distribution system;

Determine the minimum rainfall rate necessary to create sheet flow;

Test the containment berms and collection apparatus for performance and effectiveness;

Determine a method to contain water generated during rainfall simulation; and

Develop safety protocol to ensure that RGO personnel and customers were not exposed to hazards during the testing period.

4.3 *Water Application*

The test was designed to simulate a significant storm as defined by the National Oceanic and Atmospheric Administration (NOAA). A significant storm is defined as a continuous discharge of storm water for a minimum of one hour, or intermittent discharges of storm water for a minimum of three hours, in a 12-hour period.

During the test, potable water was distributed over the pump island and the driveway approach areas at a rate sufficient to provide adequate coverage of the test zone and develop sheet flow.

The test area evaluated at each RGO was approximately 400 square feet. The volume of water required to attain adequate sheet flow across each test area was determined to occur at a flow rate of about 2.0 gallons per minute (gpm). Based on this flow rate, the test was designed to run for a duration of 45 minutes. The 45-minute test was divided into three, 15-minute periods.

A flow rate of 2.0 gpm was dispensed over the 400 square-foot test area (See Figure 1) for a total of 45 minutes. This flow rate was determined to be appropriate for the test area size and functional operation of the water dispensing equipment. The flow rate of 2.0 gpm was sufficient to generate sheetflow within the test area.

Water distributed at the constant flow rate of 2.0 gpm distributed approximately 0.125 inches of "rain" over the test area in the first 15-minute period (33 gallons over 400 square feet). After 30 minutes, 0.250 inches of "rain" was distributed over the test area (66 gallons over 400 square feet). After 45 minutes, 0.375 inches of "rain" was distributed over the test area (100 gallons over 400 square feet).

4.4 *Water Dispensing System*

The water dispensing system was comprised of a supply line (a flexible hose), a flow meter with an on/off valve and 1 inch diameter, schedule 80 polyvinyl chloride (PVC) pipe. One end of the supply line was attached to the source water (the RGO hose bib). The other end of the supply line was attached to the flow meter. The flow meter was attached to the network of PVC pipes. The PVC pipes were perforated at 8 to 12 inch intervals with 3/64 inch holes (See Figure 2).

At each RGO, the network of pipes was set up so that the water would cover an area approximately 20 feet x 20 feet. The location of the water

dispensing equipment was positioned at each RGO depending on the physical layout and the slope of the RGO. The volume of water was regulated by a shut-off valve and monitored by the flow meter. The water was dispensed through the network of PVC pipe.

4.5 Water Collection Apparatus

The containment berms consisted of sand-filled polyethylene tubing. The berms were constructed of 5-foot-long tubes and placed into position around the test area. The containment berms were used to channel the runoff water to the collection point. A stainless steel collection trough was placed at the lowest point of the test area and incorporated into the containment berms (See Figures 2 and 3).

At the end of each 15 minute period, an electric pump was used to pump the collected water into a 55-gallon steel drum. The 55-gallon drum was lined with a polypropylene liner. A new liner was used for each test to ensure the composite samples were representative of the test area being sampled. The electric water pump and sampling scoop were properly cleaned between sampling rounds using a solution of deionized water and alconox and then rinsed with deionized water.

4.6 Staged Spill and Cleanup Sampling Event

A staged spill was conducted at the Category 5 RGO. The RGO was randomly picked from the five categories. The spill was conducted to simulate the type of spill that would occur at the pump island if a motorist were to drop the pump nozzle while in the process of fueling an automobile. No cleanup or sweeping was performed prior to conducting the spill.

To simulate the spill the pump nozzle was used to dispense one quart of regular unleaded gasoline onto the ground. The gasoline was allowed to spread out naturally. After one minute, absorbent material was applied to the spill area and allowed to soak up the gasoline. When the absorbent material appeared saturated and the gasoline appeared to be completely soaked up, the absorbent was swept up.

After sweeping up the absorbent, the water dispensing equipment was set up and the storm water runoff test begun. The spill was conducted at the pump island area only.

5.0 SAMPLE COLLECTION

A total of 28 samples were collected at each RGO. Tables 1 through 5 identify the site-specific conditions for each round of samples collected at the five RGOs. The sample source, collection time, date, weather conditions, and the specified analyses for the samples are listed in the tables.

Appendix E lists rainfall dates and amounts prior to the simulated rainfall runoff testing. Appendix F contains volume calculations of the simulated runoff at each RGO.

5.1 Sampling Procedures

Sampling procedures followed strict sampling protocol established by SW846, "Test Methods for Evaluating Solid Waste" (including surface and groundwater). Samples were obtained using cleaned sampling equipment and placed into laboratory supplied and certified "clean" sample containers. The samples were kept at or below 4 degrees Celsius.

Prior to starting each test, a background sample was collected from the RGO's potable water at the end of the supply line used to deliver water to the network of PVC pipes, this sample was the Round 1 sample. After the simulation started, the predetermined flow rate was adjusted and three successive samples were collected from the collection trough at 15-minute intervals.

Trip blanks are sent along with field samples as a measure of quality assurance. Trip blanks are used to ensure that the field samples represent the material sampled and not material or chemicals introduced during transport. The trip blanks were analyzed to verify that contamination was not introduced to the samples while they are in transit between point of collection and the laboratory.

For the RGO runoff sampling the same type of vials were used for the trip blanks as were used to collect the water samples at the RGOs. The vials were filled with purified water and handled in the same manner as the other samples, which were analyzed for VOCs and TPH. One trip blank was stored in each cooler together with the field samples. See Appendix D - Sampling Procedures for detailed sampling procedures followed for this study.

5.2 *Sample Time and Location*

At each RGO the following samples were obtained:

One background sample from the RGO potable water source;

Three discrete grab samples of runoff from the pump island area collected at 15-minute intervals;

One composite sample of total runoff from the 55-gallon drum collected from the pump island area over the 45-minute test duration;

Three discrete grab samples of runoff from the driveway approach area collected at 15-minute intervals;

One composite sample of total runoff from the 55-gallon drum collected from the driveway approach area over the 45-minute test duration; and

One trip blank sample for quality assurance was filled with deionized water prior to arriving at the RGO for the sampling event.

See Figure 2 for sample time, location and sample round numbers.

5.3 *Sample Analytical Methods*

The samples were analyzed by the methods listed below.

Volatile Organic Compounds -	EPA method 8020
Total Petroleum Hydrocarbons -	EPA method 8015
Total Suspended Solids -	EPA method 160.2
Total Recoverable Oil and Grease -	EPA method 413.2
Title 26 Metals -	EPA method 6010 and EPA method 7470

6.0 RESULTS AND DISCUSSION

6.1 Physical Condition of Retail Gasoline Outlets

The laboratory test results indicate that the physical condition of the RGO did not influence the concentrations of chemicals detected in the storm water at the pump island areas and the driveway approach areas. This was for both asphalt and concrete ground surfaces.

The analytical data for the samples collected at the five selected RGOs are summarized in Tables 6 through 9. The GTEL analytical data sheets are presented in Appendix A.

6.2 Volatile Organic Compounds and Total Petroleum Hydrocarbons

All samples were determined to be below the EPA MCLs for the VOCs (benzene, toluene, ethylbenzene and total xylenes). Data presented in Table 6 indicates that most concentrations of VOCs in the runoff samples are below analytical detection limits. Some samples had detectable concentrations of VOCs, but the concentrations were below the EPA MCLs. The only clear pattern emerging from the data is that total xylenes are the most prevalent VOC to be detected; this pattern is logical due to total xylenes having a lower vapor pressure (i.e., lesser tendency to volatilize) compared to benzene, toluene, and ethylbenzene.

The EPA MCLs for the BTEX compounds are as follows:

Compound	EPA MCLs
benzene	5 μg/L
toluene	1,000 μg/L
ethylbenzene	700 μg/L
total xylenes	10,000 μg/L

At the Category 1 RGO, concentrations of VOCs were detected in each sample of runoff from the pump island area. Toluene was detected at a maximum of 0.8 micrograms per liter (μg/L) and total xylenes were detected at a maximum of 1.4 μg/L. The VOCs were not detected in the runoff samples from the driveway approach area.

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At the Category 2 RGO, VOCs were not detected in the samples from the pump island area. VOCs were detected in the samples from the driveway approach area. Benzene was detected at 1.5 μg/L in the 15-minute sample (the first flush) from the driveway approach area and at 0.4 μg/L in the composite sample from the driveway approach area. Toluene was detected in the trip blank that was sent along with the samples from this RGO at 0.5 μg/L. (See Trip Blank section)

At the Category 3 RGO, the highest concentrations of VOCs were detected in the 15-minute sample from the pump island area and the 45-minute runoff sample from the driveway approach area. Toluene was detected at 7.9 μg/L and total xylenes were detected at 20 μg/L in runoff from the pump island area. Benzene was detected at 0.5 μg/L, toluene at 4.5 μg/L, ethylbenzene at 1.1 μg/L and total xylenes at 12 μg/L in the runoff from the driveway approach area.

At the Category 4 RGO, the highest concentrations of VOCs were detected in the source water and in the last runoff sample from the pump island. The application water was determined to have toluene at 0.3 μg/L and total xylenes at 7.1 μg/L. Toluene was detected at 0.4 μg/L and total xylenes were detected at 1.5 μg/L in the last runoff sample. Toluene was detected in the trip blank that was sent along with the samples from this RGO at 0.7 μg/L. (See Trip Blank section)

At the Category 5 RGO, VOCs were detected in the runoff from the pump island following the spill and cleanup of one quart of gasoline. The highest concentrations of VOCs detected at this RGO were benzene at 1.0 μg/L, toluene at 14 μg/L, ethylbenzene at 6.3 μg/L and total xylenes at 41 μg/L. VOC concentrations were below detection limits in the runoff samples from the driveway approach area.

6.3 Suspended Solids

The analytical results for total suspended solids are presented in Table 7. Most of the results are below analytical detection limits. Total Suspended Solids were not detected at the Category 1 and 2 RGOs. Total Suspended Solids were detected in the application water at the Category 3 and 4 RGOs at 11 and 14 mg/L, respectively. These results were slightly above the detection limit of 10 mg/L. These levels were reflected in the runoff data. At the Category 5 RGO, the 45-minute sample from the driveway approach

area had 13 milligrams per liter of total suspended solids, slightly above the detection limit of 10 mg/L.

6.4 Metals

The analytical results for the metals are presented in Table 8. The data represent the metal concentrations in the 15-minute sample from the pump island area at each of the RGOs. Subsequent samples were not analyzed for metals. All of the concentrations reported in the data are below analytical detection limits with the exceptions of barium, copper and zinc.

The EPA MCLs and detection limits for barium, copper and zinc are listed below:

element	EPA MCL	Detection Limit
barium	1,000 μg/L	20 μg/L
copper	1,000 μg/L	200 μg/L
zinc	5,000 μg/L	100 μg/L

At the Category 1 RGO, barium was detected at 130 μg/L.

At the Category 2 RGO, all metals analyzed for were ND, not detected.

At the Category 3 RGO, barium was detected at 60 μg/L and zinc at 200 μg/L.

At the Category 4 RGO, barium was detected at 60 μg/L and zinc at 200 μg/L.

At the Category 5 RGO, barium was detected at 80 μg/L, copper at 200 μg/L and zinc at 600 μg/L.

6.5 *Recoverable Oil and Grease*

The analytical results for total recoverable oil and grease are listed in Table 9. The detection limit for the oil and grease test was 1 mg/L. The highest detected concentration of oil and grease was 34 mg/L.

At the Category 1 RGO, total recoverable oil and grease was at the detection limit in the 15-minute sample and the 45-minute sample from the pump island area. In the driveway approach area, the 15-minute sample and the 45-minute sample had oil and grease concentrations of 2 mg/L.

At the Category 2 RGO, total recoverable oil and grease was at the detection limit in the 15-minute sample from the driveway approach area and composite sample from the driveway approach area.

At the Category 3 RGO, the highest total recoverable oil and grease was detected at 8 mg/L in the 15-minute sample from the pump island area. The subsequent samples in the pump island area for the 30, 45-minute and composite samples were 3, 2 and 3 mg/L, respectively.

At the Category 4 RGO, an unexpected result in the analytical data is reported. A 15 mg/L concentration of total recoverable oil and grease is reported in the source water. The 15 mg/L concentration in the background sample is higher than the 4, 2, and 8 mg/L concentrations reported in the 15, 30, and 45-minute runoff water samples collected.

At the Category 5 RGO, the total recoverable oil and grease concentrations detected were the highest among the RGOs. The composite sample at the pump island area had a concentration of 34 mg/L, The composite sample at the driveway approach area had a concentration of 29 mg/L.

6.6 *Trip Blanks*

Toluene was detected in the quality control trip blanks that were sent with the runoff samples from the Category 2 and 4 RGOs at concentrations of 0.5 μg/L and 0.7 μg/L, respectively. These concentrations are slightly above the analytical detection limit of 0.3 μg/L. The laboratory did not provide the trip blanks used for this test. The trip blanks were filled with bottled water prior to arriving at each RGO from different bottles of purified water. In the two trip blanks with detectable levels of toluene, the concentrations of toluene were higher than the levels detected in the runoff

water. Contamination was not introduced through sample handling or transportation because toluene was not detected in the other samples from this site.

The GTEL laboratory director, Ms. Joan Greenwood, indicated that GTEL has detected toluene in batches of purified bottled water. At our request, Ms. Greenwood prepared a letter to explain their findings. The letter is included in Appendix H. The letter states that GTEL has detected toluene in bottles of "pure" water from commercial bottled water companies. Water in glass containers has frequently contained toluene in concentrations up to 2 $\mu g/L$. GTEL found plastic containers to contain toluene in even higher concentrations.

7.0 WATER QUALITY COMPARISON

The average concentrations for the chemical compounds studied during the runoff test are compared to water quality criteria and typical urban runoff in Tables 10 through 14.

7.1 EPA MCLs

The data indicate that the average concentrations observed at the five RGOs are lower than the current EPA primary and secondary drinking water MCLs with a few exceptions. The exceptions are antimony, arsenic, beryllium, cadmium, and lead. These exceptions exist because laboratory analytical detection limits are higher than the drinking water MCLs.

We note here that this study illustrates a problem typical of many water quality studies; the analyses employed in the study were performed using standard methods approved by regulatory agencies. However, the detection limits inherent to the standard methods are higher than current and proposed water quality criteria identified in the CA Draft Freshwater and Saltwater Aquatic Life Water Quality Objectives. Achieving lower detection limits requires specialized and expensive analytical techniques sometimes by non-standard research-oriented methods.

7.2 Federal Freshwater and Marine Aquatic Life

The EPA has published chronic exposure water quality criteria for freshwater and marine aquatic life. Concentrations from the RGO runoff which exceed these criteria are copper and zinc. Many of the EPA freshwater and marine aquatic life criteria are below the analytical detection

limits attainable by laboratory methods employed for sample analysis in this study.

7.3 Draft California Freshwater/Saltwater Aquatic Life Water Quality

The State of California is proposing water quality objectives for freshwater and saltwater aquatic life. Comparisons of the RGO runoff with the proposed four-day exposure freshwater aquatic life objectives are difficult because many of the objectives must be calculated by use of the hardness concentrations in the aquatic environment. With respect to the proposed four-day exposure marine chronic objectives, the standards are set below the analytical detection limits attainable by the laboratory methods employed for this study except for chromium and selenium; neither of which were detected in the runoff in concentrations above the proposed objectives.

7.4 Range of Concentrations Typical in Urban Runoff

Tables 10 through 14 also list ranges of chemical concentrations typical of urban runoff as reported in the EPA's Nationwide Urban Runoff Program (NURP). Comparison of the analytical data obtained from the runoff at the five RGOs represented by this study show the chemical concentrations from runoff water are similar to the ranges reported by NURP. The data from this study showed slightly higher concentrations of toluene and copper. The data produced by this study are in the lower ranges of many of the concentrations reported in the NURP, for example, benzene and total suspended solids.

8.0 CONCLUSION

All volatile organic compound concentrations detected in the samples of runoff water were below EPA MCLs. More testing will be necessary to determine the levels of gasoline constituents present in stormwater.

The results of the incidental spill performed at the Category 5 RGO indicate that good housekeeping practices minimize the amount of gasoline constituents present on the RGO ground surface. By minimizing the gasoline constituents present on the ground surface, minimal gasoline constituents will be available to be washed away with the runoff water from the RGO surface during a storm event.

Station Category 1
9/4/92

Table 1

Sample ID	Time	Location	Analysis	Weather
101-1	Water Sample 9:25	Background (Service Station Source Water)	EPA 8015M EPA 8020	Clear and sunny Temp. 72°F Rel. Hum. 63%
101-2	Water Sample 9:25	Background (Service Station Source Water)	EPA 160.2	Temp. 72°F Rel. Hum. 63%
101-3	Water Sample 9:25	Background (Service Station Source Water)	EPA 413.2	Temp. 72°F Rel. Hum. 63%
102-1	15-minute sample 9:33	Pump Island	EPA 8015M EPA 8020	Temp. 72°F Rel. Hum. 63%
102-2	15-minute sample 9:33	Pump Island	EPA 160.2	Temp. 72°F Rel. Hum. 63%
102-3	15-minute sample 9:33	Pump Island	EPA 413.2	Temp. 72°F Rel. Hum. 63%
102-4	15-minute sample 9:33	Pump Island	CAM 22 Metals	Temp. 72°F Rel. Hum. 63%
103-1	30-minute sample 9:48	Pump Island	EPA 8015M EPA 8020	Temp. 73°F Rel. Hum. 61%
103-2	30-minute sample 9:48	Pump Island	EPA 160.2	Temp. 73°F Rel. Hum. 61%
103-3	30-minute sample 9:48	Pump Island	EPA 413.2	Temp. 73°F Rel. Hum. 61%
104-1	45-minute sample 10:04	Pump Island	EPA 8015M EPA 8020	Temp. 72°F Rel. Hum. 62%
104-2	45-minute sample 10:04	Pump Island	EPA 160.2	Temp. 72°F Rel. Hum. 62%
104-3	45-minute sample 10:04	Pump Island	EPA 413.2	Temp. 72°F Rel. Hum. 62%
105-1	Composite Sample 10:10	Pump Island	EPA 8015M EPA 8020	Temp. 72°F Rel. Hum. 62%
105-2	Composite Sample 10:10	Pump Island	EPA 160.2	Temp. 72°F Rel. Hum. 62%
105-3	Composite Sample 10:10	Pump Island	EPA 413.2	Temp. 72°F Rel. Hum. 62%
106-1	15-minute sample 12:04	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 49%
106-2	15-minute sample 12:04	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 49%
106-3	15-minute sample 12:04	Driveway Approach	EPA 413.2	Temp. 80°F Rel. Hum. 49%
107-1	30-minute sample 12:19	Driveway Approach	EPA 8015M EPA 8020	Temp. 81°F Rel. Hum. 49%
107-2	30-minute sample 12:19	Driveway Approach	EPA 160.2	Temp. 81°F Rel. Hum. 49%
107-3	30-minute sample 12:19	Driveway Approach	EPA 413.2	Temp. 81°F Rel. Hum. 49%
108-1	45-minute sample 12:33	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 46%
108-2	45-minute sample 12:33	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 46%
108-3	45-minute sample 12:33	Driveway Approach	EPA 413.2	Temp. 80°F Rel. Hum. 46%
109-1	Composite Sample 12:45	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 46%
109-2	Composite Sample 12:45	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 46%
109-3	Composite Sample 12:45	DrivewayApproach	EPA 413.2	Temp. 80°F Rel. Hum. 46%

Category 2
9/10/92

Table 2

Sample ID	Time	Location	Analysis	Weather
301-1	Water Sample 7:30	Background (Service Station Source Water)	EPA 8015M EPA 8020	Temp. 62°F Rel. Hum. 47%
301-2	Water Sample 7:30	Background (Service Station Source Water)	EPA 160.2	Temp. 62°F Rel. Hum. 47%
301-3	Water Sample 7:30	Background (Service Station Source Water)	EPA 413.2	Temp. 62°F Rel. Hum. 47%
302-1	15-minute sample 7:56	Pump Island	EPA 8015M EPA 8020	Temp. 65°F Rel. Hum. 44%
302-2	15-minute sample 7:56	Pump Island	EPA 160.2	Temp. 65°F Rel. Hum. 44%
302-3	15-minute sample 7:56	Pump Island	EPA 413.2	Temp. 65°F Rel. Hum. 44%
302-4	15-minute sample 7:56	Pump Island	CAM 22 Metals	Temp. 65°F Rel. Hum. 44%
303-1	30-minute sample 8:11	Pump Island	EPA 8015M EPA 8020	Temp. 66°F Rel. Hum. 43%
303-2	30-minute sample 8:11	Pump Island	EPA 160.2	Temp. 66°F Rel. Hum. 43%
303-3	30-minute sample 8:11	Pump Island	EPA 413.2	Temp. 66°F Rel. Hum. 43%
304-1	45-minute sample 8:26	Pump Island	EPA 8015M EPA 8020	Temp. 69°F Rel. Hum. 37%
304-2	45-minute sample 8:26	Pump Island	EPA 160.2	Temp. 69°F Rel. Hum. 37%
304-3	45-minute sample 8:26	Pump Island	EPA 413.2	Temp. 69°F Rel. Hum. 37%
305-1	Composite Sample 8:30	Pump Island	EPA 8015M EPA 8020	Temp. 69°F Rel. Hum. 37%
305-2	Composite Sample 8:30	Pump Island	EPA 160.2	Temp. 69°F Rel. Hum. 37%
305-3	Composite Sample 8:30	Pump Island	EPA 413.2	Temp. 69°F Rel. Hum. 37%
306-1	15-minute sample 9:40	Driveway Approach	EPA 8015M EPA 8020	Temp. 85°F Rel. Hum. 25%
306-2	15-minute sample 9:40	Driveway Approach	EPA 160.2	Temp. 85°F Rel. Hum. 25%
306-3	15-minute sample 9:40	Driveway Approach	EPA 413.2	Temp. 85°F Rel. Hum. 25%
307-1	30-minute sample 10:35	Driveway Approach	EPA 8015M EPA 8020	Temp. 88°F Rel. Hum. 21%
307-2	30-minute sample 10:35	Driveway Approach	EPA 160.2	Temp. 88°F Rel. Hum. 21%
307-3	30-minute sample 10:35	Driveway Approach	EPA 413.2	Temp. 88°F Rel. Hum. 21%
308-1	45-minute sample 10:50	Driveway Approach	EPA 8015M EPA 8020	Temp. 89°F Rel. Hum. 20%
308-2	45-minute sample 10:50	Driveway Approach	EPA 160.2	Temp. 89°F Rel. Hum. 20%
308-3	45-minute sample 10:50	Driveway Approach	EPA 413.2	Temp. 89°F Rel. Hum. 20%
309-1	Composite Sample 10:55	Driveway Approach	EPA 8015M EPA 8020	Temp. 89°F Rel. Hum. 20%
309-2	Composite Sample 10:55	Driveway Approach	EPA 160.2	Temp. 89°F Rel. Hum. 20%
309-3	Composite Sample 10:55	Driveway Approach	EPA 413.2	Temp. 89°F Rel. Hum. 20%

Category 3
9/3/92

Table 3

Sample ID	Time	Location	Analysis	Weather
1-1	Water Sample 11:30	Background (Service Station Source Water)	EPA 8015M EPA 8020	Cloudy & cool Temp. 82°F Rel. Hum. 63%
1-2	Water Sample 11:30	Background (Service Station Source Water)	EPA 160.2	Temp. 82°F Rel. Hum. 63%
1-3	Water Sample 11:30	Background (Service Station Source Water)	EPA 413.2	Temp. 82°F Rel. Hum. 63%
2-1	15-minute sample 12:06	Pump Island	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 60%
2-2	15-minute sample 12:06	Pump Island	EPA 160.2	Temp. 83°F Rel. Hum. 60%
2-3	15-minute sample 12:06	Pump Island	EPA 413.2	Temp. 83°F Rel. Hum. 60%
2-4	15-minute sample 12:06	Pump Island	CAM 22 Metals	Temp. 83°F Rel. Hum. 60%
3-1	30-minute sample 12:22	Pump Island	EPA 8015M EPA 8020	Temp. 84°F Rel. Hum. 59%
3-2	30-minute sample 12:22	Pump Island	EPA 160.2	Temp. 84°F Rel. Hum. 59%
3-3	30-minute sample 12:22	Pump Island	EPA 413.2	Temp. 84°F Rel. Hum. 59%
4-1	45-minute sample 12:38	Pump Island	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 60%
4-2	45-minute sample 12:38	Pump Island	EPA 160.2	Temp. 83°F Rel. Hum. 60%
4-3	45-minute sample 12:38	Pump Island	EPA 413.2	Temp. 83°F Rel. Hum. 60%
5-1	Composite Sample 12:44	Pump Island	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 60%
5-2	Composite Sample 12:44	Pump Island	EPA 160.2	Temp. 83°F Rel. Hum. 60%
5-3	Composite Sample 12:44	Pump Island	EPA 413.2	Temp. 83°F Rel. Hum. 60%
6-1	15-minute sample 14:55	Driveway Approach	EPA 8015M EPA 8020	Temp. 78°F Rel. Hum. 67%
6-2	15-minute sample 14:55	Driveway Approach	EPA 160.2	Temp. 78°F Rel. Hum. 67%
6-3	15-minute sample 14:55	Driveway Approach	EPA 413.2	Temp. 78°F Rel. Hum. 67%
7-1	30-minute sample 15:11	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 63%
7-2	30-minute sample 15:11	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 63%
7-3	30-minute sample 15:11	Driveway Approach	EPA 413.2	Temp. 80°F Rel. Hum. 63%
8-1	45-minute sample 15:25	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 63%
8-2	45-minute sample 15:25	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 63%
8-3	45-minute sample 15:25	Driveway Approach	EPA 413.2	Temp. 80°F Rel. Hum. 63%
9-1	Composite Sample 15:42	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 63%
9-2	Composite Sample 15:42	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 63%
9-3	Composite Sample 15:42	Driveway Approach	EPA 413.2	Temp. 80°F Rel. Hum. 63%

Category 4
9/9/92

Table 4

Sample ID	Time	Location	Analysis	Weather
201-1	Source Water Sample 9:30	Background (Servic eStation Source Water)	EPA 8015M EPA 8020	Clear Temp. 72°F Rel. Hum. 67%
201-2	Source Water Sample 9:30	Background (Servic eStation Source Water)	EPA 160.2	Temp. 72°F Rel. Hum. 67%
201-3	Source Water Sample 9:30	Background (Servic eStation Source Water)	EPA 413.2	Temp. 72°F Rel. Hum. 67%
202-1	15-minute sample 9:55	Pump Island	EPA 8015M EPA 8020	Temp. 75°F Rel. Hum. 66%
202-2	15-minute sample 9:55	Pump Island	EPA 160.2	Temp. 75°F Rel. Hum. 66%
202-3	15-minute sample 9:55	Pump Island	EPA 413.2	Temp. 75°F Rel. Hum. 66%
202-4	15-minute sample 9:55	Pump Island	CAM 22 Metals	Temp. 75°F Rel. Hum. 66%
203-1	30-minute sample 10:10	Pump Island	EPA 8015M EPA 8020	Temp. 75°F Rel. Hum. 65%
203-2	30-minute sample 10:10	Pump Island	EPA 160.2	Temp. 75°F Rel. Hum. 65%
203-3	30-minute sample 10:10	Pump Island	EPA 413.2	Temp. 75°F Rel. Hum. 65%
204-1	45-minute sample 10:25	Pump Island	EPA 8015M EPA 8020	Temp. 77°F Rel. Hum. 64%
204-2	45-minute sample 10:25	Pump Island	EPA 160.2	Temp. 77°F Rel. Hum. 64%
204-3	45-minute sample 10:25	Pump Island	EPA 413.2	Temp. 77°F Rel. Hum. 64%
205-1	Composite Sample 10:30	Pump Island	EPA 8015M EPA 8020	Temp. 77°F Rel. Hum. 64%
205-2	Composite Sample 10:30	Pump Island	EPA 160.2	Temp. 77°F Rel. Hum. 64%
205-3	Composite Sample 10:30	Pump Island	EPA 413.2	Temp. 77°F Rel. Hum. 64%
206-1	15-minute sample 13:25	Driveway Approach	EPA 8015M EPA 8020	Temp. 84°F Rel. Hum. 48%
206-2	15-minute sample 13:25	Driveway Approach	EPA 160.2	Temp. 84°F Rel. Hum. 48%
206-3	15-minute sample 13:25	Driveway Approach	EPA 413.2	Temp. 84°F Rel. Hum. 48%
207-1	30-minute sample 13:40	Driveway Approach	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 48%
207-2	30-minute sample 13:40	Driveway Approach	EPA 160.2	Temp. 83°F Rel. Hum. 48%
207-3	30-minute sample 13:40	Driveway Approach	EPA 413.2	Temp. 83°F Rel. Hum. 48%
208-1	45-minute sample 13:55	Driveway Approach	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 48%
208-2	45-minute sample 13:55	Driveway Approach	EPA 160.2	Temp. 83°F Rel. Hum. 48%
208-3	45-minute sample 13:55	Driveway Approach	EPA 413.2	Temp. 83°F Rel. Hum. 48%
209-1	Composite Sample 13:55	Driveway Approach	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 48%
209-2	Composite Sample 13:55	Driveway Approach	EPA 160.2	Temp. 83°F Rel. Hum. 48%
209-3	Composite Sample 13:55	Driveway Approach	EPA 413.2	Temp. 83°F Rel. Hum. 48%

Category 5
9/17/92

Table 5

Sample ID	Time	Location	Analysis	Weather
401-1	Source Water Sample 5:25	Background (Service Station Water Source)	EPA 8015M EPA 8020	Cloudy & sprinkling Temp. 84°F Rel. Hum. 36%
401-2	Water Sample 5:25	Background (Source)	EPA 160.2	Temp. 84°F Rel. Hum. 36%
401-3	Water Sample 5:25	Background (Service Station Water Source)	EPA 413.2	Temp. 84°F Rel. Hum. 36%
402-1	15-minute sample 5:56	Pump Island	EPA 8015M EPA 8020	Temp. 84°F Rel. Hum. 36%
402-2	15-minute sample 5:56	Pump Island	EPA 160.2	Temp. 84°F Rel. Hum. 36%
402-3	15-minute sample 5:56	Pump Island	EPA 413.2	Temp. 84°F Rel. Hum. 36%
402-4	15-minute sample 5:56	Pump Island	CAM 22 Metals	Temp. 84°F Rel. Hum. 36%
403-1	30-minute sample 6:11	Pump Island	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 36%
403-2	30-minute sample 6:11	Pump Island	EPA 160.2	Temp. 83°F Rel. Hum. 36%
403-3	30-minute sample 6:11	Pump Island	EPA 413.2	Temp. 83°F Rel. Hum. 36%
404-1	45-minute sample 6:26	Pump Island	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 35%
404-2	45-minute sample 6:26	Pump Island	EPA 160.2	Temp. 83°F Rel. Hum. 35%
404-3	45-minute sample 6:26	Pump Island	EPA 413.2	Temp. 83°F Rel. Hum. 35%
405-1	Composite Sample 6:30	Pump Island	EPA 8015M EPA 8020	Temp. 83°F Rel. Hum. 35%
405-2	Composite Sample 6:30	Pump Island	EPA 160.2	Temp. 83°F Rel. Hum. 35%
405-3	Composite Sample 6:30	Pump Island	EPA 413.2	Temp. 83°F Rel. Hum. 35%
406-1	15-minute sample 7:45	Driveway Approach	EPA 8015M EPA 8020	Temp. 80°F Rel. Hum. 45%
406-2	15-minute sample 7:45	Driveway Approach	EPA 160.2	Temp. 80°F Rel. Hum. 45%
406-3	15-minute sample 7:45	Driveway Approach	EPA 413.2	Temp. 80°F Rel. Hum. 45%
407-1	30-minute sample 8:00	Driveway Approach	EPA 8015M EPA 8020	Temp. 78°F Rel. Hum. 58%
407-2	30-minute sample 8:00	Driveway Approach	EPA 160.2	Temp. 78°F Rel. Hum. 58%
407-3	30-minute sample 8:00	Driveway Approach	EPA 413.2	Temp. 78°F Rel. Hum. 58%
408-1	45-minute sample 8:15	Driveway Approach	EPA 8015M EPA 8020	Temp. 78°F Rel. Hum. 58%
408-2	45-minute sample 8:15	Driveway Approach	EPA 160.2	Temp. 78°F Rel. Hum. 58%
408-3	45-minute sample 8:15	Driveway Approach	EPA 413.2	Temp. 78°F Rel. Hum. 58%
409-1	Composite Sample 8:20	Driveway Approach	EPA 8015M EPA 8020	Temp. 78°F Rel. Hum. 58%
409-2	Composite Sample 8:20	Driveway Approach	EPA 160.2	Temp. 78°F Rel. Hum. 58%
409-3	Composite Sample 8:20	Driveway Approach	EPA 413.2	Temp. 78°F Rel. Hum. 58%

Table 6
AROMATIC VOLATILES AND TPH RESULTS

WSPA Category	Sample ID	Date Sampled	Benzene in µg/L (ppb) 0.3 µg/L [1]	Toluene in µg/L (ppb) 0.3 µg/L[1]	Ethylbenzene in µg/L (ppb) 0.3 µg/L[1]	Total Xylenes in µg/L (ppb) 0.6 µg/L[1]	TPH as Gasoline in µg/L (ppb) 100 µg/L[1]
1	101-1	9/4/92	<0.3	<0.3	<0.3	<0.6	<100
1	102-1	9/4/92	<0.3	0.5	<0.3	0.7	<100
1	103-1	9/4/92	<0.3	0.6	<0.3	0.8	<100
1	104-1	9/4/92	<0.3	0.8	<0.3	1.4	<100
1	105-1	9/4/92	<0.3	0.8	<0.3	1.3	<100
1	106-1	9/4/92	<0.3	<0.3	<0.3	<0.6	<100
1	107-1	9/4/92	<0.3	<0.3	<0.3	<0.6	<100
1	108-1	9/4/92	<0.3	<0.3	<0.3	<0.6	<100
1	109-1	9/4/92	<0.3	<0.3	<0.3	<0.6	<100
1	TB	9/4/92	<0.3	<0.3	<0.3	<0.6	<100
2	301-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	302-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	303-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	304-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	305-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	306-1	9/10/92	1.5	<0.3	<0.3	<0.6	<100
2	307-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	308-1	9/10/92	<0.3	<0.3	<0.3	<0.6	<100
2	309-1	9/10/92	0.4	<0.3	<0.3	<0.6	<100
2	TB	9/10/92	<0.3	0.5	<0.3	<0.6	<100
3	1-1	9/3/92	<0.3	<0.3	<0.3	1.5	<100
3	2-1	9/3/92	<3.0	7.9	<3.0	20	<1000
3	3-1	9/3/92	<0.3	<0.3	<0.3	<0.6	<100
3	4-1	9/3/92	<0.3	0.4	<0.3	1.1	<100
3	5-1	9/3/92	<0.3	0.3	<0.3	1.1	<100
3	6-1	9/3/92	<3.0	<3.0	<3.0	<6.0	<1000
3	7-1	9/3/92	<3.0	<3.0	<3.0	<6.0	<1000
3	8-1	9/3/92	0.5	4.5	1.1	12	<100
3	9-1	9/3/92	<0.3	0.8	<0.3	3.4	<100
3	TB	9/3/92	<0.3	<0.3	<0.3	<0.6	<100
4	201-1	9/9/92	<0.3	0.3	<0.3	7.1	<100
4	202-1	9/9/92	<0.3	<0.3	<0.3	<0.6	<100
4	203-1	9/9/92	<0.3	<0.3	<0.3	<0.6	<100
4	204-1	9/9/92	<0.3	0.4	<0.3	1.5	<100
4	205-1	9/9/92	<0.3	<0.3	<0.3	1.4	<100
4	206-1*	9/9/92	<3.0	<3.0	<3.0	<6.0	<1000
4	207-1	9/9/92	<0.3	<0.3	<0.3	<0.6	<100
4	208-1	9/9/92	<0.3	<0.3	<0.3	<0.6	<100
4	209-1	9/9/92	<0.3	<0.3	<0.3	<0.6	130
4	TB	9/9/92	<0.3	0.7	<0.3	<0.6	<100
5	401-1	9/17/92	<0.3	<0.3	<0.3	<0.6	<100
5	402-1*	9/17/92	<3.0	9.5	<3.0	19	<1000
5	403-1*	9/17/92	<3.0	14	5.0	37	<1000
5	404-1	9/17/92	1.0	13	6.3	41	180
5	405-1*	9/17/92	<3.0	9.5	3.4	22	<1000
5	406-1*	9/17/92	<7.5	<7.5	<7.5	<15	<2500
5	407-1*	9/17/92	<3.0	<3.0	<3.0	<6.0	<1000
5	408-1*	9/17/92	<7.5	<7.5	<7.5	<15	<2500
5	409-1*	9/17/92	<7.5	<7.5	<7.5	<15	<2500
5	TB	9/17/92	<0.3	<0.3	<0.3	<0.6	<100

1 - Detection Limit
* - Detection limit increased due to matrix effect (foaming)

Table 7
TOTAL SUSPENDED SOLIDS RESULTS

WSPA Category No.	Sample ID	Date Sampled	Total Suspended Solids in mg/L (ppm)
1	101-2	9/4/92	<10
1	102-2	9/4/92	<10
1	103-2	9/4/92	<10
1	104-2	9/4/92	<10
1	105-2	9/4/92	<10
1	106-2	9/4/92	<10
1	107-2	9/4/92	<10
1	108-2	9/4/92	<10
1	109-2	9/4/92	<10
2	301-2	9/10/92	<10
2	302-2	9/10/92	<10
2	303-2	9/10/92	<10
2	304-2	9/10/92	<10
2	305-2	9/10/92	<10
2	306-2	9/10/92	<10
2	307-2	9/10/92	<10
2	308-2	9/10/92	<10
2	309-2	9/10/92	<10
3	1-2	9/3/92	11
3	2-2	9/3/92	13
3	3-2	9/3/92	<10
3	4-2	9/3/92	<10
3	5-2	9/3/92	<10
3	6-2	9/3/92	<10
3	7-2	9/3/92	<10
3	8-2	9/3/92	<10
3	9-2	9/3/92	<10
4	201-2	9/9/92	14
4	202-2	9/9/92	<10
4	203-2	9/9/92	<10
4	204-2	9/9/92	<10
4	205-2	9/9/92	13
4	206-2	9/9/92	11
4	207-2	9/9/92	10
4	208-2	9/9/92	12
4	209-2	9/9/92	<10
5	401-2	9/17/92	<10
5	402-2	9/17/92	<10
5	403-2	9/17/92	<10
5	404-2	9/17/92	<10
5	405-2	9/17/92	<10
5	406-2	9/17/92	<10
5	407-2	9/17/92	<10
5	408-2	9/17/92	13
5	409-2	9/17/92	<10

Table 8
METALS RESULTS

WSPA Category No:	1	2	3	4	5
Sample ID:	102-4	302-4	2-4	202-4	402-4
Date Sampled:	9/4/92	9/10/92	9/3/92	9/9/92	9/17/92
Metals in µg/L (ppb)					
Antimony	<40	<40	<40	<40	<40
Arsenic	<100	<100	<100	<100	<100
Barium	130	<20	60	60	80
Beryllium	<10	<10	<10	<10	<10
Cadmium	<30	<30	<30	<30	<30
Chromium	<40	<40	<40	<40	<40
Cobalt	<20	<20	<20	<20	<20
Copper	<200	<200	<200	<200	200
Lead	<100	<100	<100	<100	<100
Mercury	<1	<1	<1	<1	<1
Molybdenum	<20	<20	<20	<20	<20
Nickel	<100	<100	<100	<100	<100
Selenium	<40	<40	<40	<40	<40
Silver	<50	<50	<50	<50	<50
Thalium	<400	<400	<400	<400	<400
Vanadium	<200	<200	<200	<200	<200
Zinc	<100	<100	200	200	600

Table 9
TOTAL RECOVERABLE OIL AND GREASE RESULTS

WSPA Category No.	Sample ID	Date Sampled	Total Oil and Grease in mg/L (ppm)
1	101-3	9/4/92	<1
1	102-3	9/4/92	1
1	103-3	9/4/92	<1
1	104-3	9/4/92	1
1	105-3	9/4/92	<1
1	106-3	9/4/92	2
1	107-3	9/4/92	1
1	108-3	9/4/92	2
1	109-3	9/4/92	1
2	301-3	9/10/92	<1
2	302-3	9/10/92	<1
2	303-3	9/10/92	<1
2	304-3	9/10/92	<1
2	305-3	9/10/92	<1
2	306-3	9/10/92	1
2	307-3	9/10/92	<1
2	308-3	9/10/92	<1
2	309-3	9/10/92	1
3	1-3	9/3/92	<1
3	2-3	9/3/92	8
3	3-3	9/3/92	3
3	4-3	9/3/92	2
3	5-3	9/3/92	3
3	6-3	9/3/92	1
3	7-3	9/3/92	<1
3	8-3	9/3/92	1
3	9-3	9/3/92	<1
4	201-3	9/9/92	15
4	202-3	9/9/92	4
4	203-3	9/9/92	2
4	204-3	9/9/92	8
4	205-3	9/9/92	1
4	206-3	9/9/92	2
4	207-3	9/9/92	1
4	208-3	9/9/92	<1
4	209-3	9/9/92	<1
5	401-3	9/17/92	<1
5	402-3	9/17/92	9
5	403-3	9/17/92	7
5	404-3	9/17/92	9
5	405-3	9/17/92	34
5	406-3	9/17/92	9
5	407-3	9/17/92	11
5	408-3	9/17/92	6
5	409-3	9/17/92	29

Table 10
COMPARISON OF ANALYTICAL RESULTS FOR THE CATEGORY 1 STATION VERSUS WATER QUALITY CRITERIA AND TYPICAL CONCENTRATIONS IN URBAN RUNOFF

	Average Concentration Observed in Runoff	USEPA Drinking Water MCL (a)	CA Drinking Water Objective (b)	USEPA Freshwater Aquatic Life Chronic (c)	USEPA Marine Aquatic Life Chronic (c)	CA Draft Freshwater Aquatic Life Water Quality Objectives (d)	CA Draft Saltwater Aquatic Life Water Quality Objectives (e)	Range of Concentrations Typical in Urban Runoff (f)
Aromatic Volatiles in µg/L (ppb)								
Benzene	<0.3	5	0.34	--	700	--	--	1-13
Toulene	<0.47	1,000	--	--	5,000	--	--	3-9
Ethylbenzene	<0.3	700	--	--	--	--	--	--
Total Xylenes	<0.8	10,000	--	--	--	--	--	--
Total suspended solids in mg/L (ppm)	<10							17-2,900
Metals in µg/L (ppb)								
Antimony	<40	5	14	1,600	--	--	--	2.6 - 23
Arsenic	<100	50	5	--	--	190	36	1 - 50.5
Barium	130	1,000	--	--	--	--	--	--
Beryllium	<10	1	0.008	5.3	--	--	--	1 - 49
Cadmium	<30	5	10	1.1	9.3	(g)	9.3	0.1 - 14
Chromium (Hexavalent)	<40	100	50	11	50	11	50	1 - 190
Cobalt	<20	--	--	--	--	--	--	--
Copper	<200	1,000	1,000	12	2.9	(g)	--	10 - 100
Lead	<100	50	50	3.2	5.6	(g)	5.6	6 - 460
Mercury	<1	2	12	0.012	0.025	--	--	0.6 - 1.2
Molybdenum	<20	--	--	--	--	--	--	--
Nickel	<100	100	600	160	8.3	(g)	8.3	1 - 182
Selenium	<40	50	10	35	54	5	71	2 - 77
Silver	<50	50	500	0.12	--	--	--	0.2 - 0.8
Thallium	<400	1	1.7	40	--	--	--	1 - 14
Vanadium	<200	--	--	--	--	--	--	--
Zinc	<100	5,000	5,000	110	58	(g)	86	10 - 2,400

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Table 11
COMPARISON OF ANALYTICAL RESULTS FOR THE CATEGORY 2 STATION VERSUS WATER QUALITY CRITERIA AND TYPICAL CONCENTRATIONS URBAN RUNOFF

	Average Concentration Observed in Runoff	USEPA Drinking Water MCL (a)	CA Drinking Water Objective (b)	USEPA Freshwater Aquatic Life Chronic (c)	USEPA Marine Aquatic Life Chronic (c)	CA Draft Freshwater Aquatic Life Water Quality Objectives (d)	CA Draft Saltwater Aquatic Life Water Quality Objectives (e)	Range of Concentrations Typical in Urban Runoff (f)
Aromatic Volatiles in µg/L (ppb)								
Benzene	<0.44	5	0.34	--	700	--	--	1-13
Toulene	<0.3	1,000	--	--	5,000	--	--	3-9
Ethylbenzene	<0.3	700	--	--	--	--	--	--
Total Xylenes	<0.6	10,000	--	--	--	--	--	--
Total suspended solids in mg/l (ppm)	<10							17-2,900
Metals in µg/L (ppb)								
Antimony	<40	5	14	1,600	--	--	--	2.6 - 23
Arsenic	<100	50	5	--	--	190	36	1 - 50.5
Barium	<20	1,000	--	--	--	--	--	--
Beryllium	<10	1	0.008	5.3	--	--	--	1 - 49
Cadmium	<30	5	10	1.1	9.3	(g)	9.3	0.1 - 14
Chromium (Hexavalent)	<40	100	50	11	50	11	50	1 - 190
Cobalt	<20	--	--	--	--	--	--	--
Copper	<200	1,000	1,000	12	2.9	(g)	--	10 - 100
Lead	<100	50	50	3.2	5.6	(g)	5.6	6 - 460
Mercury	<1	2	12	0.012	0.025	--	--	0.6 - 1.2
Molybdenum	<20	--	--	--	--	--	--	--
Nickel	<100	100	600	160	8.3	(g)	8.3	1 - 182
Selenium	<40	50	10	35	54	5	71	2 - 77
Silver	<40	50	500	0.12	--	--	--	0.2 - 0.8
Thallium	<400	1	1.7	40	--	--	--	1 - 14
Vanadium	<200	--	--	--	--	--	--	--
Zinc	<100	5,000	5,000	110	58	(g)	86	10 - 2,400

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Table 12
COMPARISON OF ANALYTICAL RESULTS FOR THE CATEGORY 3 STATION VERSUS WATER QUALITY CRITERIA AND TYPICAL CONCENTRATIONS URBAN RUNOFF

	Average Concentration Observed in Runoff	USEPA Drinking Water MCL (a)	CA Drinking Water Objective (b)	EPA Freshwater Aquatic Life Chronic (c)	EPA Marine Aquatic Life Chronic (c)	CA Draft Freshwater Aquatic Life Water Quality Objectives (d)	CA Draft Saltwater Aquatic Life Water Quality Objectives (e)	Range of Concentrations Typical in Urban Runoff (f)
Aromatic Volatiles in µg/L (ppb)								
Benzene	<0.32	5	0.34	--	700	--	--	1-13
Toulene	<1.68	1,000	--	--	5,000	--	--	3-9
Ethylbenzene	<1.17	700	--	--	--	--	--	--
Total Xylenes	<5.81	10,000	--	--	--	--	--	--
Total suspended solids in mg/l (ppm)	<10.4							17-2,900
Metals in µg/L (ppb)								
Antimony	<40	5	14	1,600	--	--	--	2.6 - 23
Arsenic	<100	50	5	--	--	190	36	1 - 50.5
Barium	60	1,000	--	--	--	--	--	--
Beryllium	<10	1	0.008	5.3	--	--	--	1 - 49
Cadmium	<30	5	10	1.1	9.3	(g)	9.3	0.1 - 14
Chromium (Hexavalent)	<40	100	50	11	50	11	50	1 - 190
Cobalt	<20	--	--	--	--	--	--	--
Copper	<200	1,000	1,000	12	2.9	(g)	--	10 - 100
Lead	<100	50	50	3.2	5.6	(g)	5.6	6 - 460
Mercury	<1	2	12	0.012	0.025	--	--	0.6 - 1.2
Molybdenum	<20	--	--	--	--	--	--	--
Nickel	<100	100	600	160	8.3	(g)	8.3	1 - 182
Selenium	<40	50	10	35	54	5	71	2 - 77
Silver	<50	50	500	0.12	--	--	--	0.2 - 0.8
Thallium	<400	1	1.7	40	--	--	--	1 - 14
Vanadium	<200	--	--	--	--	--	--	--
Zinc	200	5,000	5,000	110	58	(g)	86	10 - 2,400

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Table 13
COMPARISON OF ANALYTICAL RESULTS FOR THE CATEGORY 4 STATION VERSUS WATER QUALITY CRITERIA AND TYPICAL CONCENTRATIONS URBAN RUNOFF

	Average Concentration Observed in Runoff	USEPA Drinking Water MCL (a)	CA Drinking Water Objective (b)	USEPA Freshwater Aquatic Life Chronic (c)	USEPA Marine Aquatic Life Chronic (c)	CA Draft Freshwater Aquatic Life Water Quality Objectives (d)	CA Draft Saltwater Aquatic Life Water Quality Objectives (e)	Range of Concentrations Typical in Urban Runoff (f)
Aromatic Volatiles in µg/L (ppb)								
Benzene	<0.3	5	0.34	--	700	--	--	1-13
Toulene	<6.1	1,000	--	--	5,000	--	--	3.9
Ethylbenzene	<0.6	700	--	--	--	--	--	--
Total Xylenes	<2.1	10,000	--	--	--	--	--	--
Total suspended solids in mg/l (ppm)	<11.1							17-2,900
Metals in µg/L (ppb)								
Antimony	<40	5	14	1,600	--	--	--	2.6 - 23
Arsenic	<100	50	5	--	--	190	36	1 - 50.5
Barium	60	1,000	--	--	--	--	--	--
Beryllium	<10	1	0.008	5.3	--	--	--	1 - 49
Cadmium	<30	5	10	1.1	9.3	(g)	9.3	0.1 - 14
Chromium (Hexavalent)	<40	100	50	11	50	11	50	1 - 190
Cobalt	<20	--	--	--	--	--	--	--
Copper	<200	1,000	1,000	12	2.9	(g)	--	10 - 100
Lead	<100	50	50	3.2	5.6	(g)	5.6	6 - 460
Mercury	<1	2	12	0.012	0.025	--	--	0.6 - 1.2
Molybdenum	<20	--	--	--	--	--	--	--
Nickel	<100	100	600	160	8.3	(g)	8.3	1 - 182
Selenium	<40	50	10	35	54	5	71	2 - 77
Silver	<50	50	500	0.12	--	--	--	0.2 - 0.8
Thallium	<400	1	1.7	40	--	--	--	1 - 14
Vanadium	<200	--	--	--	--	--	--	--
Zinc	200	5,000	5,000	110	58	(g)	86	10 - 2,400

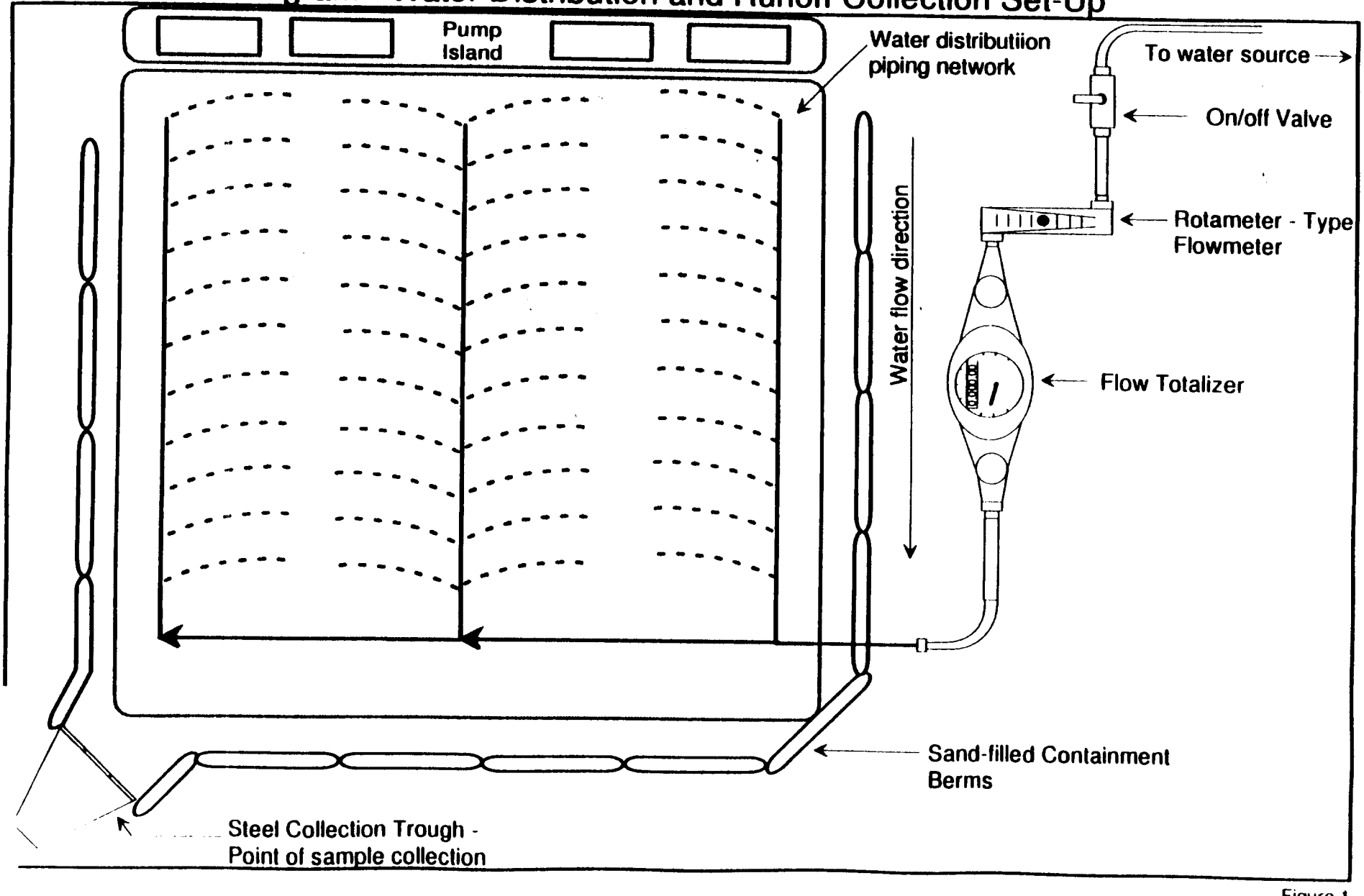
R0013245

Table 14
COMPARISON OF ANALYTICAL RESULTS FOR THE CATEGORY 5 STATION VERSUS WATER QUALITY CRITERIA AND TYPICAL CONCENTRATIONS URBAN RUNOFF

	Average Concentration Observed in Runoff	USEPA Drinking Water MCL (a)	CA Drinking Water Objective (b)	USEPA Freshwater Aquatic Life Chronic (c)	USEPA Marine Aquatic Life Chronic (c)	CA Draft Freshwater Aquatic Life Water Quality Objectives (d)	CA Draft Saltwater Aquatic Life Water Quality Objectives (e)	Range of Concentrations Typical in Urban Runoff (f)
Aromatic Volatiles in µg/L (ppb)								
Benzene	<3.98	5	0.34	--	700	--	--	1-13
Toulene	<7.98	1,000	--	--	5,000	--	--	3-9
Ethylbenzene	<4.83	700	--	--	--	--	--	--
Total Xylenes	<18.96	10,000	--	--	--	--	--	--
Total suspended solids in mg/l (ppm)	<10.3							17-2,900
Metals in µg/L (ppb)								
Antimony	<40	5	14	1,600	--	--	--	2.6 - 23
Arsenic	<100	50	5	--	--	190	36	1 - 50.5
Barium	80	1,000	--	--	--	--	--	--
Beryllium	<10	1	0.008	5.3	--	--	--	1 - 49
Cadmium	<30	5	10	1.1	9.3	(g)	9.3	0.1 - 14
Chromium (Hexavalent)	<40	100	50	11	50	11	50	1 - 190
Cobalt	<20	--	--	--	--	--	--	--
Copper	200	1,000	1,000	12	2.9	(g)	--	10 - 100
Lead	<100	50	50	3.2	5.6	(g)	5.6	6 - 460
Mercury	<1	2	12	0.012	0.025	--	--	0.6 - 1.2
Molybdenum	<20	--	--	--	--	--	--	--
Nickel	<100	100	600	160	8.3	(g)	8.3	1 - 182
Selenium	<40	50	10	35	54	5	71	2 - 77
Silver	<50	50	500	0.12	--	--	--	0.2 - 0.8
Thallium	<400	1	1.7	40	--	--	--	1 - 14
Vanadium	<200	--	--	--	--	--	--	--
Zinc	600	5,000	5,000	110	58	(g)	86	10 - 2,400

R0013246

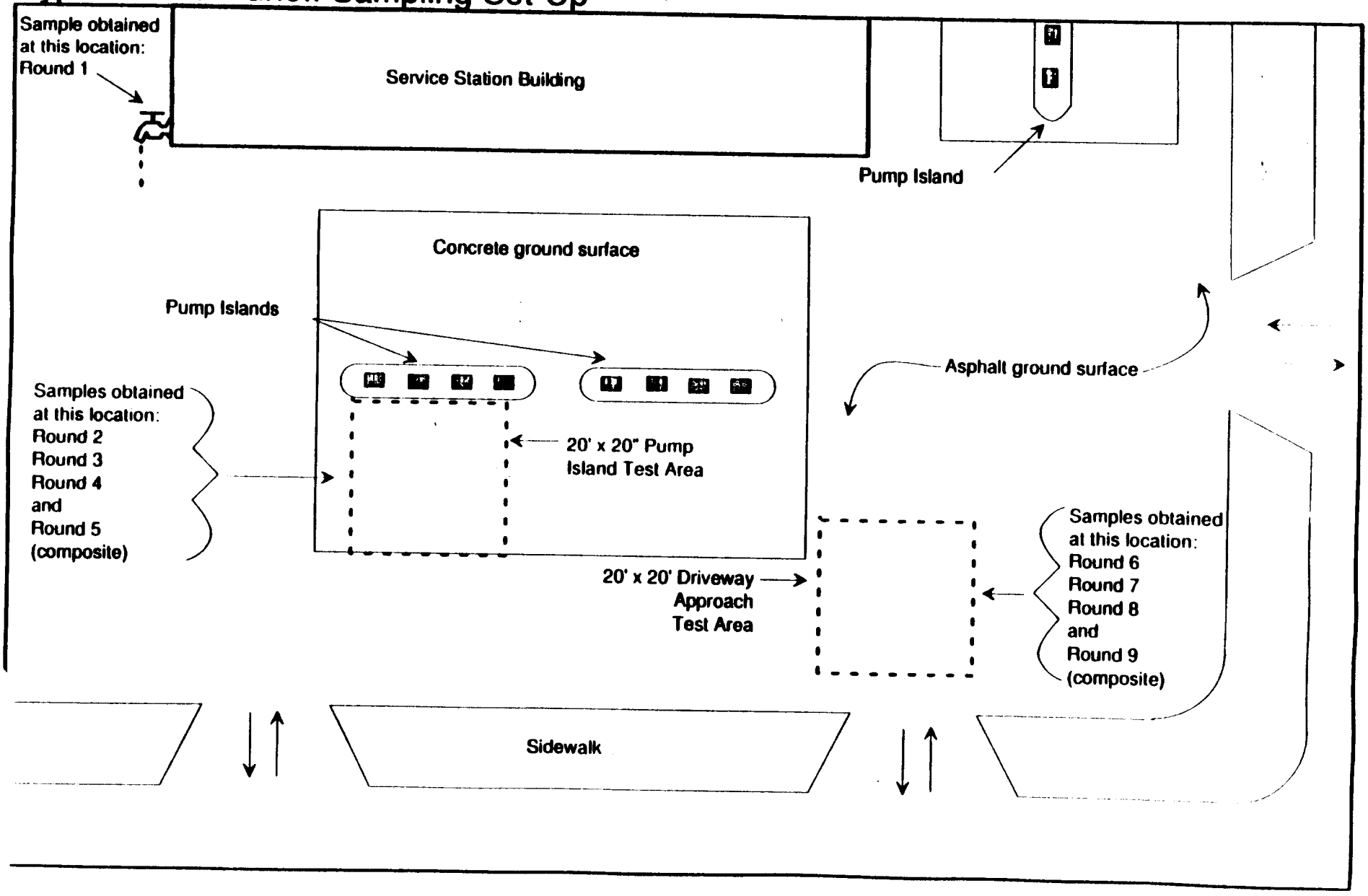
Process Flow Diagram - Water Distribution and Runoff Collection Set-Up



R0013247

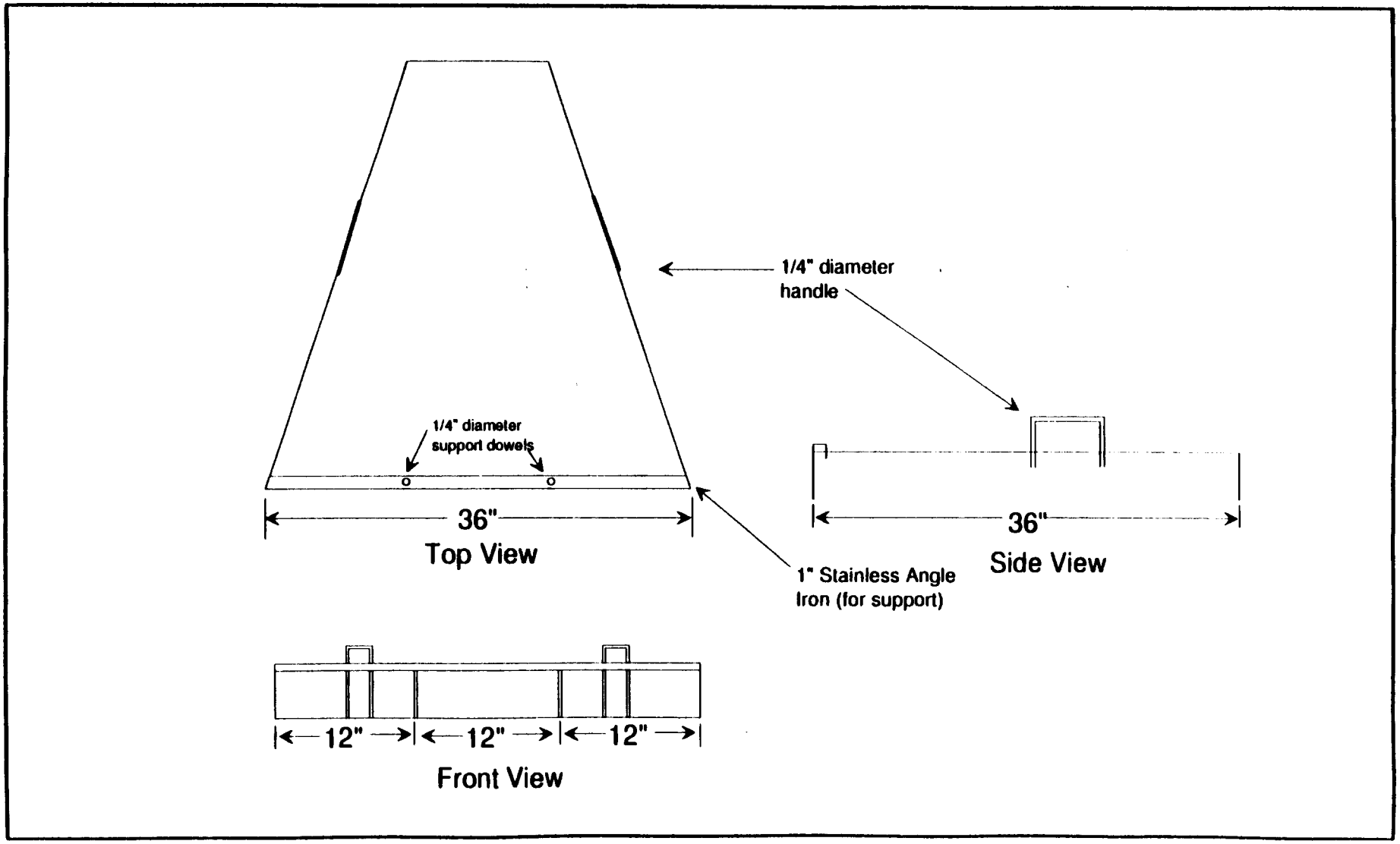
Figure 1

Typical RGO Runoff Sampling Set-Up



R0013248

22 Gauge Stainless Steel Collection Trough



R0013249

Figure 3

APPENDIX A
GTEL LABORATORY ANALYTICAL DATA SHEETS

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Southwest Region
20000 / 300 Mariner Drive
Torrance, CA 90503
(310) 371-1044
(800) 727-GTEL
Fax (310) 371-8720

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

Mr. John Netherwood
Hart Crowser
1 World Trade Center
Long Beach, CA 90831

Dear Mr. Netherwood,

This report replaces the original report, dated September 22, 1992, which is being reissued due to GTEL's inadvertant ommission of information pertaining to this project. Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 9/4/92.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the state of California under Certification #1123.

If you have any questions concerning this analysis or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,

GTEL Environmental Laboratories, Inc.

for JG

Joan Greenwood
Laboratory Director

R0013251

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		Lab Blank	09038-1A	09038-4A	09038-8A
Client Identification		-	101-1	102-1	103-1
Date Sampled		-	9/4/92	9/4/92	9/4/92
Date Analyzed		9/14/92	9/14/92	9/14/92	9/14/92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<0.3	<0.3
Toluene	0.3	<0.3	<0.3	0.5	0.6
Ethylbenzene	0.3	<0.3	<0.3	<0.3	<0.3
Xylene, total	0.6	<0.6	<0.6	0.7	0.8
BTEX, total	-	-	-	1.2	1.4
TPH as Gasoline	100	<100	<100	<100	<100
Dilution Multiplier[b]		1	1	1	1
TFT surrogate[c], % recovery		100	94.0	97.0	95.0

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013252

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09038-11A	09038-14A	09038-17A	09038-20A
Client Identification		104-1	105-1	106-1	107-1
Date Sampled		9/4/92	9/4/92	9/4/92	9/4/92
Date Analyzed		9/15/92	9/15/92	9/15/92	9/15/92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<0.3	<0.3
Toluene	0.3	0.8	0.8	<0.3	<0.3
Ethylbenzene	0.3	<0.3	<0.3	<0.3	<0.3
Xylene, total	0.6	1.4	1.3	<0.6	<0.6
BTEX, total	-	2.2	2.1	-	-
TPH as Gasoline	100	<100	<100	<100	<100
Dilution Multiplier[b]		1	1	1	1
TFT surrogate[c], % recovery		106	86.1	96.9	94.0

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013253

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09038-23A	09038-26A	09038-29A	
Client Identification		108-1	109-1	TRIP BLANK	
Date Sampled		9/4/92	9/4/92	9/4/92	
Date Analyzed		9/15/92	9/15/92	9/15/92	
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<0.3	
Toluene	0.3	<0.3	<0.3	<0.3	
Ethylbenzene	0.3	<0.3	<0.3	<0.3	
Xylene, total	0.6	<0.6	<0.6	<0.6	
BTEX, total	-	-	-	-	
TPH as Gasoline	100	<100	<100	<100	
Dilution Multiplier[b]		1	1	1	
TFT surrogate[c], % recovery		93.4	96.8	98.2	

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013254

GTEL ENVIRONMENTAL LABORATORIES, INC

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

ANALYTICAL RESULTS

Total Suspended Solid in Water
Standard Method 209 C[a]

Sample Identification		Date Sampled	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID				
Blank		9/4/92	9/15/92	10	<10
09038-2	101-2	9/4/92	9/15/92	10	<10
09038-5	102-2	9/4/92	9/15/92	10	<10
09038-9	103-2	9/4/92	9/15/92	10	<10
09038-12	104-2	9/4/92	9/15/92	10	<10
09038-15	105-2	9/4/92	9/15/92	10	<10
09038-18	106-2	9/4/92	9/15/92	10	<10
09038-21	107-2	9/4/92	9/15/92	10	<10
09038-24	108-2	9/4/92	9/15/92	10	<10
09038-27	109-2	9/4/92	9/15/92	10	<10

a. Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.

R0013255

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

ANALYTICAL RESULTS

Total Recoverable Oil and Grease in Water by Infrared Spectrometry EPA 413.2[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID					
Blank	–	–	9/16/92	9/17/92	1	<1
09038-3	101-3	9/4/92	9/16/92	9/17/92	1	<1
09038-6	102-3	9/4/92	9/16/92	9/17/92	1	1
09038-10	103-3	9/4/92	9/16/92	9/17/92	1	<1
09038-13	104-3	9/4/92	9/16/92	9/17/92	1	1
09038-16	105-3	9/4/92	9/16/92	9/17/92	1	<1
09038-19	106-3	9/4/92	9/16/92	9/17/92	1	2
09038-22	107-3	9/4/92	9/16/92	9/17/92	1	1
09038-25	108-3	9/4/92	9/16/92	9/17/92	1	2
09038-28	109-3	9/4/92	9/16/92	9/17/92	1	1

a. EPA 600/4-79-020, March 1983 revision.

R0013256

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

ANALYTICAL RESULTS

Metals in Water
Total Threshold Limit Concentration
California Title 22 (C.A.M.)

GTEL Sample Number			Blank	09038-7		
Client Identification			–	102-4		
Date Sampled			–	9/14/92		
Date Analyzed (Method 6010)			9/14/92	9/14/92		
Date Analyzed (Method 7470)			9/17/92	9/17/92		
Analyte	Method[a]	Reporting Limit, mg/L	Concentration, mg/L			
Antimony	EPA 6010	0.04	<0.04	<0.04		
Arsenic	EPA 6010	0.1	<0.1	<0.1		
Barium	EPA 6010	0.02	<0.02	0.13		
Beryllium	EPA 6010	0.01	<0.01	<0.01		
Cadmium	EPA 6010	0.03	<0.03	<0.03		
Chromium	EPA 6010	0.04	<0.04	<0.04		
Cobalt	EPA 6010	0.02	<0.02	<0.02		
Copper	EPA 6010	0.2	<0.2	<0.2		
Lead	EPA 6010	0.1	<0.1	<0.1		
Mercury	EPA 7470	0.001	<0.001	<0.001		
Molybdenum	EPA 6010	0.02	<0.02	<0.02		
Nickel	EPA 6010	0.1	<0.1	<0.1		
Selenium	EPA 6010	0.04	<0.04	<0.04		
Silver	EPA 6010	0.05	<0.05	<0.05		
Thallium	EPA 6010	0.4	<0.4	<0.4		
Vanadium	EPA 6010	0.2	<0.2	<0.2		
Zinc	EPA 6010	0.1	<0.1	<0.1		
EPA 6010: Dilution Multiplier[b]			1	1		
EPA 7470: Dilution Multiplier[b]			1	1		

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Digestion by EPA Method, 3010 (ICP)

b. Indicates the adjustments made for sample dilutions.

R0013257

GTEL ENVIRONMENTAL LABORATORIES, INC.

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

CONFORMANCE/NONCONFORMANCE SUMMARY

Abbreviations:

X = Requirements Met
VOA = Volatiles
* = See Comments
SV = Semi Volatiles
NA = Not Applicable
ND = Not Detected
- = Test Not Required

#	Conformance Item	VOA GC	VOA GC/MS	SV GC	SV GC/MS	Metals	Wet Chem
1	Holding Time	X				X	X
2	Method Accuracy	X				X	X
3	Method Precision	X				X	X
4	Surrogate Recovery	X				NA	NA
5	Blank	ND				X	X

Comments:

R0013258

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

QC Check Sample Results

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[a], %
GC:					
Benzene	Ultra Scientific	9/14/92	150	ug/L	92.0 (81.1-118)
Toluene	Ultra Scientific	9/14/92	150	ug/L	94.0 (79.9-123)
Ethylbenzene	Ultra Scientific	9/14/92	150	ug/L	97.3 (81.1-123)
Xylene, total	Ultra Scientific	9/14/92	450	ug/L	95.8 (82.9-123)
Metals:					
Arsenic	Spex	9/14/92	1.00	mg/L	105 (80-120)
Barium	Spex	9/14/92	1.00	mg/L	101 (80-120)
Cadmium	Spex	9/14/92	1.00	mg/L	104 (80-120)
Chromium	Spex	9/14/92	1.00	mg/L	106 (80-120)
Lead	Spex	9/14/92	1.00	mg/L	107 (80-120)
Mercury	Perkin-Elmer	9/17/92	0.002	mg/L	101 (80-120)
Selenium	Spex	9/14/92	1.00	mg/L	105 (80-120)
Silver	Spex	9/14/92	1.00	mg/L	97.0 (80-120)
Inorganic Chemistry:					
Oil and Grease/IR	J.T. Baker	9/16/92	25.2	mg/L	87.7 (80-120)

a. Acceptability limits are in parentheses.
NA = Not Applicable.

R0013259

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

Matrix Spike and Duplicate Spike Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Amount	Spike Amount	Units	Recovery, %	Duplicate Recovery[a] %	RPD[a], %
GC:								
Benzene	T209038	9/15/92	<0.3	150	ug/L	92.0	86.7 (76.3-110)	5.93 (30)
Toluene	T209038	9/15/92	<0.3	150	ug/L	94.0	88.7 (73-112)	5.80 (30)
Ethylbenzene	T209038	9/15/92	<0.3	150	ug/L	97.3	90.0 (75.1-109)	7.79 (30)
Xylene, total	T209038	9/15/92	<0.6	450	ug/L	95.8	90.7 (78.1-109)	5.47 (30)
Metals:								
Arsenic	T209038	9/14/92	<0.1	2.00	mg/L	102	NA (68.6-112)	NA
Barium	T209038	9/14/92	0.0982	2.00	mg/L	95.6	NA (67.5-110)	NA
Cadmium	T209038	9/14/92	<0.03	2.00	mg/L	99.0	NA (67.2-111)	NA
Chromium	T209038	9/14/92	<0.04	2.00	mg/L	101	NA (66.8-115)	NA
Lead	T209038	9/14/92	<0.1	2.00	mg/L	101	NA (67.1-110)	NA
Mercury	T209038	9/17/92	<0.001	0.002	mg/L	101	NA (64.8-110)	NA
Selenium	T209038	9/14/92	<0.04	2.00	mg/L	101	NA (69.5-111)	NA
Silver	T209038	9/14/92	<0.05	2.00	mg/L	92.0	NA (45.2-110)	NA
Inorganic Chemistry:								
Oil and Grease/IR	T209038	9/16/92	1.92	5.66	mg/L	74.8	NA (64-127)	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013260

GTEL ENVIRONMENTAL LABORATORIES INC

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

Sample and Sample Duplicate Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Results	Sample Duplicate Results	Units	RPD[a], %
Metals:						
Arsenic	T209038-7	9-14-92	<0.1	<0.1	mg/L	NA
Barium	T209038-7	9-14-92	0.129	0.0673	mg/L	NA
Cadmium	T209038-7	9-14-92	<0.03	<0.03	mg/L	NA
Chromium	T209038-7	9-14-92	<0.04	<0.04	mg/L	NA
Lead	T209038-7	9-14-92	<0.1	<0.1	mg/L	NA
Mercury	T209038-7	9-17-93	<0.001	<0.001	mg/L	NA
Selenium	T209038-7	9-14-93	<0.04	<0.04	mg/L	NA
Silver	T209038-7	9-14-93	<0.05	<0.05	mg/L	NA
Inorganic Chemistry:						
Oil and Grease/IR	T209038-22	9-16-93	1.13	1.39	mg/L	NA
Total Suspended Solid	T309038-27	9-15-93	<10	<10	mg/L	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013261

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: 5-6565
Work Order Number: T209038
Report Issue Date: July 1, 1993

Reagent Water Spike Results for Organic Analyses and LCS for Inorganic Analyses[a]

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[b], %
Metals:					
Arsenic	Spex	9/14/92	1.00	mg/L	104 (70-130)
Barium	Spex	9/14/92	1.00	mg/L	97.8 (70-130)
Cadmium	Spex	9/14/92	1.00	mg/L	102 (70-130)
Chromium	Spex	9/14/92	1.00	mg/L	104 (70-130)
Lead	Spex	9/14/92	1.00	mg/L	106 (70-130)
Mercury	Perkin-Elmer	9/17/92	0.002	mg/L	101 (70-130)
Selenium	Spex	9/14/92	1.00	mg/L	103 (70-130)
Silver	Spex	9/14/92	1.00	mg/L	93.4 (70-130)
Inorganic Chemistry:					
Oil and Grease/IR	E.M. Science, J.T. Baker	9/16/92	5.0	mg/L	74.8 (70-130)

a. As required to support method accuracy or precision when matrix spike or RPD are out of control limits.
b. Acceptability limits are in parentheses.
NA Not applicable

R0013262

Do not bill Chevron
Attn: Jacks

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WSPA - STORMWATER RUNOFF
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER LONG BEACH 90831
PROJECT CONTACT (NAME) JOAN NETHERWOOD
(PHONE) 310 495 6360
CHEVRON FACILITY No. J-6565
CHEVRON CONTACT (NAME) Allison Tang
(PHONE) 818 543-5331

LABORATORY NAME GTEL ENVIRON. LABS
CONTRACT NUMBER T-320
COLLECTED BY (NAME) DAVID C. DARROW
(SIGNATURE) David C. Darrow
COLLECTION DATE 9.4.92

CHAIN-OF-CUSTODY RECORD

T2-09-038

6°C

SAMPLE No	LAB No	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS ( )	OTHER EPA 413.2 OIL + GREASE	EPA 160.2 TOTAL SUSPENDED SOLIDS		DETECTION LIMIT	REMARKS
105-1		2		X	X		9.4		X	X	X		X							
105-2		1			X		9.4										X			
105-3		1			X		9.4									X				
106-1		2			X		9.4	12:02	X		X		X							
106-2		1			X		9.4	12:02									X			
106-3		1			X		9.4	12:02								X				
107-1		2			X		9.4	12:24	X		X		X							
107-2		1			X		9.4	12:24									X			
107-3		1			X		9.4	12:24								X				
108-1		2			X		9.4	12:33	X		X		X							
108-2		1			X		9.4	12:33									X			
108-3		1			X		9.4	12:33								X				
109-1		2		R0013263		X	9.4	12:45	X		X		X							

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
David C. Darrow	HART CROWSER	9.4.92 6:38 pm			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS

Deliver to: Aram Terzy

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90633-2833

PROJECT NAME LWSPA STORMWATER Runoff
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 World Trade Center Long Beach 90831
PROJECT CONTACT (NAME) John Wetherwood
(PHONE) 310 495 6360
CHEVRON FACILITY No. J-6565
CHEVRON CONTACT (NAME) Allison Fong
(PHONE) 818 543-5333

LABORATORY NAME GTEL ENV. LABS
CONTRACT NUMBER T320
COLLECTED BY (NAME) DAVID G. DARROW
(SIGNATURE)
COLLECTION DATE 9.4.92

CHAIN-OF-CUSTODY RECORD

T2-09-038

6°C

SAMPLE No	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	ANALYSES TO BE PERFORMED: MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS ( )	OTHER: EPA 413.2 Oil + GREASE	EPA 160.2 TOTAL Suspended Solids	DETECTION LIMIT	REMARKS
109-2		1		X		X	9.4	12:45		X							X		
109-3		1		X		X	9.4	12:45		X									
TRIP BLANK		2		X			9.4			X	X		X			X			

R0013264

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
[signature]	HART CROWSER	9-4-92 6:30 pm			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS
48 HRS 10 DAYS

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Southwest Region
20000 / 300 Mariner Drive
Torrance, CA 90503
(310) 371-1044
(800) 727-GTEL
Fax (310) 371-8720

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

Mr. John Netherwood
Hart Crowser
1 World Trade Center
Long Beach, CA 90831

Dear Mr. Netherwood,

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 9-11-92

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the state of California under Certification #E723.

If you have any questions concerning this analysis or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,

GTEL Environmental Laboratories, Inc.

Minsoon Song
Laboratory Director

cc: Allison Fong

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		Lab Blank	09059-1	09059-4	09059-8
Client Identification		-	301-1	302-1	303-1
Date Sampled		-	9-10-92	9-10-92	9-10-92
Date Analyzed		9-18-92	9-18-92	9-18-92	9-18-92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<0.3	<0.3
Toluene	0.3	<0.3	<0.3	<0.3	<0.3
Ethylbenzene	0.3	<0.3	<0.3	<0.3	<0.3
Xylene, total	0.6	<0.6	<0.6	<0.6	<0.6
BTEX, total	-	-	-	-	-
TPH as Gasoline	100	<100	<100	<100	<100
Dilution Multiplier[b]		-	1	1	1
TFT surrogate[c], % recovery		107	96.5	96.9	95.5

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013266

GTEL ENVIRONMENTAL LABORATORIES, INC

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09059-11	09059-14	09059-17	09059-20
Client Identification		304-1	305-1	306-1	307-1
Date Sampled		9-10-92	9-10-92	9-10-92	9-10-92
Date Analyzed		9-19-92	9-19-92	9-19-92	9-19-92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	1.5	<0.3
Toluene	0.3	<0.3	<0.3	<0.3	<0.3
Ethylbenzene	0.3	<0.3	<0.3	<0.3	<0.3
Xylene, total	0.6	<0.6	<0.6	<0.6	<0.6
BTEX, total	-	-	-	1.5	-
TPH as Gasoline	100	<100	<100	<100	<100
Dilution Multiplier[b]		1	1	1	1
TFT surrogate[c], % recovery		89.5	97.4	95.0	90.6

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013267

GTEL ENVIRONMENTAL LABORATORIES, INC.

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09059-23	09059-26	09059-29	
Client Identification		308-1	309-1	TRIP BLANK	
Date Sampled		9-10-92	9-10-92	9-10-92	
Date Analyzed		9-19-92	9-19-92	9-21-92	
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	0.4	<0.3	
Toluene	0.3	<0.3	<0.3	0.5	
Ethylbenzene	0.3	<0.3	<0.3	<0.3	
Xylene, total	0.6	<0.6	<0.6	<0.6	
BTEX, total	-	-	0.4	0.5	
TPH as Gasoline	100	<100	<100	<100	
Dilution Multiplier[b]		1	1	1	
TFT surrogate[c], % recovery		87.2	96.6	93.6	

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013268

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

ANALYTICAL RESULTS

Total Suspended Solid in Water
Standard Method 209 C[a]

Sample Identification		Date Sampled	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID				
Blank	–	9-10-92	9-21-92	10	<10
09059-2	301-2	9-10-92	9-21-92	10	<10
09059-5	302-2	9-10-92	9-21-92	10	<10
09059-9	303-2	9-10-92	9-21-92	10	<10
09059-12	304-2	9-10-92	9-21-92	10	<10
09059-15	305-3	9-10-92	9-21-92	10	<10
09059-18	306-3	9-10-92	9-21-92	10	<10
09059-21	307-3	9-10-92	9-21-92	10	<10
09059-24	308-3	9-10-92	9-21-92	10	<10
09059-27	309-2	9-10-92	9-21-92	10	<10

a. Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.

R0013269

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

ANALYTICAL RESULTS

Metals in Water
Total Threshold Limit Concentration
California Title 22 (C.A.M.)

GTEL Sample Number			Blank	09059-7		
Client Identification			-	302-4		
Date Sampled			-	9-10-92		
Date Analyzed (Method 6010)			9-14-92	9-14-92		
Date Analyzed (Method 7470)			9-17-92	9-17-92		
Analyte	Method[a]	Reporting Limit, mg/L	Concentration, mg/L			
Antimony	EPA 6010	0.04	<0.04	<0.04		
Arsenic	EPA 6010	0.1	<0.1	<0.1		
Barium	EPA 6010	0.02	<0.02	<0.02		
Beryllium	EPA 6010	0.01	<0.01	<0.01		
Cadmium	EPA 6010	0.03	<0.03	<0.03		
Chromium	EPA 6010	0.04	<0.04	<0.04		
Cobalt	EPA 6010	0.02	<0.02	<0.02		
Copper	EPA 6010	0.2	<0.2	<0.2		
Lead	EPA 6010	0.1	<0.1	<0.1		
Mercury	EPA 7470	0.001	<0.001	<0.001		
Molybdenum	EPA 6010	0.02	<0.02	<0.02		
Nickel	EPA 6010	0.1	<0.1	<0.1		
Selenium	EPA 6010	0.04	<0.04	<0.04		
Silver	EPA 6010	0.05	<0.05	<0.05		
Thallium	EPA 6010	0.4	<0.4	<0.4		
Vanadium	EPA 6010	0.2	<0.2	<0.2		
Zinc	EPA 6010	0.1	<0.1	<0.1		
EPA 6010: Dilution Multiplier[b]			1	1		
EPA 7470: Dilution Multiplier[b]			1	1		

a. Test Methods for Evaluating Solid Waste, SW-846 Third Edition Revision 0, US EPA November 1986. Digestion by EPA Method 3005 (flame), 3010 (ICP) and 3020 (furnace).

b. Indicates the adjustments made for sample dilutions.

R0013270

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

ANALYTICAL RESULTS

Total Recoverable Oil and Grease in Water by Infrared Spectrometry EPA 413.2[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID					
Blank	-	-	9-18-92	9-21-92	1	<1
09059-3	301-3	9-10-92	9-18-92	9-21-92	1	<1
09059-6	302-3	9-10-92	9-18-92	9-21-92	1	<1
09059-10	303-3	9-10-92	9-18-92	9-21-92	1	<1
09059-13	304-3	9-10-92	9-18-92	9-21-92	1	<1
09059-16	305-2	9-10-92	9-18-92	9-21-92	1	<1
09059-19	306-2	9-10-92	9-18-92	9-21-92	1	1
09059-22	307-2	9-10-92	9-18-92	9-21-92	1	<1
09059-25	308-2	9-10-92	9-18-92	9-21-92	1	<1
09059-28	309-3	9-10-92	9-18-92	9-21-92	1	1

a. EPA 600/4-79-020, March 1983 revision.

R0013271

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

CONFORMANCE/NONCONFORMANCE SUMMARY

Abbreviations:

X = Requirements Met
VOA = Volatiles
* = See Comments
SV = Semi Volatiles
NA = Not Applicable
ND = Not Detected
- = Test Not Required

#	Conformance Item	VOA GC	VOA GC/MS	SV GC	SV GC/MS	Metals	Wet Chem
1	Holding Time	X				X	X
2	Method Accuracy	X				X	X
3	Method Precision	X				X	X
4	Surrogate Recovery	X				NA	NA
5	Blank	ND				X	X

Comments:

R0013272

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

QC Check Sample Results

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[a], %
GC:					
Benzene	Ultra Scientific	9-18-92	150	ug/L	117 (81.1-118)
Toluene	Ultra Scientific	9-18-92	150	ug/L	119 (79.9-123)
Ethylbenzene	Ultra Scientific	9-18-92	150	ug/L	115 (81.1-123)
Xylene, total	Ultra Scientific	9-18-92	450	ug/L	121 (82.9-123)
Metals:					
Arsenic	Spex	9-14-92	1.00	mg/L	105 (80-120)
Barium	Spex	9-14-92	1.00	mg/L	101 (80-120)
Cadmium	Spex	9-14-92	1.00	mg/L	104 (80-120)
Chromium	Spex	9-14-92	1.00	mg/L	106 (80-120)
Lead	Spex	9-14-92	1.00	mg/L	107 (80-120)
Mercury	Perkin-Elmer	9-17-92	0.002	mg/L	101 (80-120)
Selenium	Spex	9-14-92	1.00	mg/L	105 (80-120)
Silver	Spex	9-14-92	1.00	mg/L	97.0 (80-120)
Inorganic Chemistry:					
Oil and Grease/IR	J.T. Baker	9-21-92	25.2	mg/L	103 (80-120)

a. Acceptability limits are in parentheses.

R0013273

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

Matrix Spike and Duplicate Spike Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Amount	Spike Amount	Units	Recovery, %	Duplicate Recovery[a] %	RPD[a], %
GC:								
Benzene	T209059	9-19-92	<0.3	150	ug/L	104	102 (76.3-110)	1.94 (30)
Toluene	T209059	9-19-92	<0.3	150	ug/L	106	107 (73-112)	0.935 (30)
Ethylbenzene	T209059	9-19-92	<0.3	150	ug/L	103	104 (75.1-109)	0.962 (30)
Xylene, total	T209059	9-19-92	<0.6	450	ug/L	108	109 (78.1-109)	0.917 (30)
Metals:								
Arsenic	T209038-7	9-14-92	<0.1	2.00	mg/L	102	NA (68.6-112)	NA
Barium	T209038-7	9-14-92	0.0982	2.00	mg/L	95.6	NA (67.5-110)	NA
Cadmium	T209038-7	9-14-92	<0.03	2.00	mg/L	99.0	NA (67.2-111)	NA
Chromium	T209038-7	9-14-92	<0.04	2.00	mg/L	101	NA (66.8-115)	NA
Lead	T209038-7	9-14-92	<0.1	2.00	mg/L	101	NA (67.1-110)	NA
Mercury	T209038-7	9-17-92	<0.001	0.002	mg/L	101	NA (64.8-110)	NA
Selenium	T209038-7	9-14-92	<0.04	2.00	mg/L	101	NA (69.5-111)	NA
Silver	T209038-7	9-14-92	<0.05	2.00	mg/L	92.0	NA (45.2-110)	NA
Inorganic Chemistry:								
Oil and Grease/IR	T209059-3	9-21-92	<1	4.02	mg/L	74.7	NA (64-127)	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013274

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

Sample and Sample Duplicate Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Results	Sample Duplicate Results	Units	RPD[a], %
Metals:						
Arsenic	T209038-7	9-14-92	<0.1	<0.1	mg/L	NA
Barium	T209038-7	9-14-92	0.129	0.0673	mg/L	NA
Cadmium	T209038-7	9-14-92	<0.03	<0.03	mg/L	NA
Chromium	T209038-7	9-14-92	<0.04	<0.04	mg/L	NA
Lead	T209038-7	9-14-92	<0.1	<0.1	mg/L	NA
Mercury	T209038-7	9-17-92	<0.001	<0.001	mg/L	NA
Selenium	T209038-7	9-14-92	<0.04	<0.04	mg/L	NA
Silver	T209038-7	9-14-92	<0.05	<0.05	mg/L	NA
Inorganic Chemistry:						
Oil and Grease/IR	T209059-6	9-21-92	<1	<1	mg/L	NA
Total Suspended Solid	T209059-2	9-21-92	<10	<10	mg/L	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013275

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209059
Report Issue Date: September 23, 1992

Reagent Water Spike Results for Organic Analyses and LCS for Inorganic Analyses[a]

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[b], %
Metals:					
Arsenic	Spex	9-14-92	1.00	mg/L	104 (70-130)
Barium	Spex	9-14-92	1.00	mg/L	97.8 (70-130)
Cadmium	Spex	9-14-92	1.00	mg/L	102 (70-130)
Chromium	Spex	9-14-92	1.00	mg/L	104 (70-130)
Lead	Spex	9-14-92	1.00	mg/L	106 (70-130)
Mercury	Perkin-Elmer	9-17-92	0.002	mg/L	101 (70-130)
Selenium	Spex	9-14-92	1.00	mg/L	103 (70-130)
Silver	Spex	9-14-92	1.00	mg/L	93.4 (70-130)
Organic Lead				mg/L	(70-130)
Inorganic Chemistry:					
Oil and Grease (gravimetric)	E.M. Science, J.T. Baker	9-21-92	5.38	mg/L	87.9 (70-130)

a. As required to support method accuracy or precision when matrix spike or RPD are out of control limits.
b. Acceptability limits are in parentheses.

R0013276

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WEFASTORMWATER RUNOFF
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER
PROJECT CONTACT (NAME) JOHN NETHERWOOD
(PHONE) 3109556210
CHEVRON FACILITY No. 21565
CHEVRON CONTACT (NAME) ALLISON FONG
(PHONE) 415 543-5311

LABORATORY NAME GTEL
CONTRACT NUMBER T370
COLLECTED BY (NAME) DAVID DARLOW
(SIGNATURE)
COLLECTION DATE 10-07-92

CHAIN-OF-CUSTODY RECORD

T2-09-059

SAMPLE No	LAB No	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	ANALYSES TO BE PERFORMED: MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES-BTXE	EPA 602 AROMATIC VOLATILES-BTXE	CCR22 METALS (CAM)	160.2 TDS OTHER SUSPENDED SOLIDS	413.2 OIL + GREASE		DETECTION LIMIT	REMARKS
SD1-1	R0013277	2		X	X		10-7	7:32	X	X	X		X							
SD1-2		1						7:30												
SD1-3		1						7:30								X				
SD2-1		2						7:56	X		X		X			/	X			
SD2-2		1						7:56												
SD2-3		2						7:56								X				
SD2-4		1						7:56									X			
SD3-1		2						7:56	X	X					X					
SD3-2		1						8:11			X		X							
SD3-3		1						8:11								X				
SD4-1		2						8:11									X			
SD4-2		1						8:26	X		X		X							
SD4-3		1						8:26								X				
								8:26									X			

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
[signature]	HART CROWSER	9-10-92 15:9	[signature]	GTEL-LABS	9/10/92 1500
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS
48 HRS (10 DAYS)

CHAIN-OF-CUSTODY RECORD

T209057

CHEVRON USA INC. WTGS
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME USPA STORMWATER RUNOFF
PROJECT I.D. NO.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CTR
PROJECT CONTACT (NAME) JOHN HEMPELMANN
(PHONE) 310 981 1360
CHEVRON FACILITY NO. 96515
CHEVRON CONTACT (NAME) ALISON TANG
(PHONE) 818-543-5333

LABORATORY NAME GTEL
CONTRACT NUMBER T320
COLLECTED BY (NAME) DAVID C. DAPPEN
(SIGNATURE)
COLLECTION DATE 10 SEPTEMBER 1992

SAMPLE No.	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	ANALYSES TO BE PERFORMED: MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS CAM 22	OTHER	DETECTION LIMIT	REMARKS
[illegible]	1	2		X		X	9-10-92	0830	X	X	X		X					
05-1	1	1				X		0830								X		
305-1	1	1				X		0830								X		
306-1	1	2			X			1020	X		X		X			X		
306-2	1	1						1020										
306-3	1	1						1020								X		
307-1	1	2						1036	X		X		X					
307-2	1	1						1035								X		
307-3	1	1						1035										
308-1	1	2						1050	X		X		X					
308-2	1	1						1050								X		
308-3	1	1			X			1050										
309-1	1	2				X		1055	X		X		X					

R0013278

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
	HART CROWSER	9.10.92 1530		GTEL-LABS	9/10/92 1530
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME

TURN AROUND TIME (CIRCLE ONE)
24 HRS 5 DAYS

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WSPA-STORMWATER RUNOFF
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CTR.
PROJECT CONTACT (NAME) JOHN WETHERHOLD
(PHONE) 310 495 6360
CHEVRON FACILITY No. 9565
CHEVRON CONTACT (NAME) RUDY KOLB
(PHONE) 818 543 5733

LABORATORY NAME GTEL
CONTRACT NUMBER 7320
COLLECTED BY (NAME) DAVID E. OBRIEN
(SIGNATURE)
COLLECTION DATE 10 SEPTEMBER 1992

CHAIN-OF-CUSTODY RECORD

7209059

SAMPLE No	LAB No	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARS.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARS.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS	413.2 OTHER OIL & GREASE	TOC & TOTAL SUSPENDED SOLIDS		DETECTION LIMIT	REMARKS
309-2		1		X		X	9-10-92	10:55		X					Pb Zn		X			
309-3		1		X		X		10:55		X						X	X	DUP		
TRIP BLANK		2		X			9-10-92			X	X		X							

R001279

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
[signature]	HART CROWSER	9-10-92 15:00	[signature]	GTEL - Labs	9/10/92 15:00
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS
48 HRS (10 DAYS)

GTEL
ENVIRONMENTAL
LABORATORIES, INC.
Southwest Region
20000 / 300 Mariner Drive
Torrance, CA 90503
(310) 371-1044
(800) 727-GTEL
Fax (310) 371-8720

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

Mr. John Netherwood
Hart Crowser
1 World Trade Center
Long Beach, CA 90831

Dear Mr. Netherwood,

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 9/4/92.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the state of California under Certification #E723.

If you have any questions concerning this analysis or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,

GTEL Environmental Laboratories, Inc.

Minsoon Song
Laboratory Director

cc: Allison Fong

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

ANALYTICAL RESULTS

Total Suspended Solid in Water
Standard Method 209 C[a]

Sample Identification		Date Sampled	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID				
Blank	-	9/3/92	9/15/92	10	<10
09037-2	1-2	9/3/92	9/15/92	10	11
09037-5	2-2	9/3/92	9/15/92	10	13
09037-9	3-2	9/3/92	9/15/92	10	<10
09037-12	4-2	9/3/92	9/15/92	10	<10
09037-15	5-2	9/3/92	9/15/92	10	<10
09037-18	6-2	9/3/92	9/15/92	10	<10
09037-21	7-2	9/3/92	9/15/92	10	<10
09037-24	8-2	9/3/92	9/15/92	10	<10
09037-27	9-2	9/3/92	9/15/92	10	<10

a. Standard Methods for the Examination of Water and Wastewater, 18th Edition, 1985.

R0013281

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

ANALYTICAL RESULTS

Metals in Water
Total Threshold Limit Concentration
California Title 22 (C.A.M.)

GTEL Sample Number			Blank	09037-07		
Client Identification			–	2-4		
Date Sampled			–	9/3/92		
Date Analyzed (Method 6010)			9/14/92	9/14/92		
Date Analyzed (Method 7470)			9/17/92	9/17/92		
Analyte	Method[a]	Reporting Limit, mg/L	Concentration, mg/L			
Antimony	EPA 6010	0.04	<0.04	<0.04		
Arsenic	EPA 6010	0.1	<0.1	<0.1		
Barium	EPA 6010	0.02	<0.02	0.06		
Beryllium	EPA 6010	0.01	<0.01	<0.01		
Cadmium	EPA 6010	0.03	<0.03	<0.03		
Chromium	EPA 6010	0.04	<0.04	<0.04		
Cobalt	EPA 6010	0.02	<0.02	<0.02		
Copper	EPA 6010	0.2	<0.2	<0.2		
Lead	EPA 6010	0.1	<0.1	<0.1		
Mercury	EPA 7470	0.001	<0.001	<0.001		
Molybdenum	EPA 6010	0.02	<0.02	<0.02		
Nickel	EPA 6010	0.1	<0.1	<0.1		
Selenium	EPA 6010	0.04	<0.04	<0.04		
Silver	EPA 6010	0.05	<0.05	<0.05		
Thallium	EPA 6010	0.4	<0.4	<0.4		
Vanadium	EPA 6010	0.2	<0.2	<0.2		
Zinc	EPA 6010	0.1	<0.1	0.2		
EPA 6010: Dilution Multiplier[b]			1	1		
EPA 7470: Dilution Multiplier[b]			1	1		

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Digestion by EPA Method, 3010 (ICP)

b. Indicates the adjustments made for sample dilutions.

R0013282

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

ANALYTICAL RESULTS

Total Recoverable Oil and Grease in Water by Infrared Spectrometry EPA 413.2[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID					
Blank	–	9/10/92	9/10/92	9/10/92	1	<1
09037-3	1-3	9/3/92	9/10/92	9/10/92	1	<1
09037-6	2-3	9/3/92	9/10/92	9/10/92	1	8
09037-10	3-3	9/3/92	9/10/92	9/10/92	1	3
09037-13	4-3	9/3/92	9/10/92	9/10/92	1	2
09037-16	5-3	9/3/92	9/10/92	9/10/92	1	3
09037-19	6-3	9/3/92	9/10/92	9/10/92	1	1
09037-22	7-3	9/3/92	9/10/92	9/10/92	1	<1
09037-25	8-3	9/3/92	9/10/92	9/10/92	1	1
09037-28	9-3	9/3/92	9/10/92	9/10/92	1	<1

a. EPA 600/4-79-020, March 1983 revision

R0013283

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		Lab Blank	09037-1A	09037-4A*	09037-8A
Client Identification		–	1-1	2-1	3-1
Date Sampled		–	9/3/92	9/3/92	9/3/92
Date Analyzed		9/11/92	9/11/92	9/12/92	9/11/92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<3.0	<0.3
Toluene	0.3	<0.3	<0.3	7.9	<0.3
Ethylbenzene	0.3	<0.3	<0.3	<3.0	<0.3
Xylene, total	0.6	<0.6	1.5	20	<0.6
BTEX, total	–	–	1.5	28	–
TPH as Gasoline	100	<100	<100	<1000	<100
Dilution Multiplier[b]		1	1	10	1
TFT surrogate[c], % recovery		100	89.5	78.8	90.6

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

* Detection limit increased due to matrix effect (foaming).

R0013284

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09037-11A	09037-14A	09037-17A*	09037-20A*
Client Identification		4-1	5-1	6-1	7-1
Date Sampled		9/3/92	9/3/92	9/3/92	9/3/92
Date Analyzed		9/11/92	9/11/92	9/15/92	9/15/92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<3.0	<3.0
Toluene	0.3	0.4	0.3	<3.0	<3.0
Ethylbenzene	0.3	<0.3	<0.3	<3.0	<3.0
Xylene, total	0.6	1.1	1.1	<6.0	<6.0
BTEX, total	-	1.5	1.4	-	-
TPH as Gasoline	100	<100	<100	<1000	<1000
Dilution Multiplier[b]		1	1	10	10
TFT surrogate[c] % recovery		76.2	97.3	100	77.1

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

* Detection limit increased due to matrix effect (foaming).

R0013285

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09037-23A	09037-26A	09037-29A	
Client Identification		8-1	9-1	TRIP BLANK	
Date Sampled		9/3/92	9/3/92	9/3/92	
Date Analyzed		9/12/92	9/12/92	9/11/92	
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	0.5	<0.3	<0.3	
Toluene	0.3	4.5	0.8	<0.3	
Ethylbenzene	0.3	1.1	<0.3	<0.3	
Xylene, total	0.6	12	3.4	<0.6	
BTEX, total	-	18	4.2	-	
TPH as Gasoline	100	<100	<100	<100	
Dilution Multiplier[b]		1	1	1	
TFT surrogate[c], % recovery		84.4	93.4	85.4	

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013286

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

CONFORMANCE/NONCONFORMANCE SUMMARY

Abbreviations:

X = Requirements Met
VOA = Volatiles
* = See Comments
SV = Semi Volatiles
NA = Not Applicable
ND = Not Detected
- = Test Not Required

#	Conformance Item	VOA GC	VOA GC/MS	SV GC	SV GC/MS	Metals	Wet Chem
1	Holding Time	X				X	X
2	Method Accuracy	X				X	X
3	Method Precision	X				X	X
4	Surrogate Recovery	X				NA	NA
5	Blank	ND				X	X

Comments:

R0013287

GTEL ENVIRONMENTAL LABORATORIES INC

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

QC Check Sample Results

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[a], %
GC:					
Benzene	Ultra Scientific	9/11/92	150	ug/L	99.3 (81.1-118)
Toluene	Ultra Scientific	9/11/92	150	ug/L	111 (79.9-123)
Ethylbenzene	Ultra Scientific	9/11/92	150	ug/L	107 (81.1-123)
Xylene, total	Ultra Scientific	9/11/92	450	ug/L	119 (82.9-123)
Metals:					
Arsenic	Spex	9/14/92	1.00	mg/L	105 (80-120)
Barium	Spex	9/14/92	1.00	mg/L	101 (80-120)
Cadmium	Spex	9/14/92	1.00	mg/L	104 (80-120)
Chromium	Spex	9/14/92	1.00	mg/L	106 (80-120)
Lead	Spex	9/14/92	1.00	mg/L	107 (80-120)
Mercury	Perkin-Elmer	9/17/92	0.002	mg/L	101 (80-120)
Selenium	Spex	9/14/92	1.00	mg/L	105 (80-120)
Silver	Spex	9/14/92	1.00	mg/L	97.0 (80-120)
Inorganic Chemistry:					
Oil and Grease/IR	J.T. Baker	9/10/92	25.5	mg/L	102 (80-120)

a. Acceptability limits are in parentheses.
NA = Not Applicable.
* Indicates absolute difference.

R0013288

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

Matrix Spike and Duplicate Spike Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Amount	Spike Amount	Units	Recovery, %	Duplicate Recovery[a] %	RPD[a], %
GC:								
Benzene	T209037	9/11/92	<0.3	150	ug/L	99.3	82.7 (76.3-110)	18.2 (30)
Toluene	T209037	9/11/92	<0.3	150	ug/L	111	88.0 (73-112)	23.1 (30)
Ethylbenzene	T209037	9/11/92	<0.3	150	ug/L	107	86.7 (75.1-109)	21.0 (30)
Xylene, total	T209037	9/11/92	<0.3	450	ug/L	119	93.8 (78.1-109)	23.7 (30)
Metals:								
Arsenic	T209038	9/14/92	<0.1	2.00	mg/L	102	NA (68.6-112)	NA
Barium	T209038	9/14/92	0.0982	2.00	mg/L	95.6	NA (67.5-110)	NA
Cadmium	T209038	9/14/92	<0.03	2.00	mg/L	99.0	NA (67.2-111)	NA
Chromium	T209038	9/14/92	<0.04	2.00	mg/L	101	NA (66.8-115)	NA
Lead	T209038	9/14/92	<0.1	2.00	mg/L	101	NA (67.1-110)	NA
Mercury	T209038	9/17/92	<0.001	0.002	mg/L	101	NA (64.8-110)	NA
Selenium	T209038	9/14/92	<0.04	2.00	mg/L	101	NA (69.5-111)	NA
Silver	T209038	9/14/92	<0.05	2.00	mg/L	92.0	NA (45.2-110)	NA
Inorganic Chemistry:								
Oil and Grease/IR	09037-3	9/10/92	<1	4.78	mg/L	124	NA (64-127)	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013289

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

Sample and Sample Duplicate Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Results	Sample Duplicate Results	Units	RPD[a], %
Metals:						
Arsenic	T209038	9/14/92	<0.1	<0.1	mg/L	NA
Barium	T209038	9/14/92	0.129	0.0673	mg/L	NA
Cadmium	T209038	9/14/92	<0.03	<0.03	mg/L	NA
Chromium	T209038	9/14/92	<0.04	<0.04	mg/L	NA
Lead	T209038	9/14/92	<0.1	<0.1	mg/L	NA
Mercury	T209038	9/17/92	<0.001	<0.001	mg/L	NA
Selenium	T209038	9/14/92	<0.04	<0.04	mg/L	NA
Silver	T209038	9/14/92	<0.05	<0.05	mg/L	NA
Inorganic Chemistry:						
Oil and Grease/IR	T209037	9/10/92	<1	1.3	mg/L	NA
Total Suspended Solid	T209037	9/15/92	<10	<10	mg/L	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013290

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209037
Report Issue Date: September 22, 1992

Reagent Water Spike Results for Organic Analyses and LCS for Inorganic Analyses[a]

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[b], %
Metals:					
Arsenic	Spex	9/14/92	1.00	mg/L	104 (70-130)
Barium	Spex	9/14/92	1.00	mg/L	97.8 (70-130)
Cadmium	Spex	9/14/92	1.00	mg/L	102 (70-130)
Chromium	Spex	9/14/92	1.00	mg/L	104 (70-130)
Lead	Spex	9/14/92	1.00	mg/L	106 (70-130)
Mercury	Perkin-Elmer	9/17/92	0.002	mg/L	101 (70-130)
Selenium	Spex	9/17/92	1.00	mg/L	103 (70-130)
Silver	Spex	9/17/92	1.00	mg/L	93.4 (70-130)
Inorganic Chemistry:					
Oil and Grease/IR	E.M. Science, J.T. Baker	9/10/92	4.78	mg/L	83.3 (70-130)

a. As required to support method accuracy or precision when matrix spike or RPD are out of control limits.
b. Acceptability limits are in parentheses.
NA Not applicable

R0013291

CHAIN-OF-CUSTODY RECORD

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WSPA STORMWATER RUNOFF
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER, Long Beach 90831
PROJECT CONTACT (NAME) JOHN NETTLEWOOD
(PHONE) (310) 495 6360
CHEVRON FACILITY No. T-6565
CHEVRON CONTACT (NAME) Allison Rains
(PHONE) 818 543 5333

LABORATORY NAME GTEL Environ. Labs
CONTRACT NUMBER T320
COLLECTED BY (NAME) David C. Darrow
(SIGNATURE)
COLLECTION DATE 9.3.92

T2-09-037
7°C
Quote T320

SAMPLE No	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS	EPA 8240 OTHER OIL+GREASE 413.2	EPA 1601,2 TOTAL 3 vs POINTED SAMPLE	CCR TITLE 22 Cam 22	DETECTION LIMIT	REMARKS
1-1	R0013292	1		X	X		9.3.92	11:30	X	X	X		X							
1-2		1		X	X		9.3.92	11:30		X							X			
1-3		1		X	X		9.3.92	11:30		X						X				
2-1		1		X	X		9.3.92	12:06	X	X	X		X							
2-2		1		X	X		9.3.92	12:06		X	~~X~~ DUP		~~X~~ DUP				X			
2-3		1		X	X		9.3.92	12:06		X						X				
2-4		1		X	X		9.3.92	12:06	X	X								X		
3-1		1		X	X		9.3.92	12:22	X	X	X		X							
3-2		1		X	X		9.3.92	12:22		X							X			
3-3		1		X	X		9.3.92	12:22		X						X				
4-1		1		X	X		9.3.92	12:38	X	X	X		X							
4-2		1		X	X		9.3.92	12:38		X							X			
4-3		1		X	X		9.3.92	12:38		X						X				

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
	HART CROWSER	9.4.92 6:00			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS
48 HRS (10 DAYS)

CHAIN-OF-CUSTODY RECORD

T2-09-031

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME USPA STORMWATER RUNOFF
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER
PROJECT CONTACT (NAME) JOHN NETHERWOOD
(PHONE) 310 495 6360
CHEVRON FACILITY No. 9-6585
CHEVRON CONTACT (NAME) Allice Fong
(PHONE) 818 543 5337

LABORATORY NAME GTEL ENVIRON. LABS
CONTRACT NUMBER T-320
COLLECTED BY (NAME) DAVID C. DARROW
(SIGNATURE)
COLLECTION DATE 9.3.92

7°C

SAMPLE No	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS	OTHER EPA 413.2 OIL & GREASE	EPA 160.2 TOTAL SUSPENDED SOLIDS		DETECTION LIMIT	REMARKS
5-1	R0013293	1		X		X	9-3-92	12:44		X										
5-2		1				X	9-3-92	12:44		X	X		X							
5-3		1				X	9-3-92	12:44		X							X			
6-1		1			X		9-3-92	2:55	X	X						X				
6-2		1			X		9-3-92	2:55		X	X		X							
6-3		1			X		9-3-92	2:55		X							X			
7-1		1			X		9-3-92	3:11	X	X						X				
7-2		1			X		9-3-92	3:11		X	X		X							
7-3		1			X		9-3-92	3:11		X							X			
8-1		1			X		9-3-92	3:25	X	X						X				
8-2		1			X		9-3-92	3:25		X	X		X							
8-3		1			X		9-3-92	3:25		X							X			
9-1		1				X	9-3-92	3:42	X	X	X		X			X				

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
	HART CROWSER	9-4-92 1:00p			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS
48 HRS (10 DAYS)

Dominic Di Toro
Manhattan College

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WSPA STORMWATER RUNOFF
PROJECT I.D. No.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER
PROJECT CONTACT (NAME) JOHN NETHERWOOD
(PHONE) 213 495 6366
CHEVRON FACILITY No. J-6565
CHEVRON CONTACT (NAME) Allison Fong
(PHONE) 818 973 3333

LABORATORY NAME GTEL ENVIRON. LABS
CONTRACT NUMBER T-320
COLLECTED BY (NAME) DAVID C. DARROW
(SIGNATURE) David C. Darrow
COLLECTION DATE 9.3.92

CHAIN-OF-CUSTODY RECORD

92-09-037

7°C

SAMPLE No	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS ( )	OTHER EPA 413.2 Oil & Grease	EPA 160.2 Total Dissolved Solids		DETECTION LIMIT	REMARKS
92		1		X		X	9.3.92	3:42		X							X			
93		1		X		X	9.3.92	3:42		X						X				
TRIP BLANK		2		X			9.3.92			X	X		X							

R001294

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
D. T. D.	HART CROWSER	9.4.92 6:00 pm			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME

TURN AROUND TIME (CIRCLE CHOICE)
24 HRS 5 DAYS
48 HRS (10 DAYS)

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Southwest Region
20000 / 300 Manner Drive
Torrance, CA 90503
(310) 371-1044
(800) 727-GTEL
Fax (310) 371-8720

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

Mr. John Netherwood
Hart Crowser
1 World Trade Center
Long Beach, CA 90831

Dear Mr. Netherwood,

Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 9-10-92.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the state of California under Certification #E723.

If you have any questions concerning this analysis or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,

GTEL Environmental Laboratories, Inc.

Minsoon Song
Laboratory Director

cc: Allison Fong

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		Lab Blank	09058-1	09058-4	09058-8
Client Identification		–	201-1	202-1	203-1
Date Sampled		–	9-9-92	9-9-92	9-9-92
Date Analyzed		9-18-92	9-19-92	9-19-92	9-19-92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<0.3	<0.3
Toluene	0.3	<0.3	0.3	<0.3	<0.3
Ethylbenzene	0.3	<0.3	<0.3	<0.3	<0.3
Xylene, total	0.6	<0.6	7.1	<0.6	<0.6
BTEX, total	–	–	7.4	–	–
TPH as Gasoline	100	<100	<100	<100	<100
Dilution Multiplier[b]		–	1	1	1
TFT surrogate[c], % recovery		107	94.6	85.6	90.4

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013296

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09058-11	09058-14	09058-17*	09058-20
Client Identification		204-1	205-1	206-1	207-1
Date Sampled		9-9-92	9-9-92	9-9-92	9-9-92
Date Analyzed		9-19-92	9-19-92	9-21-92	9-18-92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<3.0	<0.3
Toluene	0.3	0.4	<0.3	<3.0	<0.3
Ethylbenzene	0.3	<0.3	<0.3	<3.0	<0.3
Xylene, total	0.6	1.5	1.4	<6.0	<0.6
BTEX, total	–	1.9	1.4	–	–
TPH as Gasoline	100	<100	<100	<1000	<100
Dilution Multiplier[b]		1	1	10	1
TFT surrogate[c], % recovery		90.9	91.8	85.5	100

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

*. Detection limit was increased due to matrix effect (foaming).

R0013297

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09058-23	09058-26	09058-29	
Client Identification		208-1	209-1	TRIP BLANK	
Date Sampled		9-9-92	9-9-92	9-10-92	
Date Analyzed		9-18-92	9-18-92	9-23-92	
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<0.3	
Toluene	0.3	<0.3	<0.3	0.7	
Ethylbenzene	0.3	<0.3	<0.3	<0.3	
Xylene, total	0.6	<0.6	<0.6	<0.6	
BTEX, total	-	-	-	0.7	
TPH as Gasoline	100	<100	130	<100	
Dilution Multiplier[b]		1	1	1	
TFT surrogate[c], % recovery		95.0	90.7	99.8	

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

R0013298

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

ANALYTICAL RESULTS

Metals in Water
Total Threshold Limit Concentration
California Title 22 (C.A.M.)

GTEL Sample Number			Blank	09056-7		
Client Identification			-	202-4		
Date Sampled			-	9-9-92		
Date Analyzed (Method 6010)			9-14-92	9-14-92		
Date Analyzed (Method 7470)			9-17-92	9-17-92		
Analyte	Method[a]	Reporting Limit, mg/L	Concentration, mg/L			
Antimony	EPA 6010	0.04	<0.04	<0.04		
Arsenic	EPA 6010	0.1	<0.1	<0.1		
Barium	EPA 6010	0.02	<0.02	0.06		
Beryllium	EPA 6010	0.01	<0.01	<0.01		
Cadmium	EPA 6010	0.03	<0.03	<0.03		
Chromium	EPA 6010	0.04	<0.04	<0.04		
Cobalt	EPA 6010	0.02	<0.02	<0.02		
Copper	EPA 6010	0.2	<0.2	<0.2		
Lead	EPA 6010	0.1	<0.1	<0.1		
Mercury	EPA 7470	0.001	<0.001	<0.001		
Molybdenum	EPA 6010	0.02	<0.02	<0.02		
Nickel	EPA 6010	0.1	<0.1	<0.1		
Selenium	EPA 6010	0.04	<0.04	<0.04		
Silver	EPA 6010	0.05	<0.05	<0.05		
Thallium	EPA 6010	0.4	<0.4	<0.4		
Vanadium	EPA 6010	0.2	<0.2	<0.2		
Zinc	EPA 6010	0.1	<0.1	0.2		
EPA 6010: Dilution Multiplier[b]			1	1		
EPA 7470: Dilution Multiplier[b]			1	1		

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Digestion by EPA Method 3010 (ICP).

b. Indicates the adjustments made for sample dilutions.

R0013299

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

ANALYTICAL RESULTS

Total Recoverable Oil and Grease in Water by Infrared Spectrometry EPA 413.2[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID					
Blank	-	9-9-92	9-18-92	9-18-92	1	1
09058-3	201-3	9-9-92	9-18-92	9-18-92	1	15
09058-6	202-3	9-9-92	9-18-92	9-18-92	1	4
09058-10	203-3	9-9-92	9-18-92	9-18-92	1	2
09058-13	204-3	9-9-92	9-18-92	9-18-92	1	8
09058-16	205-3	9-9-92	9-18-92	9-18-92	1	1
09058-19	206-3	9-9-92	9-18-92	9-18-92	1	2
09058-22	207-3	9-9-92	9-18-92	9-18-92	1	1
09058-25	208-3	9-9-92	9-18-92	9-18-92	1	<1
09058-27	209-2	9-10-92	9-18-92	9-18-92	1	<1

a. EPA 600/4-79-020, March 1983 revision.

R0013300

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

ANALYTICAL RESULTS

Total Suspended Solid in Water
Standard Method 209 C[a]

Sample Identification		Date Sampled	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID				
Blank	-	9-9-92	9-21-92	10	<10
09058-2	201-2	9-9-92	9-21-92	10	14
09058-5	202-2	9-9-92	9-21-92	10	<10
09058-9	203-2	9-9-92	9-21-92	10	<10
09058-12	204-2	9-9-92	9-21-92	10	<10
09058-15	205-2	9-9-92	9-21-92	10	13
09058-18	206-2	9-9-92	9-21-92	10	11
09058-21	207-2	9-9-92	9-21-92	10	10
09058-24	208-2	9-9-92	9-21-92	10	12
09058-28	209-3	9-10-92	9-21-92	10	<10

a. Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.

R0013301

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

CONFORMANCE/NONCONFORMANCE SUMMARY

Abbreviations:

X = Requirements Met
VOA = Volatiles
* = See Comments
SV = Semi Volatiles
NA = Not Applicable
ND = Not Detected
- = Test Not Required

#	Conformance Item	VOA GC	VOA GC/MS	SV GC	SV GC/MS	Metals	Wet Chem
1	Holding Time	X				X	X
2	Method Accuracy	X				X	X
3	Method Precision	X				X	X
4	Surrogate Recovery	X				NA	NA
5	Blank	ND				X	X

Comments:

R0013302

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

QC Check Sample Results

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[a], %
GC:					
Benzene	Ultra Scientific	9-18-92	150	ug/L	117 (81.1-118)
Toluene	Ultra Scientific	9-18-92	150	ug/L	119 (79.9-123)
Ethylbenzene	Ultra Scientific	9-18-92	150	ug/L	115 (81.1-123)
Xylene, total	Ultra Scientific	9-18-92	450	ug/L	121 (82.9-123)
Metals:					
Arsenic	Spex	9-14-92	1.00	mg/L	105 (80-120)
Barium	Spex	9-14-92	1.00	mg/L	101 (80-120)
Cadmium	Spex	9-14-92	1.00	mg/L	104 (80-120)
Chromium	Spex	9-14-92	1.00	mg/L	106 (80-120)
Lead	Spex	9-14-92	1.00	mg/L	107 (80-120)
Mercury	Perkin-Elmer	9-17-92	0.002	mg/L	101 (80-120)
Selenium	Spex	9-14-92	1.00	mg/L	105 (80-120)
Silver	Spex	9-14-92	1.00	mg/L	97.0 (80-120)
Inorganic Chemistry:					
Oil and Grease/IR	J.T. Baker	9-18-92	25.2	mg/L	88.9 (80-120)

a. Acceptability limits are in parentheses.

R0013303

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

Matrix Spike and Duplicate Spike Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Amount	Spike Amount	Units	Recovery, %	Duplicate Recovery[a] %	RPD[a], %
GC:								
Benzene	T209119	9-19-92	<0.3	150	ug/L	104	102 (76.3-110)	1.94 (30)
Toluene	T209119	9-19-92	<0.3	150	ug/L	106	107 (73-112)	0.935 (30)
Ethylbenzene	T209119	9-19-92	<0.3	150	ug/L	103	104 (75.1-109)	0.962 (30)
Xylene, total	T209119	9-19-92	<0.6	450	ug/L	108	109 (78.1-109)	0.917 (30)
Metals:								
Arsenic	T209038-7	9-14-92	<0.1	2.00	mg/L	102	NA (68.6-112)	NA
Barium	T209038-7	9-14-92	0.0982	2.00	mg/L	95.6	NA (67.5-110)	NA
Cadmium	T209038-7	9-14-92	<0.03	2.00	mg/L	99.0	NA (67.2-111)	NA
Chromium	T209038-7	9-14-92	<0.04	2.00	mg/L	101	NA (66.8-115)	NA
Lead	T209038-7	9-14-92	<0.1	2.00	mg/L	101	NA (67.1-110)	NA
Mercury	T209038-7	9-17-92	<0.001	0.002	mg/L	101	NA (64.8-110)	NA
Selenium	T209038-7	9-14-92	<0.04	2.00	mg/L	101	NA (69.5-111)	NA
Silver	T209038-7	9-14-92	<0.05	2.00	mg/L	92.0	NA (45.2-110)	NA
Inorganic Chemistry:								
Oil and Grease/IR	T209058-25	9-18-92	1.27	4.42	mg/L	87.1	NA (64-127)	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013304

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

Sample and Sample Duplicate Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Results	Sample Duplicate Results	Units	RPD[a], %
Metals:						
Arsenic	T209038-7	9-14-92	<0.1	<0.1	mg/L	NA
Barium	T209038-7	9-14-92	0.129	0.0673	mg/L	NA
Cadmium	T209038-7	9-14-92	<0.03	<0.03	mg/L	NA
Chromium	T209038-7	9-14-92	<0.04	<0.04	mg/L	NA
Lead	T209038-7	9-14-92	<0.1	<0.1	mg/L	NA
Mercury	T209038-7	9-17-92	<0.001	<0.001	mg/L	NA
Selenium	T209038-7	9-14-92	<0.04	<0.04	mg/L	NA
Silver	T209038-7	9-14-92	<0.05	<0.05	mg/L	NA
Inorganic Chemistry:						
Oil and Grease/IR	T209058-22	9-18-92	1.52	1.84	mg/L	NA
Total Suspended Solid	T209058-2	9-21-92	<10	<10	mg/L	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013305

GTEL Client Number: WSP01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209058
Report Issue Date: September 25, 1992

Reagent Water Spike Results for Organic Analyses and LCS for Inorganic Analyses[a]

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[b], %
Metals:					
Arsenic	Spex	9-14-92	1.00	mg/L	104 (70-130)
Barium	Spex	9-14-92	1.00	mg/L	97.8 (70-130)
Cadmium	Spex	9-14-92	1.00	mg/L	102 (70-130)
Chromium	Spex	9-14-92	1.00	mg/L	104 (70-130)
Lead	Spex	9-14-92	1.00	mg/L	106 (70-130)
Mercury	Perkin Elmer	9-17-92	0.002	mg/L	101 (70-130)
Selenium	Spex	9-14-92	1.00	mg/L	103 (70-130)
Silver	Spex	9-14-92	1.00	mg/L	93.4 (70-130)
Inorganic Chemistry:					
Oil and Grease/IR	E.M. Science, J.T. Baker	9-18-92	4.42	mg/L	95.5 (70-130)

a. As required to support method accuracy or precision when matrix spike or RPD are out of control limits.
b. Acceptability limits are in parentheses.
NA Not applicable.

R0013306

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WSPA STORMWATER RUNOFF
PROJECT I.D. NO.
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER
PROJECT CONTACT (NAME) JOHN NETHERWOOD
(PHONE) 310 495 6360
CHEVRON FACILITY NO. J-6565
CHEVRON CONTACT (NAME) Allison Fong
(PHONE) 818 543 5333

LABORATORY NAME GTEL ENVIRONMENTAL LABORATORIES
CONTRACT NUMBER T320
COLLECTED BY (NAME) DAVID C. DARROW
(SIGNATURE)
COLLECTION DATE 9 SEPTEMBER 1992

CHAIN-OF-CUSTODY RECORD

T2-09-058

Quote T320

SAMPLE No	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	ANALYSES TO BE PERFORMED: MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS (Cam 22)	OTHER 413.2 OIL+GREASE	160.2 TOTAL SUSPENDED SOLIDS	DETECTION LIMIT	REMARKS
201-1	1	2		X	X		9.9.92	9:30	X	X	X		X						
201-2	2	1						9:30									X		
201-3	3	1						9:30								X			
202-1	4	2						9:55	X		X		X						
202-2	5	1						9:55									X		
202-3	6	2						9:55								X			
202-4	7	1						9:55	X						X				
203-1	8	2						10:10	X		X		X						
203-2	9	1						10:10									X		
203-3	10	1						10:10								X			
204-1	11	2						10:25	X		X		X						
204-2	12	1						10:25									X		
204-3	13	1						10:25								X			

R0013307

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
David C. Darrow	HART CROWSER	9.10.92 15:00	Michael Rose	GTEL-Labs	9/10/92 15:00
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME

TURN AROUND TIME (CIRCLE ONE)
24 HRS 5 DAYS
48 HRS 10 DAYS

CHAIN-OF-CUSTODY RECORD

CHEVRON USA Inc.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME: WSPA STORMWATER RUNOFF
PROJECT I.D. NO.:
CONSULTANT NAME: HART CROWSER
ADDRESS: 1 WORLD TRADE CENTER
PROJECT CONTACT (NAME): JOHN NETHERWOOD
(PHONE): 310 495 6360
CHEVRON FACILITY NO.: J-6565
CHEVRON CONTACT (NAME): Allison Fong
(PHONE): 818 543 5333

LABORATORY NAME: GTEL ENVIRON. LABS
CONTRACT NUMBER: T320
COLLECTED BY (NAME): DAVID C. DARROW
(SIGNATURE): David C Darrow
COLLECTION DATE: 9 SEPTEMBER 1992

ANALYSES TO BE PERFORMED

SAMPLE No	LAB No	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	CCR 22 METALS (Cam)	413.2 OTHER OIL & GREASE	160.2 TOTAL SUSPENDED SOLIDS		DETECTION LIMIT
205-1	14	2		X		X	9/9/92	10:30	X	X	X	X	X						
205-2	15	1				X		10:30									X		
205-3	16	1				X		10:30								X			
206-1	17	2			X			12:25	X		X	X	X						
206-2	18	1						12:25									X		
206-3	19	1						12:25								X			
207-1	20	2						12:40	X		X	X	+						
207-2	21	1						12:40									+		
207-3	22	1						12:40								X			
208-1	03	2						12:50	+		X	X	X						
208-2	24	1						12:50									X		
208-3	25	1			X			12:50								+			
209-1	26	2				X		12:55	+		+	X	X						

R0013308

REMARKS: Quote T320

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
David C. Darrow	HART CROWSER	9/10/92 15:10		GTEL-lox	9/10/92 15:10
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME 15:10

TURN AROUND TIME (CIRCLE ONE)
24 HRS 5 DAYS
48 HRS 10 DAYS

CHAIN-OF-CUSTODY RECORD

CHEVRON USA INC
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME: WSPA STORMWATER RUNOFF
PROJECT I.D. NO.:
CONSULTANT NAME: HART CROWSER
ADDRESS: 1 WORLD TRADE CENTER
PROJECT CONTACT (NAME): JOHN NETTERWOOD
(PHONE): (310) 415-6360
CHEVRON FACILITY NO.: 1-1525
CHEVRON CONTACT (NAME): ALLISON FOX
(PHONE): 818-543-5333

LABORATORY NAME: GTEL
CONTRACT NUMBER: T320
COLLECTED BY (NAME): DAVID C. OPPROW
(SIGNATURE):
COLLECTION DATE: 9 SEPTEMBER 1992

ANALYSES TO BE PERFORMED

SAMPLE No.	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME	ACID/FIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS ( )	OTHER 413.2 Chlorine	TOTAL SVOP. SOLID LIST 2		DETECTION LIMIT
209-2	27	1		X		X	9-10-92	13:35		X						X			
209-3	28	1		X		X	9-10-92	18:35		X							X		
TRIP BLANK	29	2		X			9/10/92			X	X		X						

Quote T320

REMARKS

R0013309

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME	TURN AROUND TIME (CIRCLE ONE)
[signature]	HART CROWSER	9.10.92 15:00	[signature]	GTEL-Labs	9/10/92 15:00	24 HRS 5 DAYS
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME	48 HRS 10 DAYS
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME	

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Southwest Region
20000 / 300 Manner Drive
Torrance, CA 90503
(213) 371-1044
(800) 727-GTEL
Fax (213) 371-8720

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

Mr. John Netherwood
Hart Crowser
1 World Trade Center
Long Beach, CA 90831-2300

Dear Mr. Netherwood,

This report replaces the previous report issued on 10-2-92 due to a typographical error in the dilution multiplier on page 2. Enclosed please find the analytical results for the samples received by GTEL Environmental Laboratories, Inc. on 9-18-92.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria unless otherwise stated in the footnotes.

GTEL is certified by the state of California under Certification #E723.

If you have any questions concerning this analysis or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,

GTEL Environmental Laboratories, Inc.

Minsoon Song
Laboratory Director

cc: Allison Fong

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		Lab Blank	09137-1	09137-4*	09137-8*
Client Identification		–	401-1	402-1	403-1
Date Sampled		–	9-17-92	9-17-92	9-17-92
Date Analyzed		9-24-92	9-24-92	9-24-92	9-24-92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	<0.3	<3.0	<3.0
Toluene	0.3	<0.3	<0.3	9.5	14
Ethylbenzene	0.3	<0.3	<0.3	<3.0	5.0
Xylene, total	0.6	<0.6	<0.6	19	37
BTEX, total	–	–	–	29	56
TPH as Gasoline	100	<100	<100	<1000	<1000
Dilution Multiplier[b]		1	1	10	10
TFT surrogate[c], % recovery		100	99.6	94.7	97.1

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

* Detection limit increased due to matrix effect (foaming)

R0013311

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09137-11	09137-14*	09137-17*	09137-20*
Client Identification		404-1	405-1	406-1	407-1
Date Sampled		9-17-92	9-17-92	9-17-92	9-17-92
Date Analyzed		9-24-92	9-24-92	9-24-92	9-24-92
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	1.0	<3.0	<7.5	<3.0
Toluene	0.3	13	9.5	<7.5	<3.0
Ethylbenzene	0.3	6.3	3.4	<7.5	<3.0
Xylene, total	0.6	41	22	<15	<6.0
BTEX, total	-	61	35	-	-
TPH as Gasoline	100	180	<1000	<2500	<1000
Dilution Multiplier[b]		1	10	25	10
TFT surrogate[c], % recovery		83.7	97.4	89.6	95.9

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

* Detection limit increased due to matrix effect (foaming)

R0013312

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

ANALYTICAL RESULTS

Volatile Organics in Water
EPA Methods Modified 8020 and Modified 8015[a]

GTEL Sample Number		09137-23*	09137-26*	09137-29	
Client Identification		408-1	409-1	Trip Blank	
Date Sampled		9-17-92	9-17-92	9-17-92	
Date Analyzed		9-24-92	9-24-92	9-24-92	
Analyte	Reporting Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<7.5	<7.5	<0.3	
Toluene	0.3	<7.5	<7.5	<0.3	
Ethylbenzene	0.3	<7.5	<7.5	<0.3	
Xylene, total	0.6	<15	<15	<0.6	
BTEX, total	-	-	-	-	
TPH as Gasoline	100	<2500	<2500	<100	
Dilution Multiplier[b]		25	25	1	
TFT surrogate[c], % recovery		97.7	97.8	99.8	

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Modification for TPH as gasoline as per California State Water Resources Board LUFT Manual procedures.

b. Indicates the adjustments made for sample dilution.

c. TFT surrogate recovery acceptability limits of 72.8-123% are derived from the 99% confidence interval of all samples during the previous quarter. Expected surrogate value is 100 ug/L.

* Detection limit increased due to matrix effect (foaming)

R0013313

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

ANALYTICAL RESULTS

Total Recoverable Oil and Grease in Water
by Infrared Spectrometry
EPA 413.2[a]

Sample Identification		Date Sampled	Date Extracted	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID					
Blank	–	–	9-30-92	10-1-92	1	<1
09137-3	401-3	9-17-92	9-30-92	10-1-92	1	<1
09137-6	402-3	9-17-92	9-30-92	10-1-92	1	9
09137-10	403-3	9-17-92	9-30-92	10-1-92	1	7
09137-13	404-3	9-17-92	9-30-92	10-1-92	1	9
09137-16	405-3	9-17-92	9-30-92	10-1-92	1	34
09137-19	406-3	9-17-92	9-30-92	10-1-92	1	9
09137-22	407-3	9-17-92	9-30-92	10-1-92	1	11
09137-25	408-3	9-17-92	9-30-92	10-1-92	1	6
09137-28	409-3	9-17-92	9-30-92	10-1-92	1	29

a. EPA 600/4-79-020, March 1983 revision.

R0013314

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

ANALYTICAL RESULTS

Total Suspended Solid in Water
Standard Method 209 C[a]

Sample Identification		Date Sampled	Date Analyzed	Reporting Limit, mg/L	Concentration, mg/L
GTEL No.	Client ID				
09137-2	401-2	9-17-92	9-25-92	10	<10
09137-5	402-2	9-17-92	9-25-92	10	<10
09137-9	403-2	9-17-92	9-25-92	10	<10
09137-12	404-2	9-17-92	9-25-92	10	<10
09137-15	405-2	9-17-92	9-25-92	10	<10
09137-18	406-2	9-17-92	9-25-92	10	<10
09137-21	407-2	9-17-92	9-25-92	10	<10
09137-24	408-2	9-17-92	9-25-92	10	13
09137-27	409-2	9-17-92	9-25-92	10	<10

a. Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1985.

R0013315

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

ANALYTICAL RESULTS

Metals in Water
Total Threshold Limit Concentration
California Title 22 (C.A.M.)

GTEL Sample Number			Blank	09137-7		
Client Identification			-	402-4		
Date Sampled			-	9-17-92		
Date Analyzed (Method 6010)			9-28-92	9-28-92		
Date Analyzed (Method 7470)			9-29-92	9-29-92		
Analyte	Method[a]	Reporting Limit, mg/L	Concentration, mg/L			
Antimony	EPA 6010	0.04	<0.04	<0.04		
Arsenic	EPA 6010	0.1	<0.1	<0.1		
Barium	EPA 6010	0.02	<0.02	0.08		
Beryllium	EPA 6010	0.01	<0.01	<0.01		
Cadmium	EPA 6010	0.03	<0.03	<0.03		
Chromium	EPA 6010	0.04	<0.04	<0.04		
Cobalt	EPA 6010	0.02	<0.02	<0.02		
Copper	EPA 6010	0.2	<0.2	0.2		
Lead	EPA 6010	0.1	<0.1	<0.1		
Mercury	EPA 7470	0.001	<0.001	<0.001		
Molybdenum	EPA 6010	0.02	<0.02	<0.02		
Nickel	EPA 6010	0.1	<0.1	<0.1		
Selenium	EPA 6010	0.04	<0.04	<0.04		
Silver	EPA 6010	0.05	<0.05	<0.05		
Thallium	EPA 6010	0.4	<0.4	<0.4		
Vanadium	EPA 6010	0.2	<0.2	<0.2		
Zinc	EPA 6010	0.1	<0.1	0.6		
EPA 6010: Dilution Multiplier[b]			1	1		
EPA 7470: Dilution Multiplier[b]			1	1		

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Digestion by EPA Method 3010 (ICP)

b. Indicates the adjustments made for sample dilutions.

R0013316

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

CONFORMANCE/NONCONFORMANCE SUMMARY

Abbreviations:

X = Requirements Met
VOA = Volatiles
* = See Comments
SV = Semi Volatiles
NA = Not Applicable
ND = Not Detected
- = Test Not Required

#	Conformance Item	VOA GC	VOA GC/MS	SV GC	SV GC/MS	Metals	Wet Chem
1	Holding Time	X				X	X
2	Method Accuracy	X				X	X
3	Method Precision	X				X	X
4	Surrogate Recovery	X				NA	NA
5	Blank	ND				X	X

Comments:

R0013317

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

QC Check Sample Results

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[a], %
GC:					
Benzene	Ultra Scientific	9-23-92	150	ug/L	110 (81.1-118)
Toluene	Ultra Scientific	9-23-92	150	ug/L	109 (79.9-123)
Ethylbenzene	Ultra Scientific	9-23-92	150	ug/L	102 (81.1-123)
Xylene, total	Ultra Scientific	9-23-92	450	ug/L	112 (82.9-123)
Metals:					
Arsenic	Spex	9-28-92	1.00	mg/L	107 (80-120)
Barium	Spex	9-28-92	1.00	mg/L	100 (80-120)
Cadmium	Spex	9-28-92	1.00	mg/L	106 (80-120)
Chromium	Spex	9-28-92	1.00	mg/L	110 (80-120)
Lead	Spex	9-28-92	1.00	mg/L	109 (80-120)
Mercury	Perkin-Elmer	9-29-92	0.002	mg/L	102 (80-120)
Selenium	Spex	9-28-92	1.00	mg/L	106 (80-120)
Silver	Spex	9-28-92	1.00	mg/L	96.0 (80-120)
Inorganic Chemistry:					
Oil and Grease/IR	J.T. Baker	10-1-92	25.2	mg/L	101 (80-120)

a. Acceptability limits are in parentheses.

R0013318

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

Matrix Spike and Duplicate Spike Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Amount	Spike Amount	Units	Recovery, %	Duplicate Recovery[a] %	RPD[a], %
GC:								
Benzene	T209137	9-23-92	<0.3	150	ug/L	110	117 (76.3-110)	6.17 (30)
Toluene	T209137	9-23-92	<0.3	150	ug/L	109	115 (73-112)	5.36 (30)
Ethylbenzene	T209137	9-23-92	<0.3	150	ug/L	102	112 (75.1-109)	9.35 (30)
Xylene, total	T209137	9-23-92	<0.6	450	ug/L	112	121 (78.1-109)	7.73 (30)
Metals:								
Arsenic	T209137-7	9-28-92	<0.1	2.00	mg/L	101	NA (68.6-112)	NA
Barium	T209137-7	9-28-92	0.0794	2.00	mg/L	99.0	NA (67.5-110)	NA
Cadmium	T209137-7	9-28-92	<0.03	2.00	mg/L	98.0	NA (67.2-111)	NA
Chromium	T209137-7	9-28-92	<0.04	2.00	mg/L	104	NA (66.8-115)	NA
Lead	T209137-7	9-28-92	<0.1	2.00	mg/L	101	NA (67.1-110)	NA
Mercury	T209137-7	9-29-92	<0.001	0.002	mg/L	102	NA (64.8-110)	NA
Selenium	T209137-7	9-28-92	<0.04	2.00	mg/L	102	NA (69.5-111)	NA
Silver	T209137-7	9-28-92	<0.05	2.00	mg/L	87.0	NA (45.2-110)	NA
Inorganic Chemistry:								
Oil and Grease/IR	T209137-3	10-1-92	<1	4.93	mg/L	87.0	NA (64-127)	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013319

GTEL Client Number: HCR01.WSP01
Contract Number: 6CSW23231X
Facility Number: J-6565
Work Order Number: T209137
Report Issue Date: October 2, 1992

Sample and Sample Duplicate Results

Matrix: Water

Analyte	Sample ID	Date of Analysis	Sample Results	Sample Duplicate Results	Units	RPD[a], %
Metals:						
Arsenic	T209137-7	9-28-92	<0.1	<0.1	mg/L	NA
Barium	T209137-7	9-28-92	0.0794	0.0803	mg/L	NA
Cadmium	T209137-7	9-28-92	<0.03	<0.03	mg/L	NA
Chromium	T209137-7	9-28-92	<0.04	<0.04	mg/L	NA
Lead	T209137-7	9-28-92	<0.1	<0.1	mg/L	NA
Mercury	T209137-7	9-29-92	<0.001	<0.001	mg/L	NA
Selenium	T209137-7	9-28-92	<0.04	<0.04	mg/L	NA
Silver	T209137-7	9-28-92	<0.05	<0.05	mg/L	NA
Inorganic Chemistry:						
Oil and Grease/IR	T209137-28	10-1-92	28.8	24.4	mg/L	16.5
Total Suspended Solid	T209137-2	9-25-92	<10	<10	mg/L	NA

a. Acceptability limits are in parentheses.
NA Not Applicable.

R0013320

Reagent Water Spike Results for Organic Analyses and LCS for Inorganic Analyses[a]

Matrix: Water

Analyte	Source	Date of Analysis	Expected Value	Units	Recovery[b], %
Metals:					
Arsenic	Spex	9-28-92	1.00	mg/L	108 (70-130)
Barium	Spex	9-28-92	1.00	mg/L	103 (70-130)
Cadmium	Spex	9-28-92	1.00	mg/L	106 (70-130)
Chromium	Spex	9-28-92	1.00	mg/L	110 (70-130)
Lead	Spex	9-28-92	1.00	mg/L	107 (70-130)
Mercury		9-29-92	0.002	mg/L	102 (70-130)
Selenium	Spex	9-28-92	1.00	mg/L	107 (70-130)
Silver	Spex	9-28-92	1.00	mg/L	96.6 (70-130)
Inorganic Chemistry:					
Oil and Grease/IR	E.M. Science, J.T. Baker	10-1-92	4.93	mg/L	98.0 (70-130)

a. As required to support method accuracy or precision when matrix spike or RPD are out of control limits.
b. Acceptability limits are in parentheses.

R0013321

CHAIN-OF-CUSTODY RECORD

DO NOT CHEVRON USA INC. P.O. BOX 2833 LA HABRA, CA 90632-2833

PROJECT NAME: WSPA STORMWATER RUNOFF
PROJECT I.D. NO.:
CONSULTANT NAME: HART CROWSER
ADDRESS: 1 WORLD TRADE CENTER LONG BEACH
PROJECT CONTACT (NAME): JOHN NETHERWOOD
(PHONE): (310) 495 6360
CHEVRON FACILITY NO.: J 6565
CHEVRON CONTACT (NAME): Allison Fong
(PHONE): 510 543 5333

LABORATORY NAME: CETEC ENVIRONMENTAL LABS
CONTRACT NUMBER: T320
COLLECTED BY (NAME): DAVID DARROW
(SIGNATURE): David T. Darrow
COLLECTION DATE: 9.17.92

SAMPLE No	LAB No	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME (P.M.)	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	CAM 22 METALS	CAM 22 - CLP 22	OTHER EPA 413.2 - Oil & Grease	EPA 160.2 - Total Suspended Solids		DETECTION LIMIT
101-1		2		X	X		9.17.92	5:50	X	X	X		X							
101-2		1						5:50										X		
101-3		1						5:50									X			
102-1		2						5:56	X		X		X							
102-2		1						5:56										X		
102-3		1						5:56									X			
102-4		1						5:56	X						X					
103-1		2						6:11	X		X		X							
103-2		1						6:11										X		
103-3		2						6:11									X			
104-1		2						6:26	X		X		X							
104-2		1						6:26										X		
104-3		1						6:26									X			

R0013322

ANALYSES TO BE PERFORMED

REMARKS: 4°C

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
David T. Darrow	HART CROWSER	9.18.92 16:00			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME

TURN AROUND TIME (CIRCLE ONE): 24 HRS 5 DAYS

CHEVRON USA Inc
P.O. BOX 2833
LA HABRA, CA 90632-2833

CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER LONG BEACH
PROJECT CONTACT (NAME) JOHN NETHERWOOD
(PHONE) (310) 495-6360
CHEVRON FACILITY NO. J-6565
CHEVRON CONTACT (NAME) Allison Fong
(PHONE) 818 543 6333

COLLECTED BY (NAME) DAVID DARROW
(SIGNATURE) David C. Darrow
COLLECTION DATE 9.17.92

ANALYSES TO BE PERFORMED

SAMPLE NO	LAB NO	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME (pm)	ACIDIFIED	ICED	MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS ( )	OTHER EPA 413.2 Oil + GREASE	EPA 160.2 TDS TOTAL DISSOLVED SOLIDS		DETECTION LIMIT
105-1		2		X	X		9.17	6:30	X	X	X		X				X		
105-2		1						6:30											
105-3		1						6:30									X		
106-1		2						7:45	X		X		X			X			
106-2		1						7:45											
106-3		1						7:45									X		
107-1		2						8:00	X		X		X			X			
107-2		1						8:00											
107-3		1						8:00									X		
108-1		2						8:15	X		X		X			X			
108-2		1						8:15											
108-3		1			X			8:15									X		
109-1		2				X		8:20	X		X		X			X			

4 °C

REMARKS

RELINQUISHED BY (Signature) David C. Darrow
RELINQUISHED BY (Signature)
RELINQUISHED BY (Signature)

ORGANIZATION HART CROWSER | DATE/TIME 9.18.92 16:00
ORGANIZATION | DATE/TIME
ORGANIZATION | DATE/TIME

RECEIVED BY (Signature)
RECEIVED BY (Signature)
RECEIVED FOR LABORATORY BY (Signature)

ORGANIZATION
ORGANIZATION

DATE/TIME
DATE/TIME
DATE/TIME 9/18/92 16:00

TURN AROUND TIME (CIRCLE ONE)
24 HRS 5 DAYS
48 HRS 10 DAYS

R0013323

CHAIN-OF-CUSTODY RECORD

CHEVRON USA Prod. Co.
P.O. BOX 2833
LA HABRA, CA 90632-2833

PROJECT NAME WSPA STORMWATER RUNOFF
PROJECT I.D. NO. [redacted]
CONSULTANT NAME HART CROWSER
ADDRESS 1 WORLD TRADE CENTER LONG BEACH
PROJECT CONTACT (NAME) JOHN NETTERWOOD
(PHONE) (310) 495 6360
CHEVRON FACILITY NO. J 6565
CHEVRON CONTACT (NAME) Allison Fong
(PHONE) 818 543 5333

LABORATORY NAME CITEC ENVIRONMENTAL LABS
CONTRACT NUMBER 7320
COLLECTED BY (NAME) DAVID DARROW
(SIGNATURE) David C. Darrow
COLLECTION DATE 9.17.92

SAMPLE No.	LAB No.	NUMBER OF CONTAINERS	MATRIX: SOIL	MATRIX: WATER	GRAB	COMPOSITE	DATE	TIME (PM)	ACIDIFIED	ICED	ANALYSES TO BE PERFORMED: MODIFIED EPA 8015 TOTAL PETRO. HYDROCARB.	EPA 418.1 TOTAL RECOVERABLE PETROLEUM HYDROCARB.	EPA 8020 AROMATIC VOLATILES - BTXE	EPA 602 AROMATIC VOLATILES - BTXE	METALS ( )	OTHER EPA 413.2 Oil & GREASE	EPA 160.2 TOTAL SUSPENDED SOLIDS	DETECTION LIMIT
909-2		1		X		X	9.17	8:10		X							X	
909-3		1		X		X	9.17	8:20		X								
TRIP BLANK 2				X	X		9.17	—		X	X		X			X		

R0013324

REMARKS: 4°C

RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
David C. Darrow	HART CROWSER	9.18.92 16:00			
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED BY (Signature)	ORGANIZATION	DATE/TIME
RELINQUISHED BY (Signature)	ORGANIZATION	DATE/TIME	RECEIVED FOR LABORATORY BY (Signature)		DATE/TIME

TURN AROUND TIME (CIRCLE ONE)
24 HRS 5 DAYS
48 HRS 10 DAYS

APPENDIX B
KEY LITERATURE SEARCH ABSTRACTS

Item 62

Accession Number	100143
Main Title	Contributions of Urban Roadway Usage to Water Pollution
Personal Author	Shaheen., Donald G.;
Corporate Author	Biospherics, Inc., Rockville, Md.;Environmental Protection Agency. Washington, D.C. Office of Research an Development.
Year Published	1975
Call Number	PB-245 854
Report Number	EPA-68-01-0197; EPA-ROAP-21ASY-005; EPA/600/2-75-004;
Abstract	Street surface contaminants are deposited on roadways from many sources within an urban area. Industrial operations, land use activities, fallout of air pollutants, roadway usage and other activities contribute to the loading of particulates on urban roadways. These materials are then carried into receiving waters by storm runoff where they constitute a substantial portion of the overall water pollution problems of cities. Metropolitan Washington, D.C., with its low background of industrial emissions, was the area chosen for study of contributions of motor vehicle usage to urban roadway loading factors. Specific roadway study sites within this area were selected so as to provide minimal interference from nontraffic-related land use activities and thus isolate, as much as possible, the traffic-related depositions.

Item 108

Accession Number	116665
Main Title	Toxicants in Urban Runoff: Metro Toxicant Program Report Number 2.
Personal Author	Galvin, D.V.; Moore, R.K.;
Corporate Author	Municipality of Metropolitan Seattle-METRO,WA. Water Quality Div.
Year Published	1982
Call Number	PB84-104124
Report Number	MMS/WOR-8210; EPA-P-000161-01:
Abstract	As part of the U.S. Environmental Protection Agency's Nationwide Urban Runoff Program, the Municipality of Metropolitan Seattle (METRO) studied the sources and presence of toxic substances in urban stormwater runoff, as well as their potential adverse effects on local freshwater receiving environments. Sampling and analysis were designed to provide concentration data for the Clean Water Act's priority pollutant metals and organics. Sampling of potential sources to stormwater runoff included airborne particles, street dust, and catchbasin sediments. Both urban control environmental samples were taken from interstitial streamwaters, stream sediments, and Lake Washington bottom sediments. Evaluations of toxicant control measures focuses on currently available removal techniques, such as street sweeping, detention basins, and oil separators. The report incorporates a thorough literature review and includes an extensive bibliography.

Item 119

Accession Number	118337
Main Title	Nationwide Urban Runoff Program, Bellevue Urban Runoff Program, Washington: Summary Report.
Personal Author	Pitt, R.; Bissonnette, P.;
Corporate Author	Bellevue Storm and Surface Utility, WA.; Environmental Protection Agency, Washington, D.C. Office of Water Program Operations.
Year Published	1984
Call Number	PB84-237213
Report Number	EPA-R-805929;
Abstract	This summary report consolidates the major findings and conclusions of several individual studies, which included: Tests conducted to contrast the biological and chemical conditions in an urban creek with a rural creek; Monitoring urban runoff quality and quantity from 3 urban areas; Analysis of many source area, urban runoff, and creek samples for metallic and organic priority pollutants; Sampling of urban stormwater and base flows rom 2 residential areas. Collection of street dirt samples and evaluation of effects of street cleaning and catchbasin cleaning on improvement of urban runoff quality.

50/5/2

03033048 E.I. Monthly No: EI9103035695

Title:	Sources of petroleum hydrocarbons in urban runoff.
Author:	Latimer, James S.; Hoffman, Eva J.; Hoffman, Gerald; Fasching, James L.; Quinn, James G.
Corporate Source:	Univ of Rhode Island, Narragansett, RI, USA
Source:	Water, Air and Soil Pollution v 52 n 1-2 Jul 1990 p 1-21
Publication Year:	1990
CODEN:	WAPLAC
ISSN:	0049-6979
Language:	English
Document Type:	JA; (Journal Article) Treatment: X; (Experimental); G; (General Review)
Journal Announcement:	9103
Abstract:	In an effort to provide a better understanding of the sources of petroleum hydrocarbons in urban runoff, petroleum products as well as probable source materials were analyzed for hydrocarbons and trace metals and then compared to urban runoff samples from four different land use areas. The petroleum products considered were No.2 and No.6 fuel oil, used and virgin crankcase oils, and gasoline. Source materials included street dust, roadside soil, roadside vegetation, and atmospheric fallout; and the land use categories were commercial, residential, interstate highway, and industrial areas. The samples were compared on the basis of hydrocarbon (saturated and aromatic) and trace metal (Cd, Pb, Mn, Cu, Fe, Zn) loadings and distributions. Results indicated that the hydrocarbon content in runoff at all four land use sites originated primarily from used crankcase oil, with a small amount of No. 2 fuel oil detected at the industrial site. Only a small portion of the crankcase oil component came from the sources surveyed, and the majority of this oil probably came from: (1) oil drops within the driving lanes on the road surfaces or deposits in parking areas, and/or (2) direct dumping of waste crankcase oil down storm drains. (Author abstract) 30 Refs.
Descriptors:	*WATER POLLUTION; RUNOFF; HYDROCARBONS; PETROLEUM PRODUCTS; OIL FUEL; LUBRICATING OILS
Identifiers:	PETROLEUM HYDROCARBONS; URBAN RUNOFF; GASOLINE; STREET DUST; ROADSIDE SOIL; ROADSIDE VEGETATION
Classification Codes:	453 (Water Pollution); 442 (Flood Control & Land Reclamation); 804 (Chemical Products); 444 (Water Resources); 523 (Liquid Fuels); 607 (Lubricants & Lubrication); 45 (POLLUTION & SANITARY ENGINEERING); 44 (WATER & WATERWORKS ENGINEERING); 80 (CHEMICAL ENGINEERING); 52 (FUEL TECHNOLOGY); 60 (MECHANICAL ENGINEERING)

50/5/13

02715323 E.I. Monthly No: EI8903022181

Title:	Site design for resource recovery facilities.
Author:	Vir, Jayant; Patel, Manu; Cividini, Bruno
Corporate Source:	Burns & Roe Enterprises Inc., Oradell, N, USA
Source:	Journal of Energy Engineering v 114 n 3 Dec 1988 p 93-98
Publication Year:	1988
CODEN:	JLEED9
ISSN:	0733-9402
Language:	English
Document Type:	JA; (Journal Article) Treatment: E: (Economic/Cost Data/Market Survey); T; (Theoretical)
Journal Announcement:	8903
Abstract:	Waste-to-energy resource recovery facilities fall into two major categories: mass burn and RDF (refuse-derived fuel). Site design considerations presented here are applicable to both categories; however, layout and system description used is for mass-burn facilities. The project site is identified through a complex screening process that includes issues such as environmental compatibility and public sentiment. This paper considers the design within the selected site. Site layout and aesthetics of the facility are of utmost importance to win public support. Traffic congestion is an issue which may be of particular concern to residents in the area of the project; therefore, it is essential that sufficient on-site truck queuing space is provided to avoid traffic spillover onto public streets. Storm-water drainage system must be designed to prevent water pollution during the construction, and in many instances it must be designed to maintain predevelopment runoff rate from the site. Last is the economic consideration: Site must be designed to minimize the capital cost and cost of maintenance. (Edited author abstract)
Descriptors:	*ENERGY RESOURCES --*Waste Utilization; WATER POLLUTION --Control; INDUSTRIAL PLANTS --Site Selection; ECONOMICS; FUELS--Refuse Derived Fuels
Identifiers:	ENVIRONMENTAL COMPATIBILITY; TRAFFIC SPILLOVER
Classification Codes:	913 (Production Planning & Control); 453 (Water Pollution); 525 (Energy Management); 402 (Buildings & Towers); 911 (Industrial Economics); 521 (Combustion & Fuels); 91 (ENGINEERING MANAGEMENT); 45 (POLLUTION & SANITARY ENGINEERING); 52 (FUEL TECHNOLOGY); 40 (CIVIL ENGINEERING)

50/5/18
0197188 API Document No.: 2933131
PETROLEUM HYDROCARBONS ((HC) CONCENTRATION) IN URBAN RUNOFF FROM A COMMERCIAL LAND-USE AREA

Author:	HOFFMAN E J; LATIMER J S; MILLS G L; QUINN J G
Corporate Source:	UNIV. R.I.
Source:	J. WATER POLLUT. CONTROL FED. V54 N.11 1517-25 (NOV. 1982
Language:	English
Publication Date:	821100
API Bulletin Headings:	AIR AND WATER CONSERVATION; PHYSICAL/CHEM. PROP. OF WATERS; WATER POLLUTION SOURCES
Index Terms:	ASPHALT; COMMERCIAL; COMPOSITION; COMPOUNDS; CONCENTRATION; DISTRICT 1; DRAINING; ECONOMIC FACTOR; FLOW RATE; HYDROCARBON; LAND USE; LEAK; LUBRICANT/INDUSTRIAL OIL; MAP; *METEOROLOGICAL PHENOMENON; MONITORING; MOTOR OIL; NORTH AMERICA; OIL WASTE; OPERATING CONDITION; PARKING FACILITY; PARTICULATES; PAVING MATERIAL; POLLUTION SOURCE; PRIMARY; *RAINFALL; RHODE ISLAND; ROAD ASPHALT; SAND; SECONDARY; SOLID; STREAM; SURFACE; *SURFACE WATER; SUSPENSION; URBAN; USA; WASTE MATERIAL; *WATER; *WATER POLLUTANT; WATER POLLUTION
Supplementary Terms:	RUNOFF
Sets of Linked Terms:	0006
Linked Terms:	COMPOUNDS; HYDROCARBON; WATER POLLUTANT LUBRICANT/INDUSTRIAL OIL; MOTOR OIL; OIL WASTE; WASTE MATERIAL; WATER POLLUTANT PARKING FACILITY; SURFACE PARTICULATES; WATER POLLUTANT PAVING MATERIAL; SAND PRIMARY; SECONDARY; WATER POLLUTION

50/5/16
625319 W91-01994
Pollution of Street Run-off by Traffic and Local Conditions
Muschack, W.
Umweltbundesamt, Berlin (Germany, F.R.).
The Science of the Total Environment STENDL, Vol. 93, p 419-431, April 1990. 6 tab, 12 ref.,
Journal Announcement: SWRA2402
Investigations were performed in the Federal Republic of Germany to determine pollutant concentrations in rainwater in order to obtain a comprehensive picture of the pollution caused by precipitation runoff. Influencing parameters included: exhaust gases, tire abrasion particles, brake lining abrasion dust, leakage of hydrocarbons, and winter street cleaning activities. The analysis of these factors was complemented by the determination of detection limits. After an assessment of all possibilities, 30 substances remained, and 22 were analyzed. Lead, chromium, copper, nickel, and zinc are the elements commonly found in the emissions/particles of the aforementioned parameters. (Stoehr-PTT)
Descriptors: *Highway effects; *Pollutant identification; *Urban runoff; *Water pollution sources; Chromium; Copper; Drinking water; Heavy metals; Hydrocarbons; Lead; Nickel; Path of pollutants; Precipitation; Rainwater; Runoff; Zinc
Section Heading Codes: 5B (Water Quality Management and Protection--Sources of Pollution); 5A (Water Quality Management and Protection--Identification of Pollutants)

50/5/45
601978 W89-04065
Rainfall and Runoff Quantity and Quality Data Collected at Four Urban Land-Use Catchments in Fresno, California: October 1981 - April 1983
Oltmann, R.N.; Guay, R.; Shay, J.M.
Geological Survey, Sacramento, CA. Water Resources Div.
Available from Books and Open File Report Section, USGS, Box 25425, Denver, Co 80225.
USGS Open-File Report 84-718, 1987. 139 p., 8 fig., 16 tab, 8 ref.,
Journal Announcement: SWRA2204
Data were collected as part of the National Urban Runoff Program to characterize urban runoff in Fresno, California. Rainfall-runoff quantity and quality data are included along with atmospheric dry-deposition and street-surface particulate quality data. The data are presented in figures, and tables that reflect four land uses: industrial, single-dwelling residential, multiple-dwelling residential, and commercial. A Total of 255 storms were monitored for rainfall and runoff quantity. Runoff samples from 112 of these storms were analyzed for physical, organic, inorganic, and biological constituents. The majority of the remaining storms have pH and specific conductance data only. Ninety-two composite rain samples were collected. Of these, 63 were analyzed for physical, inorganic and (or) organic constituents. The remaining rainfall samples have pH and specific conductance data only. Nineteen atmospheric deposition and 21 street-particulate samples were collected and analyzed for inorganic and organic constituents. The report also details equipment utilization and operation, and discusses data collection methods. (USGS)
Descriptors: *Rainfall; *Pesticides; *Path of pollutants; *California; Runoff; Nutrients; Sediments; Water pollution sources; Fresno; Central Valley; San Joaquin Valley; Metals
Section Heading Codes: 5B (Water Quality Management and Protection--Sources of Pollution); 4C (Water Quantity Management and Control--Effects on Water of Man's Nonwater Activities); 7B (Resources Data--Data Acquisition)

50/5/87
159679 W82-05557
Oil and Grease in Stormwater Runoff
Stenstrom, M. K.; Silverman, G.; Bursztynsky, T.A.; Zarzana, A.L.; Salarz, S.E.
California Univ., Los Angeles, Dept. of Engineering Systems Report, February 1982. Association of Bay Area Governments, Berkeley, California. 241 p., 41 Fig., 44 Tab., 158 Ref., 3 Append.,
Journal Announcement: SWRA1511
The objective of this project was to determine the environmental effects of oil and grease in urban stormwater on marine environments in San Francisco Bay and to recommend suitable control measures. Studies show that there are significant effects of low level oil/grease pollution and that continuous pollution from urban stormwater can change the ecology of a marine environment. Five field sampling stations were selected in a stormwater basis in Richmond, CA to determine oil/grease pollution by land-use type. Samples were taken from the mouth of the watershed, a parking lot, a commercial street, a residential area, and from a light industrial facility. Land-use strongly affects oil/grease in stormwater. The major contributing factor is motor vehicles. Areas with the most auto traffic had the highest concentration of oil/grease in stormwater and the highest hydrocarbon load factor. Mean oil/grease concentration in runoff flow ranged from 4.13 mg/1 in an upstream residential area to 15.25 mg/1 in a parking lot. A strong correlation exists between total rainfall and total mass of oil/grease pollution--contamination is higher at the beginning of a storm than at the end. Nine control techniques showed promise. Three non-structural techniques were to recycle used crankcase oil, reduce auto emissions through better inspections, and improve standards. Six structural techniques were to improve street/parking lot cleaning, sorption systems for manhole and gutter intakes, porous pavement, greenbelts around parking lots, dispersion devices, and wetlands or marshes to trap pollutants. These are site-specific techniques but it was recommended they be developed further. (Atkins-Omniplan)
Descriptors: *Storm runoff; *Urban runoff; *Oily water; *Grease; *San Francisco Bay; Storm water; Sampling; Land use; Hydrocarbons; Chromatography; Wastewater; Oil pollution; Runoff rates; Adsorption; Rainfall-runoff relationships; Environmental effects; Path of pollutants; Ecological effects
Section Heading Codes: 5C (Water Quality Management and Protection--Effects of Pollution); 5B (Water Quality Management and Protection--Sources of Pollution)

50/5/89
158640 W82-04627

Constituents of Highway Runoff: Volume I, State-of-the-Art Report
Gupta, M.K.; Agnew, R.W.; Kobriger, N.P.
Envirex Inc., Milwaukee, WI.
Available from the National Technical Information Service, Springfield, VA 22161 as PB881-241895, Price codes: A06 in paper copy, A01 in microfiche. Federal Highway Administration Report No. FHWA/RD-81/042, February, 1981. 121 p., 16 Fig., 37 Tab., 169 Ref., DOT-FH-11-8600.
Journal Announcement: SWRA1510
The factors which most affect quantity and quality of highway runoff are traffic volume, rainfall intensity and pattern, highway drainage characteristics, operation and maintenance characteristics and degree of imperviousness of the drainage area. Maintenance of adequate drainage is one of the most important aspects of highway design. Highway runoff characteristics are similar to those of urban runoff and may exert significant shock pollutional loads on receiving waters. The weighted average of total solids accumulations between successive street cleanings, a period of 2 to 12 days, for eight cities was found to be 1400 lb/curb mile. A high percentage of street surface pollutants are associated with very fine dust and dirt particles. Substantial quantities of toxic materials, such as heavy metals and pesticides, are present in street surface contaminants with the amounts varying considerably from site to site. Because of the consistent presence of heavy metals in amounts large enough to interfere with BOD5 measurements, COD is considered to be a better parameter for measuring the oxygen demand potential of highway runoff. Highway salting rates usually range from 400 to 1200 lbs per two-lane mile. Over the winter season, a typical multiple lane highway may use 100 tons or more of salt per mile. Significant amounts of vehicle released airborne matter are settled out and washed off the road surface during rainstorms. (Moore-SRC)
Descriptors: *Highways; *Roads; *Water pollution sources; *Storm runoff; *Urban runoff; *Highway effects; Drainage effects; Particulate matter; Deicers; Environmental effects; Heavy metals; Pesticides; Oxygen demand; Salt
Section Heading Codes: 4C (Water Quantity Management and Control--Effects on Water of Man's Nonwater Activities); 5B (Water Quality Management and Protection--Sources of Pollution)

50/5/91
158289 W83-04252
Water Quality Patterns During A Storm On a Mall Parking Lot
Black, P.E.
State Univ. of New York at Syracuse, Coll. of Environmental Science and Forestry.
Water Resources Bulletin, Vol 16, No. 4, p. 615-620, August, 1980, 6 Fig. 2 Tab., 13 Ref.
Journal Announcement: SWRA1510
Rainfall, surface runoff, and subsurface drainage plus streamflow upstream and downstream of a suburban New York mall parking lot were intensively sampled during and after a thunderstorm on June 18, 1978. Prior to the 11.4mm which fell within less than 1.5 hours, no rain had fallen for 4 days. Ammonia-N concentrations were high (up to 2.5mg per liter) in parking lot runoff, a result of precipitation which contained up to 2.0mg per liter ammonia-N. Surface runoff had a peak in conductivity during the rainfall and returned to prestorm levels by the end of the study period. Initial runoff appeared gray and nearly opaque. Nine constituents (K, Mn, Fe, P, Pb, Zn, Mg, Ca, and Na) showed a peak in surface runoff between 45 and 60 min after the rain started, declined to a low at 75 min, and returned to prestorm values by 105 min. Drainage from subsurface drains was brown in color and had a strong odor. In the receiving stream, water temperature increased and conductivity decreased during the beginning of the storm and returned to prestorm levels after 5 hours. (Cassar-FRC)
Descriptors: *Urban runoff; *Nonpoint pollution sources; *Runoff; Fate of pollutants; Parking lots; Water pollution sources; Paving; Water quality; Rainfall-runoff relationships; Ammonium; Metals; Subsurface runoff; Streams; Conductivity; Water temperature; Suburban malls; New York
Section Heading Codes: 5B (Water Quality Management and Protection--Sources of Pollution)

50/5/92
158226 W82-04216
The Distribution of Heavy Metals and Petroleum Residues in the Soil from Urban Surface Runoff
Owe, M.
State Univ. of New York at Syracuse. Coll. of Environmental Science and Forestry.
PhD Thesis, January, 1981, 197 p., 56 Fig., 22 Tab., 100 Ref., University Microfilms International, Ann Arbor, MI; Order No. GAX81-18121.,
Journal Announcement: SWRA1509
The soil is thought to possess an enormous capacity for immobilizing environmental contaminants, especially those typically contained in urban surface runoff. The profiles of two common area soil, a sandy, porous Arkport and a dense clayey Dunkirk, were reconstructed in 14 cm by 80cm columns in the laboratory. The design was intended to simulate a collection basin, one fourth the surface area of the test basin. Surface runoff was sampled and collected from a heavy used shopping center parking lot. Treatments simulated actual precipitation-runoff event frequency and volume occurring during the study period. The profiles were subsequently analyzed at predetermined increments for zinc, lead, cadmium, copper and petroleum residues. An overall increase in total cation and petroleum concentration was noticed with an increase in treatment concentration. A positive relationship between contaminant concentration in the soil and treatment level, exchange capacity, final soil pH and percent organic matter was realized. A negative correlation was noticed between contaminant concentration and bulk density. Treatment level and final soil pH recovered totals far below the input amounts, consistently lower hydrocarbon totals were recovered from the Arkport. This indicates the possibility of a higher rate of petroleum residue decomposition in the more porous, better aerated Arkport soil. (Sinha-OEIS)
Descriptors: *Urban runoff; *Surface runoff; *Soil properties; *Heavy metals; Oily water; Water pollution; Water pollution sources; New York
Section Heading Codes: 5B (Water Quality Management and Protection--Sources of Pollution)

APPENDIX C
PRELIMINARY FIELD TESTING PROCEDURES AND FINDINGS

Preliminary Field Testing Procedures and Findings

The preliminary field testing was successful in determining that a constant flow rate was needed to achieve uniform distribution of the application water over the selected area. The preliminary field testing of various distribution systems identified that a cascading flow of potable water dispersed through perforated Polyvinyl Chloride (PVC) pipe and measured by an accumulating water meter achieved the desired results. The flow rate was measured by a Rotameter with a scale of 0 through 10 gallons per minute. A stainless steel water collection trough was designed and constructed (Figure C-1) to function as a sampling point and accumulation sump to capture the applied water. It was determined that the leading edge of the stainless steel trough needed a flexible edge to conform to the irregular surface of the concrete and asphalt. A length of polypropylene tubing was cut and slipped over the leading edge of the trough for this purpose.

The captured water was pumped from the collection sump into a plastic-lined metal 55-gallon drum. Four-foot-long containment berms were used to contain the water flow. The berms were constructed from 6 millimeter clear polypropylene tubing, 4 inches in diameter, and filled with clean sand. The non-porous polypropylene and sand filled berms contained the water flow and diverted it to a preselected collection point at the lowest area of the sampling site.

Safety precautions included placing cones around the active test area and meeting with the station attendant to discuss the activities that were going to be conducted.

APPENDIX D
SAMPLING PROCEDURES

SAMPLING PROCEDURES

The water dispensing equipment was set up at each location using the PVC pipe apparatus to cover an area approximately 20 feet x 20 feet. The location of the equipment was determined at each station depending on the physical layout and the slope of the station island. The containment equipment was then placed into position around the area. The containment berms were used to channel the runoff water to the collection point. A stainless steel collection trough was placed at the lowest point of the test area and incorporated into the network berms.

Tables 1 through 5 list each sample round, the sample point or time and the analyses run on the samples collected during that round:

The first round of samples was collected from the source water. The source water sample was submitted for testing with the site samples. The predetermined flow rate was adjusted when the water flow was started. The second round of samples was taken 15 minutes into the water dispensing. A plastic scoop was used to fill the sample bottles from water in the collection trough.

After the second round of samples the water in the collection basin was pumped into a 55-gallon drum using an electric pump. The 55-gallon drum was lined with polypropylene that was changed between the pump island test location and the driveway approach test location at each station. The electric water pump and scoop were decontaminated between sample rounds using a solution of deionized water and alconox, followed by two rinses with deionized water.

For quality control one trip blank was filled with deionized water and stored in each cooler together with the field samples. The trip blank insures that the data obtained from the site testing represents the pollutants collected from the site surface and does not represent contaminates introduced during transport.

A background sample was collected from the service station's potable water at the end of the supply line that was used to produce the simulated rain. The sampling and analysis keys used for this project list the sample identification, station category, location, time interval and weather for each sampling event. The keys are presented in Tables 1 through 5.

At the Category 5 station an incidental spill evaluation was conducted at the pump island prior to conducting the runoff test. The incidental spill test was conducted using one-quart of gasoline. The staged spill of fuel was collected in absorbent that was applied to the spill and picked up prior to the application of the test water.

Grab samples were drawn from the collected water and caution was used to insure that the 40 ml vials for BTEX did not contain any head space. The samples were transported to GTEL Environmental Laboratories, Inc. in an ice chest maintained at 4 degrees Celcius where the samples were analyzed for the specified chemical compounds in the sampling protocol. The analytical data are intended to represent an estimate of the water quality from a storm event equivalent to the flow represented.

SAMPLING PROCEDURES (Continued)

(Round 2 at 15 minutes, Round 3 at 30 minutes, and Round 4 at 45 minutes in the pump island area and Round 6 at 15 minutes, Round 7 at 30 minutes, and Round 8 at 45 minutes in the driveway approach area). At the end of each 15-minute interval, the water in the collection trough was pumped into a 55-gallon drum using an electric pump. Upon completion of the simulation, a composite sample was collected from the 55-gallon drum (Round 5 for the pump island area and Round 9 for the driveway approach area).

Trip blanks were used to ensure that the sample obtained from a site represented the material sampled and its constituents not material or chemicals introduced during transport. Trip blanks are sent along with field samples as a measure of quality assurance. The trip blanks are analyzed to verify that contamination is not introduced to the samples while they are in transit between the point of collection and the laboratory.

APPENDIX E
ACCEPTABILITY LIMITS AND STATISTICAL ACCURACY OF LABORATORY ANALYTICAL METHODS

The Acceptability Limits for the Analytical Methods

Compound	Acceptability Limit
Benzene	81.1 to 118.0 percent of actual concentration
Toluene	79.9 to 123.0 percent of actual concentration
Ethylbenzene	81.1 to 123.0 percent of actual concentration
Total Xylenes	82.9 to 123.0 percent of actual concentration
Oil and Grease	80.0 to 120.0 percent of actual concentration
Metals	80.0 to 120.0 percent of actual concentration

The Statistical Accuracy of the Analyitcal Methods

Compound	Category One	Category Two	Category Three	Category Four	Category Five
Benzene	92.0 percent	117.0 percent	99.3 percent	117.0 percent	110.0 percent
Toluene	94.0 percent	119.0 percent	111.0 percent	119.0 percent	109.0 percent
Ethylbenzene	97.3	115.0 percent	107.0 percent	115.0 percent	102.0 percnet
Total Xylenes	95.8 percent	121. 0 percent	119.0 percent	121.0 percent	112.0 percent
Oil and Grease	87.7 percent	103.0 percent	102.0 percent	88.9 percent	101.0 percent
Metals	97.0 to 107.0 percent	97.0 to 107.0 percent	97.0 to 107.0 percent	97.0 to 107.0 percent	96.0 to 109 percent

APPENDIX F
RAINFALL DATES AND AMOUNTS PRIOR TO SAMPLING EVENT

Rainfall Dates and Amounts Prior to Sampling Event

The following charts display the five dates prior to the sampling event during which a measurable amount of rain fell at the weather monitoring station in the vicinity of the test station. The date, days prior to testing and amount of precipitation is listed in the following tables:

Category One

Date	Days Prior to Test	Rainfall in Inches
July 12, 1992	54	0.06
July 8, 1992	58	0.06
July 7, 1992	59	0.03
May 22, 1992	105	0.01
April 1, 1992	156	0.13

Distance of weather monitoring station from Category One station, approximately 24 miles.

Category Two

Date	Days Prior to Test	Rainfall in Inches
July 9, 1992	63	0.10
July 8, 1992	64	0.10
May 9, 1992	124	0.02
April 2, 1992	161	0.07
April 1 , 1992	162	0.10

Distance of weather monitoring station from Category Two station, approximately 10 miles.

Climatological Data obtained from the National Climatic Center in Asheville, North Carolina

Rainfall Dates and Amounts Prior to Sampling Event (Continued)

The following charts display the five dates prior to the sampling event during which a measurable amount of rain fell at the weather monitoring station in the vicinity of the test station. The date, days prior to testing and amount of precipitation is listed in the following tables:

Category Three

Date	Days Prior to Test	Rainfall in Inches
August 13, 1992	21	0.05
July 11, 1992	54	0.01
July 7, 1992	58	0.02
June 22, 1992	73	0.04
May 22, 1992	104	0.06

Distance of weather monitoring station from Category Three station, approximately 12 miles.

Category Four

Date	Days Prior to Test	Rainfall in Inches
July 12, 1992	59	0.12
July 8, 1992	63	0.06
July 7, 1992	64	0.05
May 6, 1992	98	0.05
April 1, 1992	161	0.19

Distance of weather monitoring station from Category Four station, approximately 18 miles.

Climatological Data obtained from the National Climatic Center in Asheville, North Carolina

Rainfall Dates and Amounts Prior to Sampling Event (Continued)

The following charts display the five dates prior to the sampling event during which a measurable amount of rain fell at the weather monitoring station in the vicinity of the test station. The date, days prior to testing and amount of precipitation is listed in the following table:

Category Five

Date	Days Prior to Test	Rainfall in Inches
July 13, 1992	66	0 .05
July 9, 1992	70	0.01
July 8, 1992	71	0.02
May 5, 1992	135	0.04
April 1, 1992	169	0.33

Distance of weather monitoring station from Category Five station, approximately 2 miles.

Climatological Data obtained from the National Climatic Center in Asheville, North Carolina

APPENDIX G
SIMULATED RAINFALL RUNOFF VOLUME CALCULATIONS

SIMULATED RAINFALL RUNOFF VOLUME CALCULATIONS

Category 1 Station

Pump Island Area:

Water flow rate approximately 1.8 gallons per minute:

86.4 gallons were dispensed in this test

Approximately 30 gallons were collected

Driveway Approach Area:

Water flow rate approximately 1.8 gallons per minute:

79.6 gallons were dispensed in this test

Approximately 30 gallons were collected

Category 2 Station

Pump Island Area:

Water flow rate approximately 1.8 gallons per minute:

86.6 gallons were dispensed in this test

Approximately 5 gallons were collected

Driveway Approach Area:

Water flow rate approximately 1.8 gallons per minute:

99.2 gallons were dispensed in this test

Approximately 53 gallons were collected

SIMULATED RAINFALL RUNOFF VOLUME CALCULATIONS

Category 3 Station

Pump Island Area:

Water flow rate approximately 2.0 gallons per minute:

100.5 gallons were dispensed in this test

Approximately 50 gallons were collected

Driveway Approach Area:

Water flow rate approximately 2.0 gallons per minute:

99.6 gallons were dispensed in this test

Approximately 25 gallons were collected

Category 4 Station

Pump Island Area:

Water flow rate approximately 1.8 gallons per minute:

86.4 gallons were dispensed in this test

Approximately 7 gallons were collected

Driveway Approach Area:

Water flow rate approximately 1.8 gallons per minute:

74.5 gallons were dispensed in this test

Approximately 50 gallons were collected

SIMULATED RAINFALL RUNOFF VOLUME CALCULATIONS

Category 5 Station

Pump Island Area:	Water flow rate approximately 1.7 gallons per minute:
	76.5 gallons were dispensed in this test
	Approximately 52 gallons were collected
Driveway Approach Area:	Water flow rate approximately 1.7 gallons per minute:
	83.4 gallons were dispensed in this test
	Approximately 45 gallons were collected

APPENDIX H
LETTER FROM GTEL LABORATORY DIRECTOR

GTEL
ENVIRONMENTAL
LABORATORIES, INC.

Southwest Region
20000 / 300 Mariner Avenue
Torrance, CA 90503
(310) 371-1044
(800) 727-GTEL
Fax (310) 371-8720

July 6, 1993

Mr. David Darrow
Hart Crowser
1 World Trade Center
Long Beach, Ca. 90831

RE: Toluene in Trip Blank

Dear Mr. Darrow:

Recently, GTEL's Torrance Laboratory investigated several commercial sources of "pure" water for use as trip blanks. It was our experience that water sold in glass containers frequently contained up to 2 parts per billion (ppb) Toluene. Water from plastic containers tended to have even higher concentrations of Toluene due to leaching. As a result of our study, we now verify purity of every trip blank prior to sending it out to Clients.

Another source of Toluene contamination in Trip Blanks is the sample container. As part of GTEL's Total Quality Management Program, evaluation of several vendors' products were conducted. One supplier's glass VOA vials consistently showed several ppb Toluene. GTEL's now purchases sample containers from a single source and receives a Certificate of Analysis with each shipment to ensure that the containers meet our specifications.

I strongly recommend that in the future, Trip Blanks be ordered directly from the Laboratory at the time the project is scheduled. It is very difficult for a consultant to make his/her own Toluene-free Trip Blanks.

If I can be of further assistance, please do not hesitate to contact me.

Very truly yours,
GTEL Environmental Laboratories, Inc.

Joan V. Greenwood
Laboratory Director

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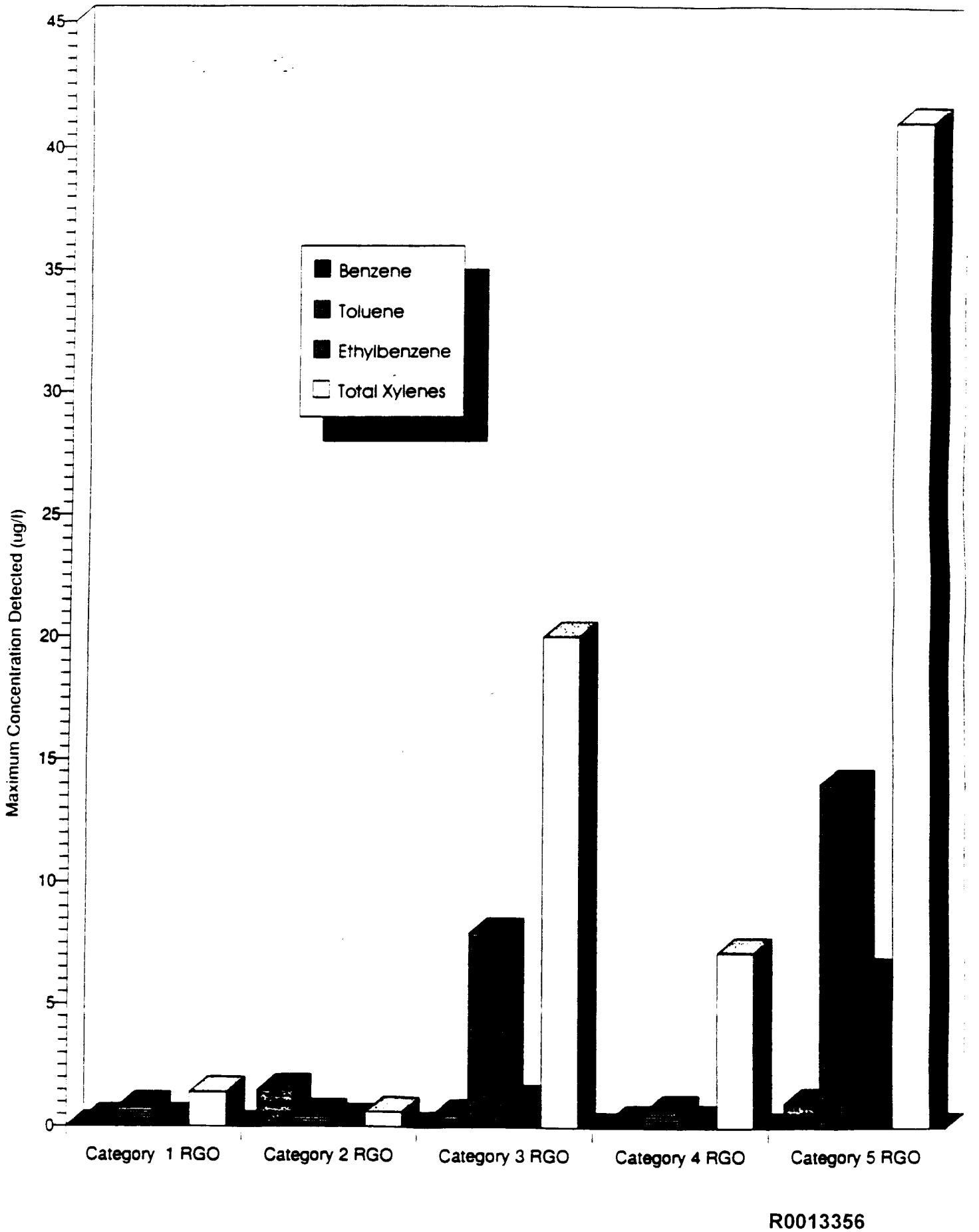
APPENDIX I
MAXIMUM CONCENTRATION GRAPHS


Maximum Concentration Detected (ug/l)
0
5
10
15
20
25
30
35
40
45
Benzene
Toluene
Ethylbenzene
Total Xylenes
Category 1 RGO
Category 2 RGO
Category 3 RGO
Category 4 RGO
Category 5 RGO

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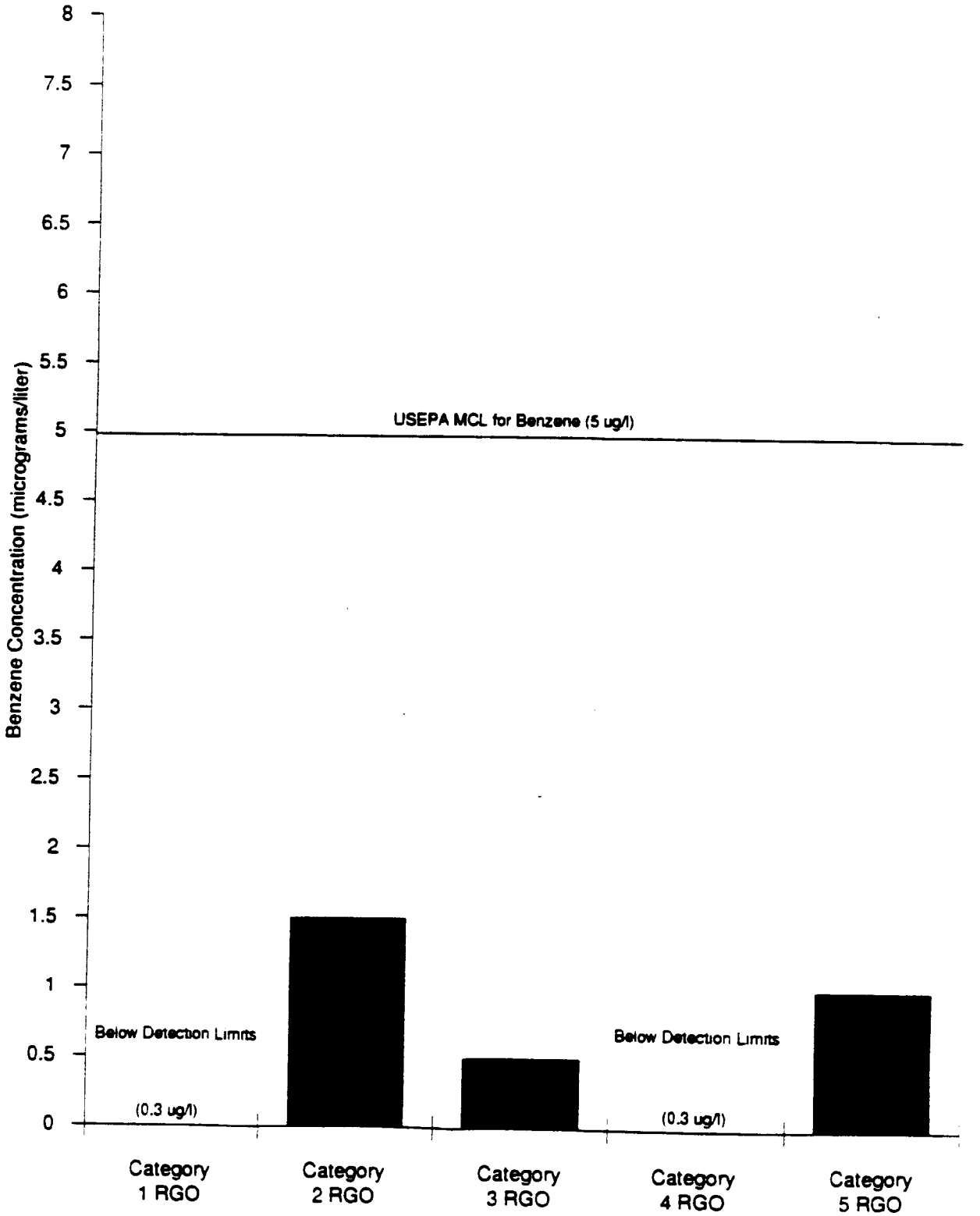
Maximum Benzene Concentration Detected



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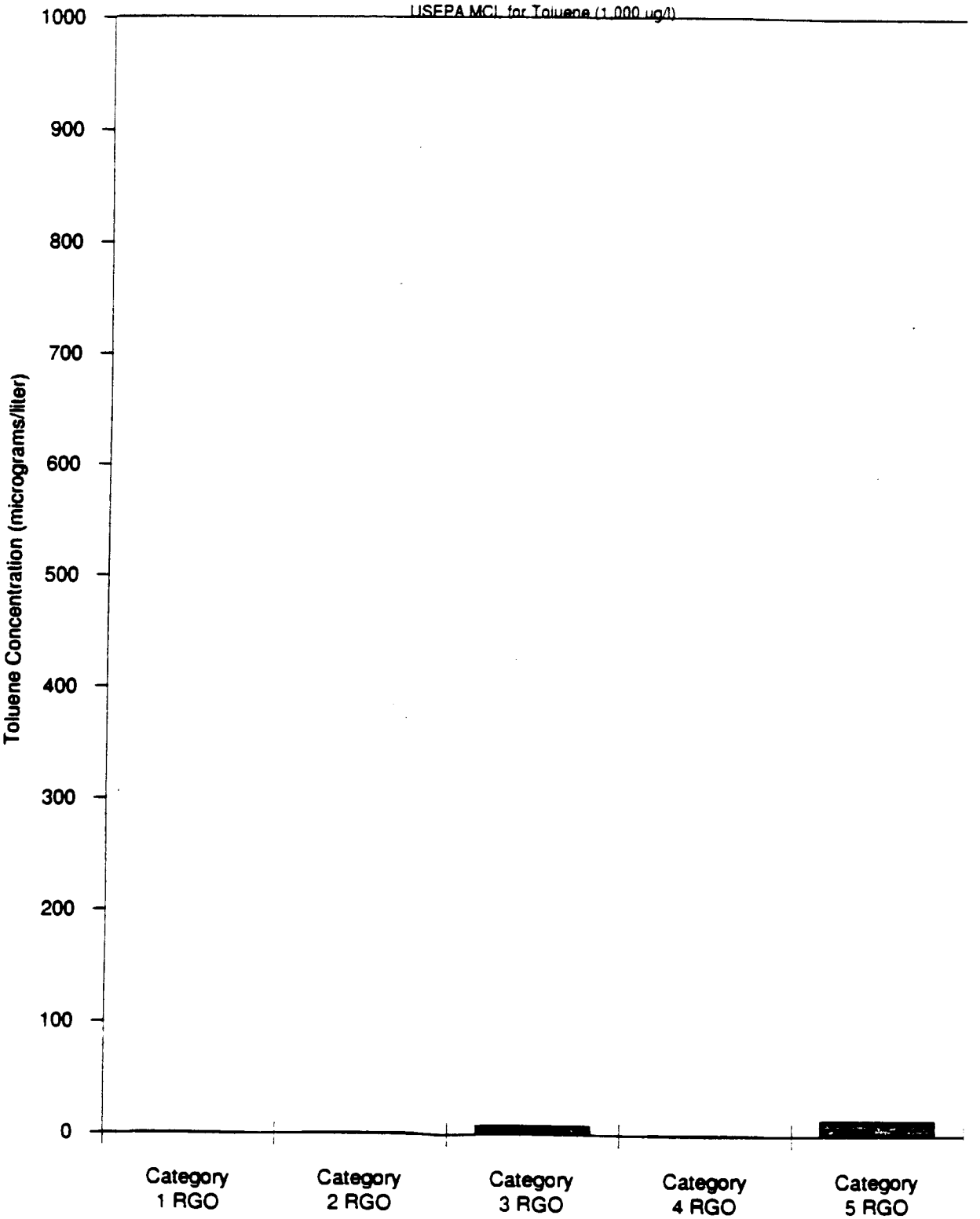
Maximum Toluene Concentration Detected



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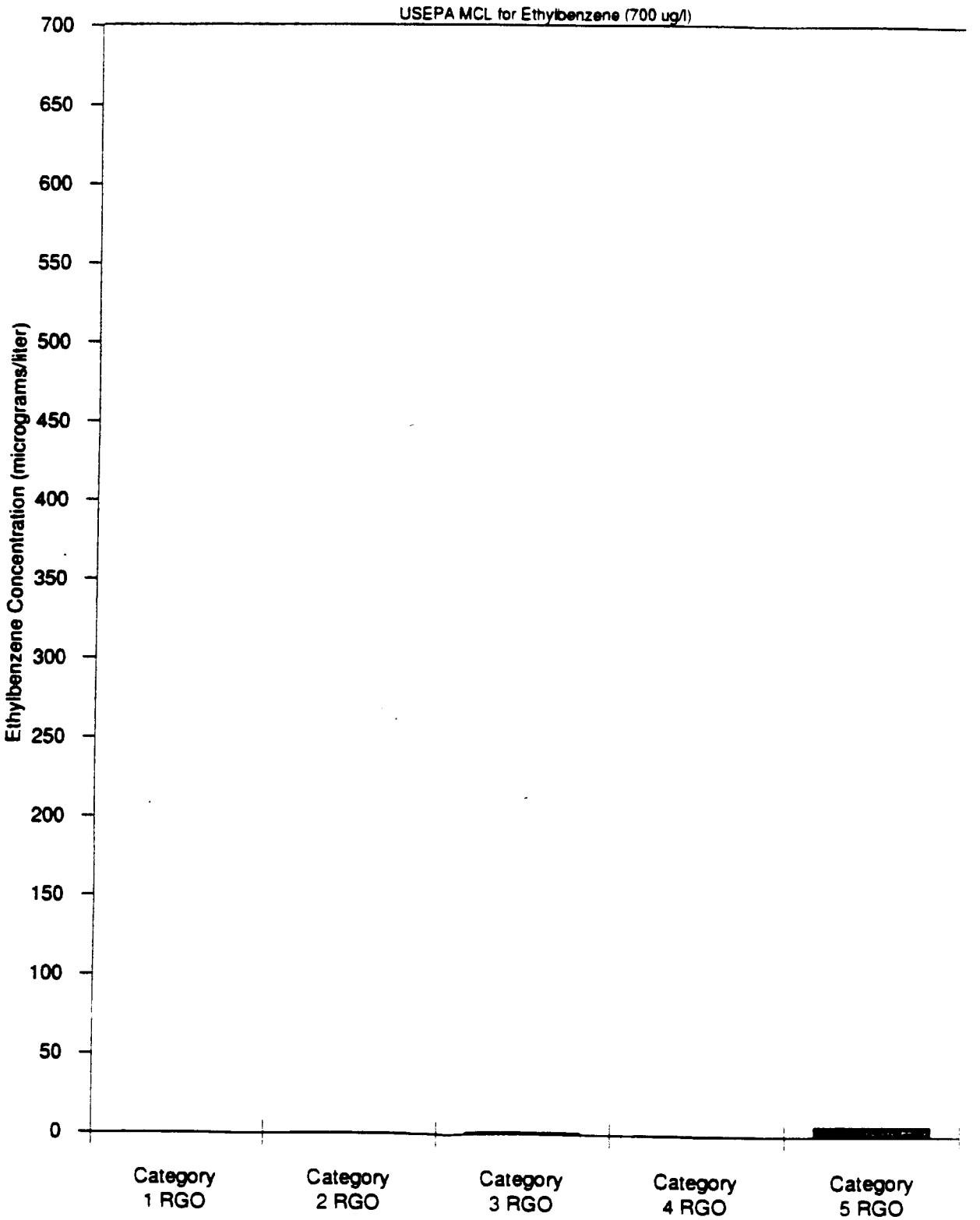
Maximum Ethylbenzene Concentration Detected



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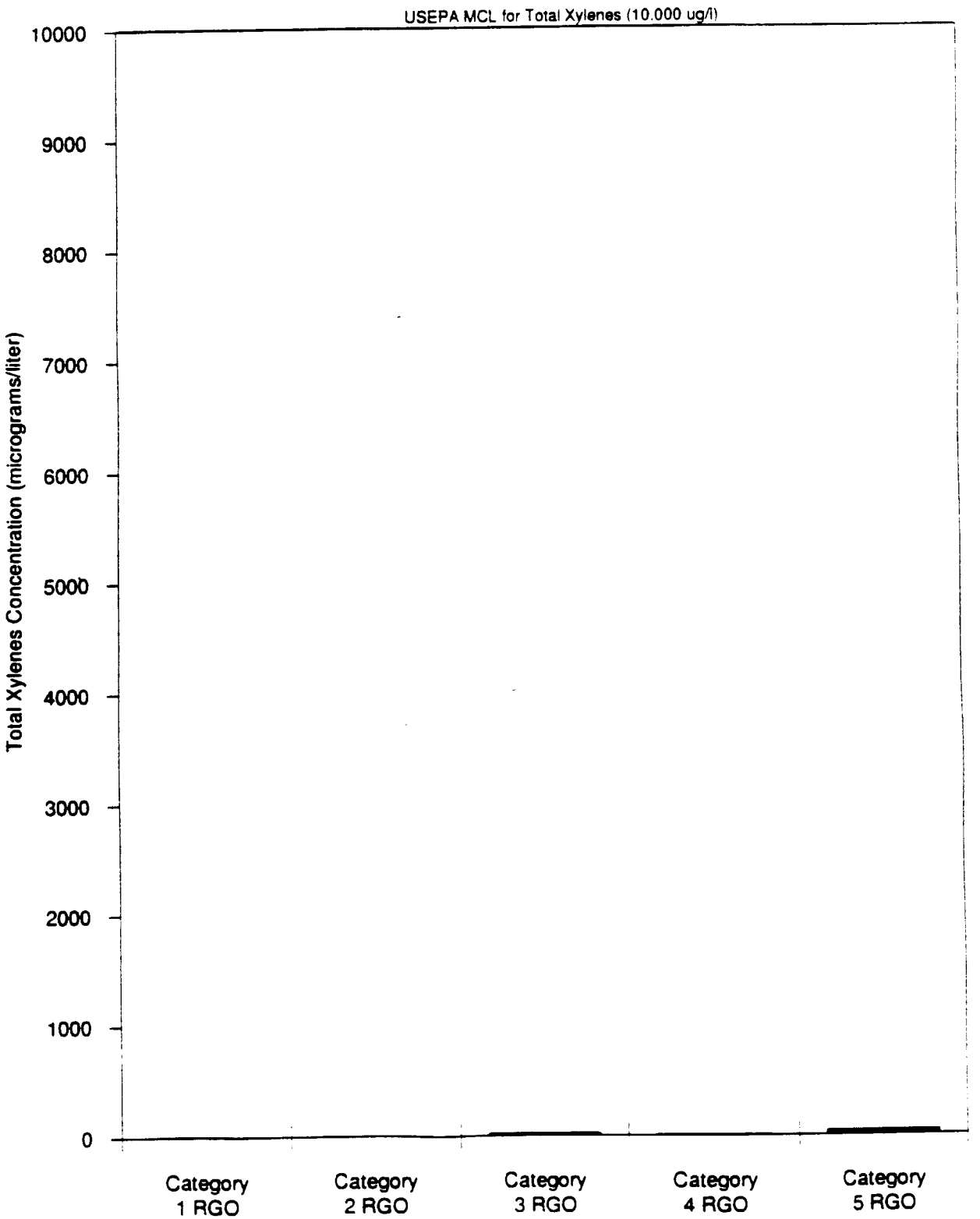
Maximum Total Xylenes Concentration Detected



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United States
Environmental Protection
Agency

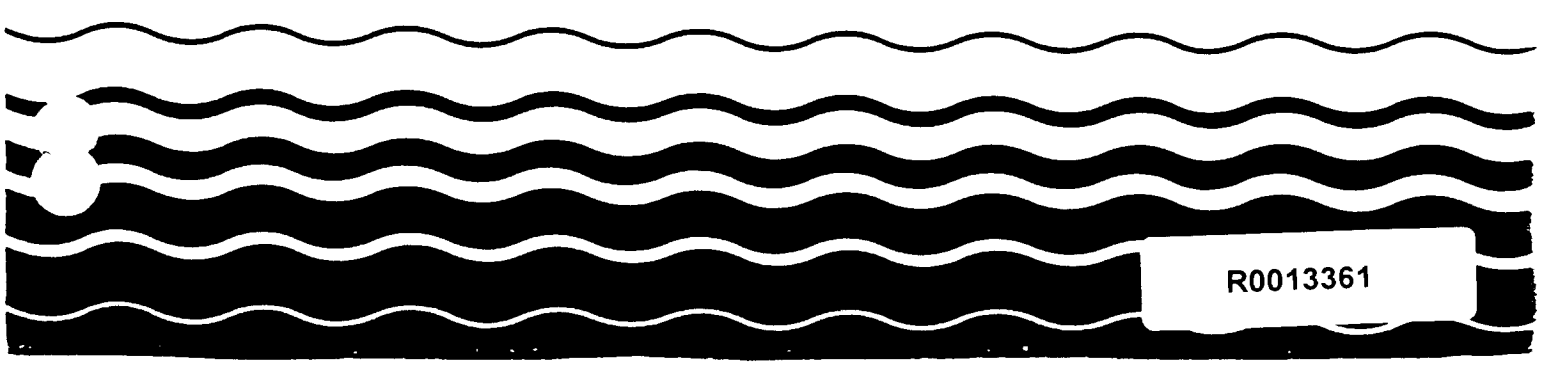
Office Of Water
(EN-336)

EPA 833-B-92-001
July 1992

EPA

NPDES Storm Water Sampling Guidance Document

Printed on Recycled Paper



DISCLAIMER

This document was issued in support of EPA regulations and policy initiatives involving the development and implementation of a national storm water program. This document is agency guidance only. It does not establish or affect legal rights or obligations. Agency decisions in any particular case will be made applying the laws and regulations on the basis of specific facts when permits are issued or regulations promulgated. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

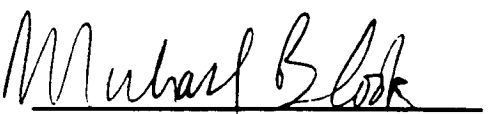
Pollutants in storm water discharges from many sources are largely uncontrolled. The National Water Quality Inventory, 1990 Report to Congress provides a general assessment of water quality based on biennial reports submitted by the States under Section 305(b) of the Clean Water Act. The report indicates that roughly 30% of identified cases of water quality impairment reported by the States are attributable to storm water discharges.

Sampling data from storm water discharges is an important tool which provides information on the types and amounts of pollutants present. This data can then be used to identify pollutant sources and to develop storm water pollution prevention plans and best management practices priorities to control these sources.

This manual is for operators of facilities that discharge storm water associated with industrial activity and operators of large and medium municipal separate storm sewer systems. This manual describes the basic sampling requirements for NPDES storm water discharge permit applications and provides procedural guidance on how to conduct sampling. Many of the concepts in this guidance may also be applicable to sampling requirements contained in NPDES storm water permits.

This document was issued in support of EPA regulations and policy initiatives involving the development and implementation of a national storm water program. This document is agency guidance only. It does not establish or affect legal rights or obligations. Agency decisions in any particular case will be made applying the laws and regulations on the basis of specific facts when permits are issued or regulations promulgated.

This document is expected to be revised periodically to reflect advances in this rapidly evolving area. Comments from users are welcomed. Send comments to the U.S. Environmental Protection Agency, Office of Wastewater Enforcement and Compliance, 401 M Street, SW, Mailcode EN-336, Washington, DC 20460.



Michael Cook,
Director
Office of Wastewater Enforcement
and Compliance

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NPDES STORM WATER SAMPLING GUIDANCE DOCUMENT

1. INTRODUCTION

The 1972 Federal Water Pollution Control Act [(FWPCA), also referred to as the Clean Water Act (CWA)] prohibits the discharge of any pollutant to waters of the U.S. from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. Efforts to improve water quality under the NPDES program have focused traditionally on reducing pollutants in industrial process wastewater discharges and from municipal sewage treatment plants. Past efforts to address storm water discharges, in particular through the NPDES program, have generally been limited to certain industrial categories, using effluent limitations for storm water as a permit condition.

Recognizing the need for more comprehensive control of storm waters discharges, Congress amended the CWA in 1987 and established a two-phase program. In Phase I, Congress required the U.S. Environmental Protection Agency (EPA) to establish NPDES requirements for certain classes of storm water discharges.

- A storm water discharge for which a permit has been issued prior to February 4, 1987
- A storm water discharge associated with industrial activity
- A storm water discharge from a municipal separate storm sewer system serving a population of 250,000 or more (large system)
- A storm water discharge from a municipal separate storm sewer system serving a population of 100,000 or more, but less than 250,000 (medium system)
- A discharge for which the Administrator or the State determines that the storm water discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to the waters of the United States.

To implement these requirements, EPA published on November 16, 1990 (55 Fed. Reg. 47990), permit application requirements that include storm water sampling. EPA and the States will subsequently issue NPDES storm water permits based on these applications, and many of these

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permits will require storm water sampling. Congress intended for EPA to address all other point source discharges of storm water in Phase II of the program.

1.1 PURPOSE OF THIS MANUAL

This manual is for operators of facilities that discharge storm water associated with industrial activity and operators of large and medium municipal separate storm sewer systems. Storm water sampling is sometimes difficult due to the unpredictability of storm events and the variable nature of storm water discharges. This manual is primarily designed to assist operators/owners in planning for and fulfilling the NPDES storm water discharge sampling requirements for permit applications as well as for other storm water sampling needs.

It is assumed that applicants already have a basic understanding of the storm water permit application requirements. This document is designed to supplement existing storm water application guidance by focusing on the technical aspects of sampling. Since many industrial storm water permits and all municipal storm water permits will require regular storm water sampling, many of the concepts in this guidance may be applicable to sampling requirements contained in NPDES storm water permits.

The information in this manual pertains specifically to individual industrial storm water applications, group storm water applications (Part 2), and municipal Part 2 storm water permit applications for storm water discharges. For information on other storm water application requirements for industrial facilities and large and medium municipal separate storm sewer systems, see EPA's Guidance Manual for the Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity (EPA-505/8-91-002, April 1991), and EPA's Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems (EPA-505/8-91-003A, April 1991), respectively. These manuals can be requested by calling the Storm Water Hotline [(703) 821-4823] or the National Technical Information Service (NTIS) [(703) 487-4650]. Additional background documents for further information are listed in Technical Appendix D.

1.2 ORGANIZATION OF THIS MANUAL

This manual explains the basic requirements of storm water sampling and provides procedural guidance on sampling for permit applications. Chapter 2 discusses background information (i.e., a

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summary of permit application requirements, who must sample, when and where to sample, and staffing considerations). Chapter 3 presents the fundamentals of sampling (i.e., types of sampling, obtaining flow data, handling samples, and sending them to the laboratory). Chapter 4 presents analytical considerations, including the storm water pollutants that must be analyzed under the regulations. Chapter 5 discusses regulatory flexibility with respect to storm water sampling, and Chapter 6 includes health and safety considerations.

Technical Appendices provide information as follows:

- Technical Appendix A—Forms 2F and 1
- Technical Appendix B—NOAA Weather Radio Information
- Technical Appendix C—Required Containers, Preservation Techniques, Holding Times and 40 Code of Federal Regulations (CFR) Part 136
- Technical Appendix D—References
- Technical Appendix E—Glossary
- Technical Appendix F—Acronyms.

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2. BACKGROUND FOR STORM WATER SAMPLING

This chapter presents background information, definitions, and a description of the fundamentals of sampling. Specifically, it covers the following areas:

- The benefits of sampling
- A summary of storm water application regulations
- Who must sample
- When sampling is required
- Where to sample
- Staffing considerations

In response to the 1987 Water Quality Act amendments to the CWA, EPA published the storm water final rule on November 16, 1990. In this rule, EPA established the initial scope of the storm water program by defining the phrase "storm water discharge associated with industrial activity" in terms of 11 categories of industrial activity and the phrase "large and medium municipal separate storm sewer systems" to include municipal systems serving a population greater than 100,000. These terms are discussed in greater detail in Section 2.6, "Who Must Sample."

In addition to defining the initial scope of the storm water program, the final rule established permit application requirements, including requirements for storm water sampling. Sampling data gathered for the application will be used to characterize storm water discharges, and will serve as a basis for establishing requirements in NPDES storm water permits. It is important to note that the applicant must report data that are representative of the storm water discharge, and that the intentional misrepresentation of discharge characteristics is unlawful.

2.1 BENEFITS OF SAMPLING

Data that characterize storm water discharges are valuable to permitting authorities and permittees for several reasons. First, storm water sampling provides a means for evaluating the environmental risk of the storm water discharge by identifying the types and amounts of pollutants present. Evaluating these data helps to determine the relative potential for the storm water discharge to contribute to water quality impacts or water quality standard violations. And, storm water sampling

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data can be used to identify potential sources of pollutants. These sources can then be either eliminated or controlled more specifically by the permit.

2.2 INDUSTRIAL FACILITY APPLICATION REQUIREMENTS

The storm water permit application regulations provide operators of facilities (including those owned by the government) that have storm water discharges associated with industrial activity with three application options: (1) submit an individual application; (2) participate in a group application (a two-part application); or (3) submit a Notice of Intent (NOI) to be covered by a general permit where general permits are available. This guidance focuses on sampling requirements for individual applications and Part 2 of group applications. Sampling data generally will not be required for an NOI, however, the general permit may require sampling during the term of the permit. State permitting authorities may also require sampling information for an NOI at their discretion, and should, therefore, be consulted prior to submittal.

Industrial facilities submitting individual applications must submit sampling data on a completed application Form 2F (entitled "Application for Permit to Discharge Storm Water Discharges Associated with Industrial Activity"). Facilities selected to be part of the sampling subgroup for a group application must submit sampling data with Part 2 of the application. Members of the sampling subgroup must complete only the quantitative data portions of Form 2F, including Sections VII, VIII, IX, and the certification in Section X. Exhibit 2-1 details the types of information required for each section of Form 2F. Exhibit 2-2 describes what sampling information must be provided in Part 2 of the group application. It should be noted that States may require the use of different forms and submittal of additional documentation.

Form 1 must also be submitted with Form 2F by applicants submitting individual permit applications. General information about the facility is provided on Form 1 (i.e., addresses, operators, etc.); it does not request sampling data. Forms 1 and 2F are reproduced in Technical Appendix A.

Facilities with unpermitted combined discharges of storm water and process or nonprocess wastewater must submit Form 2C or 2E, respectively, in addition to Forms 1 and 2F. Facilities with storm water discharges combined with new sources or new discharges of process wastewater must submit Form 2D as well as Forms 1 and 2F.

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EXHIBIT 2-1. FORM 2F APPLICATION REQUIREMENTS	
Section	**Requirement**
2F-I	Outfall location(s), including longitude and latitude and receiving water(s)
2F-II	Facility improvements which may affect the discharges described in the application
2F-III	Site drainage map
2F-IVA	Estimates of impervious area within each outfall drainage area
2F-IVB	A narrative description of pollutant sources (i.e., onsite materials which may come in contact with storm water runoff)
2F-IVC	Location and description of existing structural and nonstructural pollutant control measures
2F-VA	Certification that outfalls have been tested or evaluated for non-storm water discharges
2F-VB	Description of method used for testing/evaluating presence of non-storm water discharges
2F-VI	History of significant leaks or spills of toxic or hazardous pollutants at the facility within the last 3 years
2F-VII	Discharge characterization for all required pollutants
2F-VIII	Statement of whether biological testing for acute or chronic toxicity was performed and list of pollutants it was performed for
2F-IX	Information on contract laboratories or consulting firms
2F-X	Certification that information supplied is accurate and complete
Note: See Form 2F and the instructions for more detail on application requirements.	

2.3 MUNICIPALITIES' APPLICATION REQUIREMENTS

Operators of large and medium municipal separate storm sewer systems are required to submit a two-part application. Both parts contain sampling requirements: Part 1 requires information characterizing discharges from the separate storm sewer system, including field screening sample data for identifying illicit/illegal connections; Part 2 requires sampling at representative locations and estimates of pollutant loadings for those sites. These sampling data are to be used to design a long-term storm water monitoring plan that will be implemented during the term of the permit. The sampling data that must be submitted in Parts 1 and 2 of municipal applications are listed in Exhibit 2-3. There is no standard application form for municipalities.

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EXHIBIT 2-2. PART 2 GROUP APPLICATION SAMPLING REQUIREMENTS

Quantitative Testing Data

- For groups with 4 to 20 members, 50 percent of the facilities must submit data; for groups with 21 to 99 members, a minimum of 10 dischargers must submit quantitative data; for groups with 100 to 1,000 members, a minimum of 10 percent of the facilities must submit data; for groups with greater than 1,000 members, no more than 100 facilities must submit data; there must be 2 dischargers from each precipitation zone in which 10 or more members of the group are located, or 1 discharger from each precipitation zone in which 9 or fewer members are located.
- Sampling and analysis requirements are described in 40 Code of Federal Regulations (CFR) 122.26(c)(1)(i)(E) and 40 CFR 122.21(g)(7). Pollutants to be analyzed depend on the type(s) of industries applying as a group.
- Sampling subgroup must provide all quantitative discharge information required in Form 2F Sections VII-IX plus the certification in Section X.
- The group application sampling subgroup must collect grab samples during the first 30 minutes of the storm event and flow-weighted composite samples as required in 40 CFR 122.21(g)(7).

2.4 APPLICATION SUBMITTAL DEADLINES

Deadlines for submitting permit applications and associated sampling requirements are presented in Exhibit 2-4 for individual and group industrial applications and for municipal applications.

2.5 WHERE TO SUBMIT APPLICATIONS

Storm water discharge permit applications are generally submitted directly to the permit-issuing authority. The appropriate authority is the State, where the State has been granted the authority to issue NPDES permits, or the EPA Regional office, where the State does not have NPDES authorization. Exhibit 2-5 indicates which States have approved NPDES permitting programs. It also provides contact names and addresses where applications should be submitted for each State or EPA Regional Office (depending on who the permitting authority is in each case). It should be noted, however, that both parts of a group application must instead be submitted to EPA Headquarters. Group applications must be sent to: Director, Office of Wastewater Enforcement and Compliance, Attention Mr. William Swietlik, U.S. EPA, EN-336, 401 M Street, SW, Washington, DC 20640.

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EXHIBIT 2-3. MUNICIPAL APPLICATION SAMPLING REQUIREMENTS

Part 1

- Monthly mean rainfall and snowfall estimates
- Existing quantitative data on the depth and quality of storm water discharges
- A list of receiving water bodies and existing information concerning known water quality impacts
- Field screening analysis for illicit connections and illegal dumping
- Identification of representative outfalls for further sampling in Part 2

Part 2

- Quantitative data from 5 to 10 representative locations in approved sampling plans
- Estimates of the annual pollutant load and event mean concentration (EMC) of system discharges
- Proposed schedule to provide estimates of seasonal pollutant loads and the EMC for certain detected constituents in a representative storm event during the term of the permit
- Proposed monitoring program for representative data collection during the term of the permit

Applications submitted by industrial facilities must be certified by a responsible corporate officer as described in 40 CFR 122.22 (e.g., president, secretary, treasurer, vice president of the corporation in charge of a principal business function). Applications submitted by municipalities must be certified by a principal executive officer or ranking elected official as described in 40 CFR 122.22.

2.6 WHO MUST SAMPLE

Operators of facilities that have storm water discharges associated with industrial activity and operators of large and medium municipalities are required to conduct storm water sampling as part of their NPDES permit applications. Specifically, the following types of industries and municipalities must sample storm water discharges:

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EXHIBIT 2-4. PERMIT APPLICATION SUBMISSION DEADLINES

	Date	Sampling Requirement
Industrial		
Individual	October 1, 1992	Sampling data due
Group		
• Part 1	September 30, 1991	Sampling subgroup identified
• Part 2	October 1, 1992	Sampling data due
Municipal		
Large Municipalities		
• Part 1	November 18, 1991	Illicit connection screening due and identification of sampling points
• Part 2	November 16, 1992	Effluent characterization due Monitoring management program identified
Medium Municipalities		
• Part 1	May 18, 1992	Illicit connection screening due and identification of sampling points
• Part 2	May 17, 1993	Effluent characterization due Monitoring management program identified

*NOI under a general permit is due on October 1, 1992 or the date specified in the permit, whichever comes first.

- Storm Water Discharges Associated With Industrial Activities - Under Phase I, the storm water permit application regulations identify, by Standard Industrial Classification (SIC) code and narrative description, 11 categories of facilities considered to be "engaging in industrial activity" for the purposes of storm water permit application requirements. Those facilities included in 40 CFR 122.26(b)(14)(i) through (xi) of the storm water permit application regulations with storm water point source discharges to waters of the U.S. or separate storm sewers and those designated under Section 402(p)(2)(E) of the CWA are required to apply for storm water permit coverage by October 1, 1992. Industrial facilities include those that are Federally, State, or municipally owned or operated. Exhibit 2-6 lists these industrial facilities. The Transportation Act of 1991 provides an exemption from storm water permitting requirements for certain industrial activities owned or operated by municipalities with a population of less than 100,000. Such municipalities must submit storm water discharge permit applications for only airports, power plants, and uncontrolled sanitary landfills that they own or operate, unless a permit is otherwise required by the permitting authority

- Municipal Separate Storm Sewer Systems - Under Phase I, those municipalities with separate storm sewer systems serving 100,000 people or more are required to submit an application for discharges from the system. (Only the part of the population served by municipal separate storm sewers is to be included in the 100,000 count, not the part served by combined sewers.) Regulated municipalities are listed in Appendices F through I in the November 16, 1990, final rule or have been designated by their permitting authority.

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EXHIBIT 2-5. NPDES STORM WATER PROGRAM PERMITTING AUTHORITIES

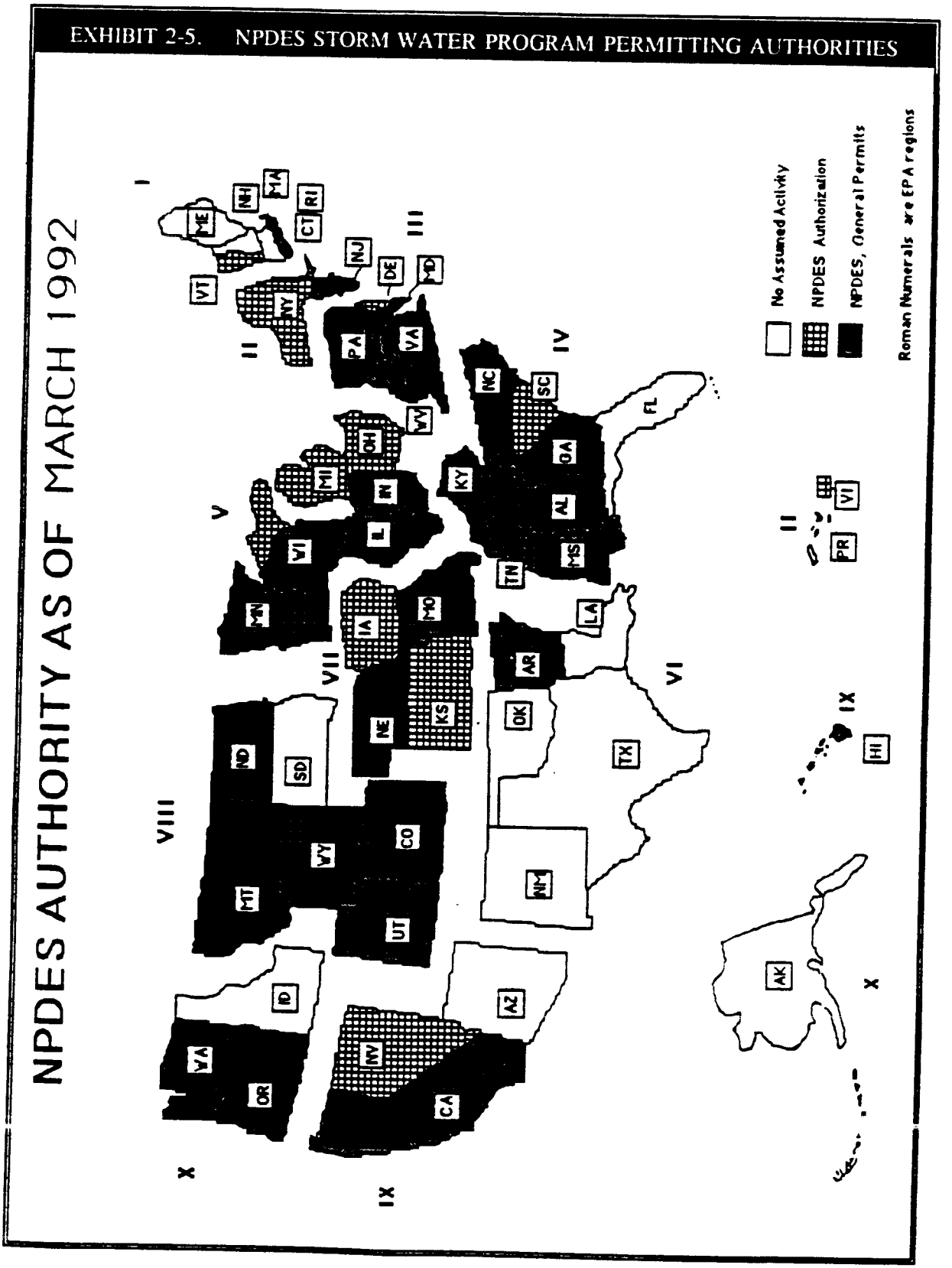

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EXHIBIT 2-5. NPDES STORM WATER PROGRAM PERMITTING AUTHORITIES (Continued)

State	Permitting Authority	Contact
Alabama	yes	Aubrey White Water Division 1751 Dickinson Dr. Montgomery, AL 36130 (205) 271-7811
Alaska	no	Steve Bubnick U.S. EPA Region 10 1200 6th Ave. WD-134 Seattle, WA 98101 (206) 553-8399
Arizona	no	Eugene Bromley U.S. EPA Region 9 75 Hawthorne St. W-5-1 San Francisco, CA 94105 (415) 744-1906
Arkansas	yes	Marysia Jastrzebski 8001 National Dr. P.O. Box 8913 Little Rock, AR 72219-8913 (501) 562-7444
California	yes	Archie Matthews Storm Water Research Control Board Water Quality 901 P St. Sacramento, CA 95814 (916) 657-1110
Colorado	yes	Patricia Nelson Dept. of Health Water Quality Control 4210 E. 11th Ave. Denver, CO 80220 (303) 331-4590
Connecticut	yes	Dick Mason Dept. of Environmental Protection Water Management Bureau Water Discharge Management 165 Capitol Ave. Hartford, CT 06106 (203) 566-7167
Delaware	yes	Sarah Cooksey Dept. of Natural Resources Surface Water Management 89 Kings Highway P.O. Box 1401 Dover, DE 19903 (302) 739-5731
Florida	no	Chris Thomas U.S. EPA Region 4 345 Courtland St. N.E. 4WM-FP Atlanta, GA 30365 (404) 347-3633
Georgia	yes	Mike Creason Dept. of Natural Resources Environmental Protection 205 Butler St. S.E. Room 1070 Atlanta, GA 30334 (404) 656-4887
Hawaii	yes	Steve Chang Dept. of Health Clean Water Branch Five Water Front Plaza #500 Ala-Moana Blvd. Honolulu, HI 96813 (808) 586-4309
Idaho	no	Steve Bubnick U.S. EPA Region 10 1200 6th Ave. WD-134 Seattle, WA 98101 (206) 553-8399
Illinois	yes	Tim Kluge EPA Water Pollution Control 2200 Churchill Rd. P.O. Box 19276 Springfield, IL 62794-9276 (217) 782-0610
Indiana	yes	Lonnie Brumfield Dept. of Environmental Management NPDES Permits Group 105 S. Meridian St. P.O. Box 6015 Indianapolis, IN 46206 (317) 232-8705
Iowa	yes	Monica Wenk Department of Natural Resources Wallace State Building 900 E. Grand St. Des Moines, IA 50319-0034 (515) 281-7017
Kansas	yes	Don Carlson Dept. of Environment Water Bureau Forbes Field, Building 740 Topeka, KS 66620 (913) 296-5555

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EXHIBIT 2-5. NPDES STORM WATER PROGRAM PERMITTING AUTHORITIES (Continued)

State	Permitting Authority	Contact
Kentucky	yes	Douglas Allgeier Dept. of Environmental Protection Water Division 18 Reilly Road Frankfort, KY 40601 (502) 564-3410
Maine	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
Massachusetts	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
Minnesota	yes	Scott Thompson Pollution Control Agency 520 Lafayette Rd. St. Paul, MN 55155-3898 (612) 296-7203
Missouri	yes	Bob Hentges Dept. of Natural Resources Water Pollution Control Program 205 Jefferson St. P.O. Box 176 Jefferson City, MO 65102 (314) 751-6825
Nebraska	yes	Clark Smith Environmental Control Water Quality Division P.O. Box 98922 Lincoln, NE 68509 (402) 471-4239
New Hampshire	no	Shelley Puleo U.S. EPA Region 1 U.S. EPA/JFK Building/WCP Boston, MA 02203 (617) 565-3525
New Mexico	no	Brent Larson U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Louisiana	no	Brent Larson U.S. EPA Region 6 1455 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Maryland	yes	Edward Gertler MD Dept. of Environment Industrial Discharge Program 2500 Broening Highway Baltimore, MD 21224 (410) 631-3323
Michigan	yes	Gary Boersen Dept. of Natural Resources Surface Water Division P.O. Box 30028 Lansing, MI 48909 (517) 373-1982
Mississippi	yes	Jerry Cain Dept. of Environmental Quality Office of Pollution Control Industrial Waste Water Branch P.O. Box 10385 Jackson, MS 39289-0385 (601) 961-5171
Montana	yes	Fred Shewman Water Quality Bureau Cogswell Building Helena, MT 59620 (406) 444-2406
Nevada	yes	Rob Saunders Conservation and Natural Resources Environmental Protection 123 W. Nye Lane Carson City, NV 89710 (702) 687-4670
New Jersey	yes	Sandra Cohen NJ DEPE Office of Regulatory Policy CN029 Trenton, NJ 08625-0029 NJ Hotline: (609) 633-7021
New York	yes	Ken Stevens Wastewater Facilities Design NY State DEC 50 Wolf Road Albany, NY 12233 (518) 457-1157

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EXHIBIT 2-5. NPDES STORM WATER PROGRAM PERMITTING AUTHORITIES (Continued)

State	Permitting Authority	Contact
North Carolina	yes	Coleen Sullins Environmental Management Water Quality Planning P.O. Box 29535 Raleigh, NC 27626-0535 (919) 733-5083
Ohio	yes	Bob Phelps OEPA Water Pollution Control P.O. Box 1049 1800 Watermark Columbus, OH 43266 (614) 644-2034
Oregon	yes	Ranei Nomura DEQ-Water Quality 811 SW 6th St. Portland, OR 97204 (503) 229-5256
Puerto Rico	no	José Rivera U.S. EPA Region 2 Water Permits & Compliance Branch 26 Federal Plaza, Room 845 New York, NY 10278 (212) 264-2911
South Carolina	yes	Birgot McDade Dept. of Health & Env. Ctrl. Industry and Agriculture Waste Water Division 2600 Bull St. Columbia, SC 29201 (803) 734-5241
Tennessee	yes	Robert Haley Dept. of Environment Water Pollution Control 150 9th Ave. N., 4th Floor Nashville, TN 37243-1534 (615) 741-2275
Utah	yes	Harry Campbell Dept. of Environmental Quality P.O. Box 16690 Salt Lake City, UT 84116 (801) 538-6146
North Dakota	yes	Sheila McClenathan Dept. of Health Water Quality Division 1200 Missouri Ave. P.O. Box 5520 Bismarck, ND 58502-5520 (701) 221-5210
Oklahoma	no	Brent Larson U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Pennsylvania	yes	R.B. Patel Environmental Resources Water Quality Management P.O. Box 2063 Harrisburg, PA 17120 (717) 787-8184
Rhode Island	yes	Angela Liberti Division of Water Resources 291 Promenade St. Providence, RI 02908 (401) 277-6519
South Dakota	no	Vern Berry U.S. EPA Region 8 999 18th St. 8-WM-C Denver, CO 80202-2466 (303) 293-1630
Texas	no	Brent Larson U.S. EPA Region 6 1445 Ross Ave. 6W-PM Dallas, TX 75202 (214) 655-7175
Vermont	yes	Brian Koiker Environmental Conservation Permits and Compliance 103 S. Main St. Annex Building Waterbury, VT 05671-0405 (802) 244-5674

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EXHIBIT 2-5. NPDES STORM WATER PROGRAM PERMITTING AUTHORITIES (Continued)

State	Permitting Authority	Contact
Virgin Islands	yes	Marc Pacifico Dept. of Planning & Natural Resources 1118 Watergut Project Christiansted St. Croix, VI 00820-5065 (809) 773-0565
Washington	yes	Gary Kruger Dept. of Ecology Water Quality Division P.O. Box 47600 Olympia, WA 98504-7600 (206) 438-7529
West Virginia	yes	Jerry Ray Division of Water Resources 1201 Greenbriar St. Charleston, WV 25311 (304) 348-0375
Wyoming	yes	John Wagner Dept. of Environmental Quality Herschler Building, 4th Floor Cheyenne, WY 82002 (307) 777-7082
Virginia	yes	Burton Tuxford Water Control Board Permits Section P.O. Box 11143 Richmond, VA 23230-1143 (804) 527-5083
Washington D.C.	no	Kevin Magerr U.S. EPA Region 3 841 Chestnut Bldg. 3WM53 Philadelphia, PA 19107 (215) 597-1651
Wisconsin	yes	Anne Mauel Dept. of Natural Resources Wastewater Management P.O. Box 7921 Madison, WI 53707 (608) 267-7364

2.7 WHEN SAMPLING IS REQUIRED

Industrial individual and group applicants must include sampling data from at least one representative storm event. Operators of large or medium municipal separate storm sewer systems must submit sampling data from three different representative storm events. How to determine "representativeness" and other considerations for when to sample are presented below.

2.7.1 STORM EVENT CRITERIA

Storm water discharge permit application requirements establish specific criteria for the type of storm event that must be sampled:

- The depth of the storm must be greater than 0.1 inch accumulation
- The storm must be preceded by at least 72 hours of dry weather
- Where feasible, the depth of rain and duration of the event should not vary by more than 50 percent from the average depth and duration.

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EXHIBIT 2-6. INDUSTRIAL FACILITIES WHICH MUST SUBMIT APPLICATIONS FOR STORM WATER PERMITS

40 CFR 122.26(b)(14) Subpart	Description
(i)	Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutants effluent standards under 40 CFR, Subchapter N [except facilities which are exempt under category (xi)].
(ii)	Facilities classified as: SIC 24 (except 2434) . . . . . Lumber and Wood Products SIC 26 (except 265 and 267) . Paper and Allied Products SIC 28 (except 283 and 285) . Chemicals and Allied Products SIC 29 . . . . . Petroleum and Coal Products SIC 311 . . . . . Leather Tanning and Finishing SIC 32 (except 323) . . . . . Stone, Clay and Glass Products SIC 33 . . . . . Primary Metal Industries SIC 3441 . . . . . Fabricated Structural Metal SIC 373 . . . . . Ship and Boat Building and Repairing
(iii)	Facilities classified as SIC 10 through 14, including active or inactive mining operations and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with, or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts, or waste products located on the site of such operations. SIC 10 . . . . . Metal Mining SIC 11 . . . . . Anthracite Mining SIC 12 . . . . . Coal Mining SIC 13 . . . . . Oil and Gas Extraction SIC 14 . . . . . Nonmetallic Minerals, except Fuels
(iv)	Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under Subtitle C of the Resource Conservation and Recovery Act (RCRA).
(v)	Landfills, land application sites, and open dumps that receive or have received any industrial wastes including those that are subject to regulation under subtitle D or RCRA.
(vi)	Facilities involved in the recycling of material, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but limited to those classified as: SIC 5015 . . . . . Motor Vehicle Parts, Used SIC 5093 . . . . . Scrap and Waste Materials
(vii)	Steam electric power generating facilities, including coal handling sites.
(viii)	Transportation facilities which have vehicle maintenance shops, equipment cleaning operations, or airport de-icing operations. Only those portions of the facility that are either involved in vehicle maintenance (including vehicle rehabilitation, mechanical repairs, painting, fuelling, and lubrication), equipment cleaning operations, or airport de-icing operations, or which are otherwise listed in another category, are included. SIC 40 . . . . . Railroad Transportation SIC 41 . . . . . Local and Suburban Transit SIC 42 (except 4221-25) . . . . Motor Freight and Warehousing SIC 43 . . . . . U.S. Postal Service SIC 44 . . . . . Water Transportation SIC 45 . . . . . Transportation by Air SIC 5171 . . . . . Petroleum Bulk Stations and Terminals

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EXHIBIT 2-6. INDUSTRIAL FACILITIES WHICH MUST SUBMIT APPLICATIONS FOR STORM WATER PERMITS (Continued)

40 CFR 122.26(b)(14) Subpart	Description
(ix)	Treatment works treating domestic sewage or any other sewage sludge or wastewater treatment device or system, used in the storage, treatment, recycling, and reclamation of municipal or domestic sewage, including lands dedicated to the disposal of the sewage sludge that are located within the confines of the facility, with a design flow of 1.0 million gallons per day or more, or required to have an approved pretreatment program under 40 CFR Part 403. Not included are farm lands, domestic gardens, or lands used for sludge management where sludge is beneficially reused and which are not physically located in the confines of the facility, or areas that are in compliance with Section 405 of the CWA.
(x)	Construction activity including clearing, grading, and excavation activities except operations that result in the disturbance of less than 5 acres of total land area and those that are not part of a larger common plan of development or sale.*
(xi)	Facilities under the following SICs [which are not otherwise included in categories (ii)-(x)], including only storm water discharges where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, byproducts, or industrial machinery are exposed to storm water.* SIC 20 . . . . . Food and Kindred Products SIC 21 . . . . . Tobacco Products SIC 22 . . . . . Textile Mill Products SIC 23 . . . . . Apparel and Other Textile Products SIC 2434 . . . . . Wood Kitchen Cabinets SIC 25 . . . . . Furniture and Fixtures SIC 265 . . . . . Paperboard Containers and Boxes SIC 267 . . . . . Converted Paper and Paper Board Products (except containers and boxes) SIC 27 . . . . . Printing and Publishing SIC 283 . . . . . Drugs SIC 285 . . . . . Paints, Varnishes, Lacquer, Enamels SIC 30 . . . . . Rubber and Misc. Plastics Products SIC 31 (except 311) . . . . . Leather and Leather Products SIC 323 . . . . . Products of Purchased Glass SIC 34 (except 3441) . . . . . Fabricated Metal Products SIC 35 . . . . . Industrial Machinery and Equipment, except Electrical SIC 36 . . . . . Electronic and Other Electric Equipment SIC 37 (except 373) . . . . . Transportation Equipment SIC 38 . . . . . Instruments and Related Products SIC 39 . . . . . Miscellaneous Manufacturing Industries SIC 4221 . . . . . Farm Products Warehousing and Storage SIC 4222 . . . . . Refrigerated Warehousing and Storage SIC 4225 . . . . . General Warehousing and Storage

Source: Federal Register, Vol. 55, No. 222, p. 48065, November 16, 1990.
*On June 11, 1992, the U.S. Court of Appeals for the Ninth Circuit remanded the exemption for construction sites of less than five acres in category (x) and for manufacturing facilities in category (xi) which do not have materials or activities exposed to storm water to the EPA for further rulemaking. (Nos. 90-70671 & 91-70200).

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These criteria were established to: (1) ensure that adequate flow would be discharged; (2) allow some build-up of pollutants during the dry weather intervals; and (3) ensure that the storm would be "representative," (i.e., typical for the area in terms of intensity, depth, and duration).

Collection of samples during a storm event meeting these criteria ensures that the resulting data will accurately portray the most common conditions for each site. However, the permitting authority is authorized to approve modifications of this definition (especially for applicants in arid areas where there are few representative events). Section 5.1 of Chapter 5 discusses general protocol for requesting modifications to application requirements, including the definition of "representative storm."

In determining whether a storm is representative, there are two important steps to take. First, data on local weather patterns should be collected and analyzed to determine the range of representative storms for a particular area. Second, these results should be compared to measurements of duration, intensity, and depth to ensure that the storm to be sampled fits the representativeness criteria.

2.7.2 OBTAINING RAINFALL DATA

Several sources provide accurate local weather information for both: (1) determining what a representative storm event is for a particular area; and (2) assessing expected storm events to determine whether a predicted rainfall will be "representative," and thus, meet the requirements for storm water sampling. The National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center's (NCDC's) Climate Services Branch is responsible for collecting precipitation data. Data on hourly, daily, and monthly precipitation for each measuring station (with latitude and longitude) are available to the public on computer diskette, microfiche, or hard copy. Orders can be placed by calling **(704) 259-0682**, by fax at **(704) 259-0876**, or by writing to NCDC, Climate Services Branch, The Federal Building, Asheville, North Carolina 28071-2733.

The National Weather Service (NWS) of NOAA can also provide information on historic, current, and future weather conditions. Local NWS telephone numbers can be obtained from the NWS Public Affairs Office at **(301) 713-0622**. Telephone numbers are also usually in local phone directory listings under "National Weather Service" or "Weather." In addition, NOAA runs the NOAA NWS

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Weather Radio, which provides continuous broadcasts of the most current weather information. This broadcast can be accessed with a radio that has a weather band feature. Approximately 90 percent of the United States population is within listening range of the 380 NWS stations. Technical Appendix B presents additional information on NOAA Weather Radio, including radio frequencies for specific locations and a listing of weather band radio manufacturers. Telephone recordings of weather conditions are also provided by most NWS offices.

Cable TV weather stations and local airports can also provide weather information. Weather information provided by the local newspaper or TV stations should be used only if more accurate data (as described above) are unavailable, since weather forecasts can change drastically within several hours.

Someone should be designated at the facility to follow current weather conditions by listening to NOAA Weather Radio, calling the local NWS offices, and watching cable TV weather news. Exhibit 2-7 presents a storm water sampling decision chart for mobilizing field personnel for a probable storm event.

Annual rainfall statistics can also be used to evaluate representativeness of storm events. For example, Exhibit 2-8 presents fifteen rain zones in the United States and related storm event statistics. (These rain zones are not those shown in 40 CFR Part 122 Appendix E.) To determine typical values of annual storm events for a particular facility, identify the zone in which the facility is located. The tabulated information lists the annual average number of storms and precipitation as well as the average duration, intensity, and depth of independent storm events for each zone. Care must be taken, however, in using annual rainfall statistics for determining representativeness of storm events, since the annual rainfall statistic may not be representative of seasonal rainfall events. If rainfall data is available at or close to a particular facility, it is preferable to use this data for determining average storm event statistics.

Rainfall data tabulated from NOAA precipitation data indicate for Alaska (not shown in Exhibit 2-8) that average storm events last from 14 to 24 hours in duration and are 0.6 to 1.05 inches in depth. Average storm event data for Hawaii are 9 to 11 hours in duration and from 0.6 to 1.6 inches in depth.

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EXHIBIT 2-7. DECISION CHART FOR STORM WATER SAMPLING

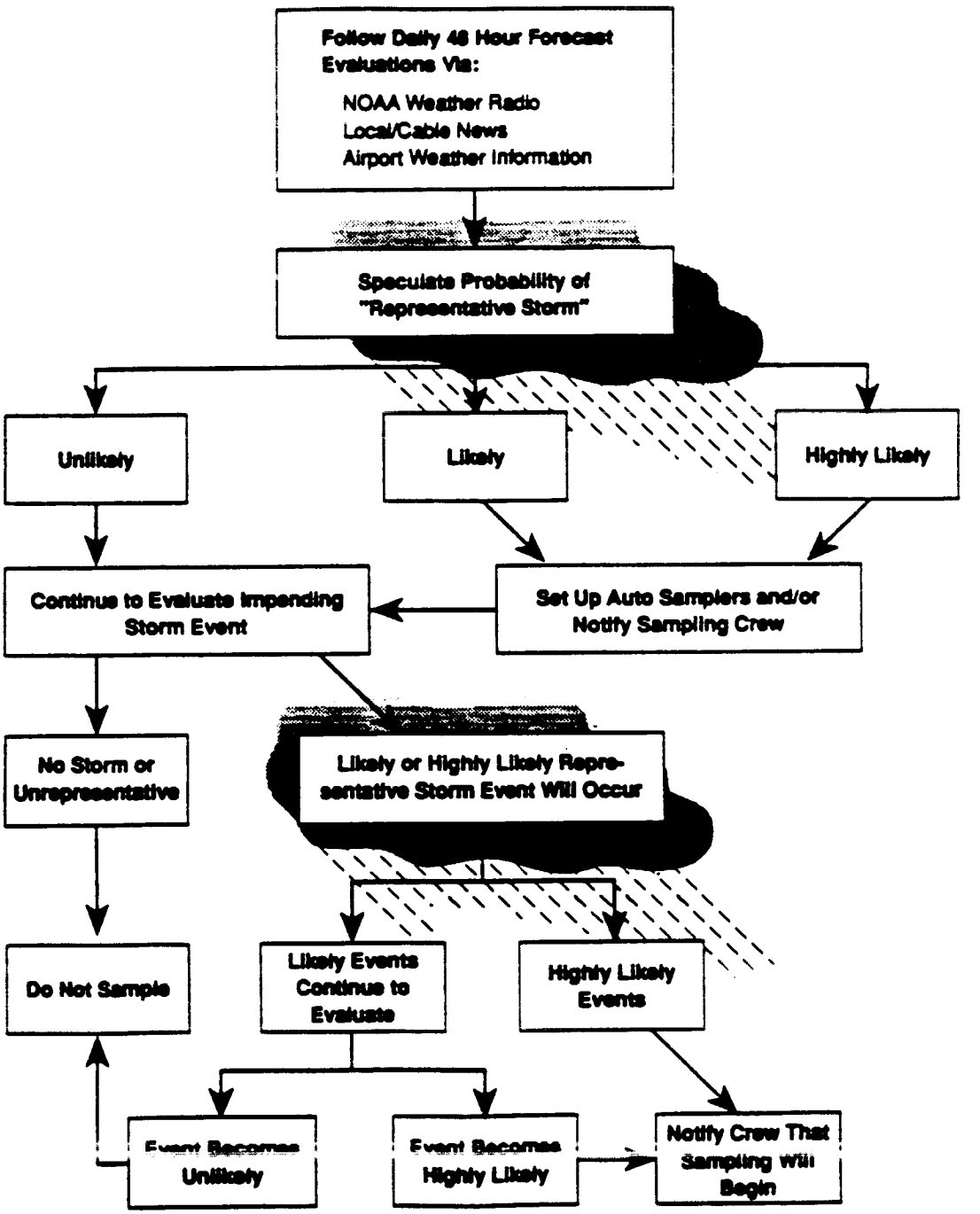

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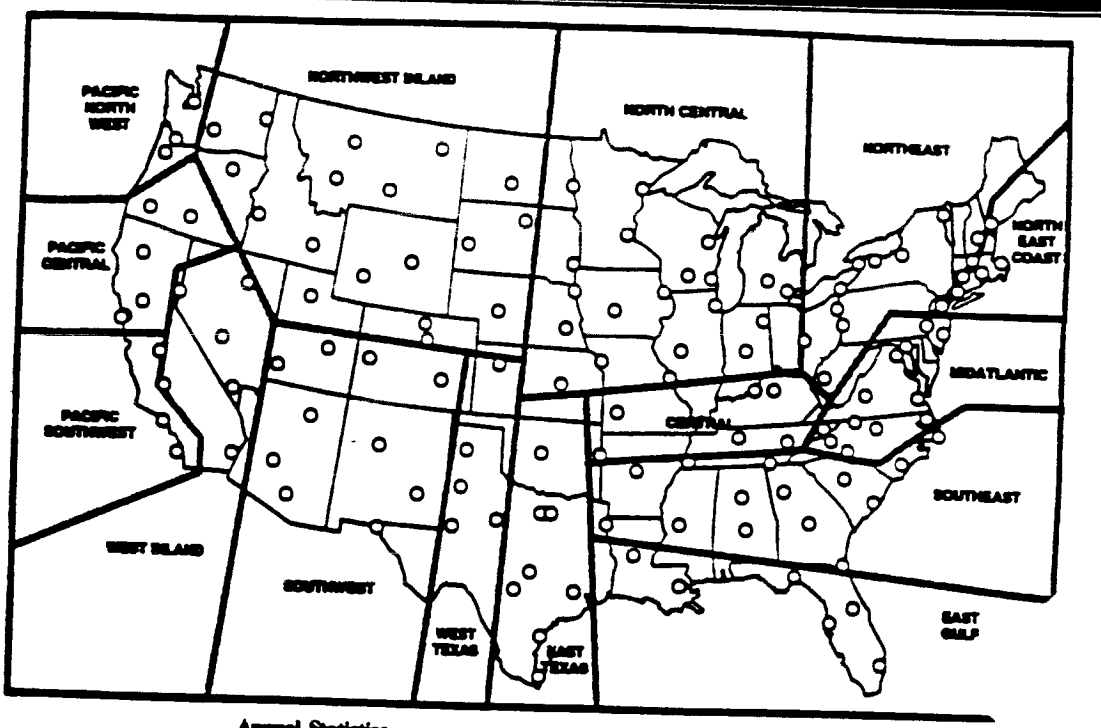
EXHIBIT 2-8. RAIN ZONES OF THE UNITED STATES



RAIN ZONE	Annual Statistics: No. of Storms Avg	No. of Storms COV	Precip. Avg (in)	Precip. COV	Independent Storm Event Statistics: Duration Avg (hr)	Duration COV	Intensity Avg (in/hr)	Intensity COV	Volume Avg (in)	Volume COV	DELTA Avg (hr)	DELTA COV
NORTH EAST	70	0.13	34.6	0.18	11.2	0.81	0.067	1.23	0.50	0.95	126	0.94
NORTH EAST—COASTAL	63	0.12	41.4	0.21	11.7	0.77	0.071	1.05	0.66	1.03	140	0.87
MIDATLANTIC	62	0.13	39.5	0.18	10.1	0.84	0.092	1.20	0.64	1.01	143	0.97
CENTRAL	68	0.14	41.9	0.19	9.2	0.85	0.097	1.09	0.62	1.00	133	0.99
NORTH CENTRAL	55	0.16	29.8	0.22	9.5	0.83	0.087	1.20	0.55	1.01	167	1.17
SOUTHEAST	65	0.15	49.0	0.20	8.7	0.92	0.122	1.09	0.75	1.10	136	1.03
EAST GULF	68	0.17	53.7	0.23	6.4	1.05	0.178	1.03	0.80	1.19	130	1.25
EAST TEXAS	41	0.22	31.2	0.29	8.0	0.97	0.137	1.08	0.76	1.18	213	1.28
WEST TEXAS	30	0.27	17.3	0.33	7.4	0.98	0.121	1.13	0.57	1.07	302	1.53
SOUTHWEST	20	0.30	7.4	0.37	7.8	0.88	0.079	1.16	0.37	0.88	473	1.46
WEST INLAND	14	0.38	4.9	0.43	9.4	0.75	0.055	1.06	0.36	0.87	786	1.54
PACIFIC SOUTH	19	0.36	10.2	0.42	11.6	0.78	0.054	0.76	0.54	0.98	476	2.09
NORTHWEST INLAND	31	0.23	11.5	0.29	10.4	0.82	0.057	1.20	0.37	0.93	304	1.43
PACIFIC CENTRAL	32	0.25	18.4	0.33	13.7	0.80	0.048	0.85	0.58	1.05	265	2.00
PACIFIC NORTHWEST	71	0.15	35.7	0.19	15.9	0.80	0.035	0.73	0.50	1.09	123	1.50

COV = Coefficient of Variation = Standard Deviation/Mean
DELTA = Interval Between Storm Midpoints
o = Rain Gauge Stations

Source: Urban Targeting and BMP Selection, U.S. EPA Region 5, November 1990.

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The NWS should be consulted for proper procedures for collecting and interpolating rainfall data if the applicant elects to collect the data rather than use existing data.

2.7.3 DETERMINING REPRESENTATIVENESS

An example of how to determine whether a rainfall event varies by more than 50 percent (i.e., is not representative) is shown in Exhibit 2-9.

EXHIBIT 2-9. EXAMPLE OF 50 PERCENT VARIANCE FROM AVERAGE RAINFALL

Event Type	Duration (hrs.)	Depth (in.)
Average event	5.2	0.43
50 percent average event	2.6	0.22
150 percent average event	7.8	0.65

Once the information on an average duration and depth storm event is obtained for a specific location, multiply these numbers by 0.5 to get the 50 percent average event numbers and multiply by 1.5 to get the 150 percent average event numbers.

A representative storm in both duration and depth for a specific area will fall between the shaded numbers above (i.e., between 2.6 and 7.8 hours in duration and 0.22 and 0.65 inches in depth).

Snowmelt creates runoff which may result in point source discharges very similar to that from other storm events. Pollutants accumulate in snow, and when a thaw occurs, the pollutants will be discharged to receiving waters much like during a rain storm event. Snowmelt may be sampled as long as the applicant works closely with the permitting authority to determine the proper sampling strategy, i.e., sampling procedures, techniques, and pollutant analyses.

For snowmelt, the sampling strategy should be developed depending on the drainage area being monitored for storm flow. The strategy should consider (1) snow removal or clearing practices, e.g., direct dumping into water bodies, plowing, and the creation of snow mounds (whether in a line along a roadway or in piles on parking lots, etc.), and (2) the melting process.

It is also important to consider what happens to snowmounds as they melt and evaporate, which can alter the pollutant concentration in the resulting runoff. In addition, pollutants from the surrounding

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air and pavement can build up on snow mound surfaces in a crust or cake-like manner eventually leaving a residue (including previously dissolved solids that become a remaining solids residue) which is later left to be washed off by rainfall, manual flushing or other mechanisms.

The sampling of snow mounds, undisturbed snow itself, and hard pack requires a carefully thought out strategy. Given the complexities associated with snowmelt sampling, applicants should have proposed sampling strategies reviewed by the permitting authority before attempting to conduct sampling.

2.7.4 LOGISTICAL PROBLEMS WITH WHEN TO SAMPLE

Applicants may encounter weather conditions that may not meet minimum "representative" storm criteria; these conditions may prevent adequate collection of storm water samples prior to application submission deadlines. For instance, sampling may be problematic in parts of the country that experience drought or near-drought conditions or areas that are under adverse weather conditions such as freezing and flooding. Events with false starts and events with stop/start rains can also cause problems. Solutions for sampling under these circumstances are discussed below.

Where the timing of storm event sampling poses a problem, it may be appropriate for the applicant to petition the permitting authority for a sampling protocol/procedure modification either prior to sampling or after sampling is conducted (if the storm event is not acceptable). When the applicant requests a sampling protocol/procedure modification, a narrative justification should be attached. This justification should be certified by a corporate official (for industrial facilities) or the principle executive officer or ranking official (for municipalities), as per 40 CFR 122.22. Section 5.1 of Chapter 5 discusses protocol/procedure modifications.

Arid Areas

For arid or drought-stricken areas where a storm event does not occur prior to the time the applicant must sample and submit data with the application form the applicant should submit the application, complete to the extent possible, with a detailed explanation of why sampling data are not provided and an appraisal of when sampling will be conducted. This explanation must be certified by the appropriate party (as described above). The applicant should also contact the permitting authority

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for further direction. Where the applicant can anticipate such problems, approval for an extension to submit sampling data should be acquired prior to the deadline.

Adverse Weather Conditions

The applicant should never conduct storm water sampling during unsafe conditions. It is likely that, in areas that experience flooding, lightening storms, high winds, etc., another representative storm event will occur for which sampling conditions will be much safer. (For further information on safety issues, see Chapter 6.) If no other storm event occurs, the applicant should submit a justification as to why the event was not sampled. This information should be certified by the appropriate official.

False Starts and Stop/Start Rains

False start and stop/start rains can also cause problems. False starts may occur when weather conditions are unpredictable and it appears that a storm event may be representative, collection begins, and then the rain stops before an adequate sample volume is obtained. (Necessary sample volumes are discussed in Section 3.6.) Some latitude may be given for the 0.1-inch rainfall requirement as long as the sample volume is adequate; the permitting authority may accept the results with applicant justification and certification. Again, see Chapter 5 for information on requesting protocol/procedure modifications to storm water sampling requirements.

During stop/start rains (those in which rainfall is intermittent), samples should be taken until an adequate sample volume is obtained. Exhibit 2-10 summarizes logistical problems of storm water sampling and presents solutions to the problems identified.

2.7.5 WHEN INDUSTRIAL FACILITIES MUST SAMPLE

Industrial applicants must generally collect two types of storm water samples: (1) grab samples collected during the first 30 minutes of discharge; and (2) flow-weighted composite samples collected during the first 3 hours of discharge (or the entire discharge, if it is less than 3 hours). Information from both types of samples is critical to fully evaluate the types and concentrations of pollutants present in the storm water discharge.

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EXHIBIT 2-10. LOGISTICAL PROBLEMS OF STORM WATER SAMPLING	
Problem:	**Arid/drought areas**
Solution:	Submit a petition requesting a modification to the protocol if problems are anticipated and, if it is approved, submit the application without sampling data by the application due date with a certified explanation. Provide sampling data to the permitting authority as soon as possible.
Problem:	**Adverse weather conditions such as freezing, flooding, winds, tornadoes, electrical storms, and gully washes**
Solution:	Sample another, less hazardous event or submit a certified justification of why the event was not sampled. Provide sampling data to the permitting authority as soon as possible.
Problem:	**False starts**
Solution:	Discard the sample if the volume is inadequate. If the volume is adequate, submit the sampling data with a certified explanation that the sample is from a non-representative event. Continue to monitor weather conditions and attempt to resample as soon as possible.
Problem:	**Stop/start rains**
Solution:	Continue to sample in case the storm event turns out to be representative and adequate sample volumes are obtained. If sample volumes are inadequate, continue to monitor weather conditions and attempt to resample as soon as possible.

The grab samples taken during the first 30 minutes of a storm event will generally contain higher concentrations of pollutants, since they pick up pollutants that have accumulated on drainage surfaces since the last storm event.

Composite samples characterize the average quality of the entire storm water discharge. Flow-weighted composite samples provide for the most accurate determination of mass load. The flow-weighted composite sample must be taken for either the first 3 hours or for the entire discharge (if the event is less than 3 hours long). Additional information on how to collect grab and composite samples is presented in Sections 3.3 and 3.4, respectively.

Industrial applicants are required at a minimum to sample only one storm event. However, if samples from more than one storm are analyzed and the results are representative of the discharge, the data representing each event must be reported. The facility must provide a description of each storm event tested. The average of all values within the last year must be determined and the

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concentration, mass, and total number of storm events sampled must be reported on Form 2F. Furthermore, sampling should be conducted during normal operating procedures (day or night), and, not when the facility has been closed for a period of time.

Industrial applicants must certify, as a separate requirement, that all outfalls have been tested or evaluated to determine whether non-storm water discharges are present (e.g., process wastewater, sanitary wastes, cooling water, or rinse water) or whether illegal/illicit connections are occurring in the system. This testing should be conducted during dry weather to avoid any flows of storm water through the conveyance.

A checklist that can be used to conduct dry weather evaluations is provided in Exhibit 2-11. A narrative description of the method used to conduct dry weather evaluations and the date and the drainage points must be included in Section V.A of Form 2F. This statement must be certified by the appropriate party as described in Section 2.7.4.

A dry weather visual inspection is the simplest way to screen for illicit discharges. If one or more of the items on the checklist in Exhibit 2-11 are answered affirmatively, or if there are other reasons to believe that illicit connections exist, more detailed investigations (such as dye tests, smoke tests, evaluation of piping designs, and TV line monitoring) may be necessary. Dye testing involves releasing fluorescent, nontoxic dye into the suspected source of non-storm water, (e.g., a drain, sink, toilet, or pipe) and checking to see whether the dye shows up in the storm water outfall. Smoke testing involves pumping smoke into a storm sewer and viewing the facility to see if smoke escapes through unknown openings or storm sewer inlets. The presence of smoke indicates that storm water may enter the sewer through these openings or inlets. However, smoke testing may prove ineffective at finding non-storm water discharges to separate storm sewers. Smoke passage may be blocked due to line traps that are intended to block sewer gas.

TV line monitoring is a technique whereby a small video camera is placed in the storm sewer and a video image of the sewer is viewed on a monitor at the surface to identify illicit connections. The camera can be moved through the sewer by remote control. For more information on smoke and dye testing and TV line monitoring, consult EPA's Guidance Manual for the Preparation of NPDES

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EXHIBIT 2-11. CHECKLIST FOR CONDUCTING DRY WEATHER EVALUATIONS

1. Date of inspection:_____
2. Facility name and address:_____
3. Date of last rain event:_____
4. Inspector name:_____
5. Type of outfall

☐ Concrete ☐ Pipe ☐ Grassed ☐ Rock ☐ Other _____

6. Is there visible flow from the pipe? ☐ Yes ☐ No
If yes, check all that apply. If no, go to number 7.

☐ Colored water (describe)_____ ☐ Oily sheen
☐ Odor* (describe)_____ ☐ Sludge present
☐ Murky ☐ Clear water
☐ Floating objects (describe)_____ ☐ Stains on conveyance
☐ Absence of plant life surrounding conveyance ☐ Notable difference in plant life surrounding conveyance
☐ Scum ☐ Suds ☐ Other:_____

*e.g., rotten eggs, earthy, chemical, chlorine, soap, putrescence, gasoline, musty, etc.

Estimate the flow either visually or by describing the width, height, and shape of the conveyance and the approximate percentage of the conveyance where flow is present or the approximate depth of the flow. Describe your estimate.

7. Is there standing water present? ☐ Yes ☐ No
If yes, check all that apply. If no, go to number 8.

☐ Colored water (describe)_____ ☐ Oily sheen
☐ Odor* (describe)_____ ☐ Sludge present
☐ Murky ☐ Clear water
☐ Floating objects (describe)_____ ☐ Stains on conveyance
☐ Absence of plant life surrounding conveyance ☐ Notable difference in plant life surrounding conveyance
☐ Suds ☐ Scum ☐ Other:_____
☐ Absence of plant life surrounding conveyance

*e.g., rotten eggs, earthy, chemical, chlorine, soap, putrescence, gasoline, musty, etc.

8. From the inspection locations, can you see any unusual piping or ditches that drain to the storm water conveyance? ☐ Yes ☐ No

9. Is there any overland flow visible from the discharge location? ☐ Yes ☐ No

10. Are there dead animals present? ☐ Yes ☐ No

Signature:

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Permit Applications for Storm Water Discharges Associated with Industrial Activity (EPA-505/8-91-002, April 1991).

A problem with the dry weather evaluation process is that the presence of a dry weather/non-storm water discharge may be caused by infiltration of ground or surface waters through cracks in the storm water drainage system. In this situation, all other possible sources of the non-storm water discharge should be examined and ruled out. If no sources are found, the physical structure of the conveyance system should be inspected for deterioration.

The applicant should make every attempt to halt non-storm water discharges to the storm sewer system unless the discharge is covered by an NPDES permit. If it is not feasible to halt the discharge of non-storm water to the storm sewer system, and the discharge is not authorized by a process wastewater or storm water permit, the applicant must submit either Form 2C (for a process water discharge) or Form 2E (for a nonprocess water discharge), and check with state officials to see if alternate forms are required.

2.7.6 WHEN MUNICIPAL FACILITIES MUST SAMPLE

Municipal applicants are required to conduct sampling for both Parts 1 and 2 of their applications. In Part 1, municipalities must conduct a field screening analysis to detect illicit connections and illegal dumping into their storm sewer system. Where flow is observed during dry weather, two grab samples must be collected during a 24-hour period with a minimum of 4 hours between samples. These samples must be analyzed for pH, total chlorine, total copper, total phenol, and detergents (surfactants). Note that these are dry weather samples, rather than storm water samples. EPA's Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems presents a description of conducting field screening sampling and provides a data sheet.

For Part 2 of the application, municipalities must submit grab (for certain pollutants) and flow-weighted sampling data from selected sites (5 to 10 outfalls) for 3 representative storm events at least 1 month apart. The flow-weighted composite sample must be taken for either the entire discharge or the first 3 hours (if the event lasts longer than 3 hours). Municipal facilities are not required to collect grab samples within the first 30 minutes of a storm event.

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In addition to submitting quantitative data for the application, municipalities must also develop programs for future sampling activities that specify sampling locations, frequency, pollutants to be analyzed, and sampling equipment. Where necessary (as determined by the municipality or if required by the permitting authority), responsibilities may also include monitoring industries connected to the municipality's storm sewers for compliance with their facility-specific NPDES permits. Refer to EPA's Guidance Manual for the Preparation of Part 1 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems for information on how to develop municipal sampling programs.

2.7.7 USE OF HISTORICAL DATA

Data from storm water samples analyzed in the past can be submitted with applications in lieu of new sampling data if:

- All data requirements in Form 2F are met
- Sampling was performed no longer than 3 years prior to submission of the permit application
- All water quality data are representative of the present discharge.

The historical data may be unacceptable if there have been significant changes since the time of that storm event in production level, raw materials, processes, or final products. Significant changes which may also impact storm water runoff include construction or installation of treatment or sedimentation/erosion control devices, buildings, roadways, or parking lots. Applicants should assess any such changes to determine whether they altered storm water runoff since the time of the storm event chosen for use in the permit application. Historical data can be used only in applications. Historical data cannot be used for fulfilling permit requirements.

2.8 WHERE TO SAMPLE STORM WATER DISCHARGES

Storm water samples should be taken at a storm water point source. A "point source" is defined as any discernible, confined, and discrete conveyance, including (but not limited to) any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel, or other floating craft from which pollutants are or may be discharged (as per 40 CFR 122.2). Included in the definition of storm water "point

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sources" is storm water from an industrial facility that enters, and is discharged through, a municipal separate storm sewer. In short, most storm water discharges can be defined as "point source" discharges, since they ultimately flow into some kind of conveyance (e.g., a channel or swale).

2.8.1 INDUSTRIAL FACILITIES

Industrial applicants submitting individual applications must collect and analyze a grab sample taken within the first 30 minutes of the storm event and flow-weighted composite samples from each of the industrial storm water "point source" outfalls identified on the site drainage map submitted for Section III of Form 2F. Applicants submitting quantitative data for Part 2 of the group application must also collect samples for each outfall discharging storm water associated with industrial activity. All outfalls should be sampled during the same representative storm event if possible. If this is not feasible, outfalls may be sampled during different representative storm events upon approval by the permitting authority. Descriptions of each storm event and which outfalls were sampled during each event must be included in the application. Storm water runoff from employee parking lots, administration buildings, and landscaped areas that is not mixed with storm water associated with industrial activity, or storm water discharges to municipal sanitary sewers, do not need to be sampled.

Outfalls With Substantially Identical Effluents—Industrial Facilities

If an applicant has two or more outfalls with "substantially identical effluents," the facility may petition the permitting authority to sample and analyze only one of the identical outfalls and submit the results as representative of the other. "Substantially identical effluents" are defined as discharges from drainage areas undergoing similar activities where the discharges are expected to be of similar quantity and quality, and indistinguishable in expected composition. Chapter 5 presents an example of a petition for substantially identical effluents and discusses this process in more detail.

2.8.2 MUNICIPALITIES

Large and medium municipalities are required to sample storm water discharges from 5 to 10 outfalls or field screening points that were proposed in Part 1 of the application. The final decision on the number and location of sampling points will be determined by the permitting authority and will

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depend on site-specific conditions such as land use or drainage area and results of data collected during the field screening analysis process for Part 1 of the application

2.8.3 LOGISTICS OF WHERE TO SAMPLE

The ideal sampling location would be the lowest point in the drainage area where a conveyance discharges storm water to waters of the U.S. or to a municipal separate storm sewer system. A sample point also should be easily accessible on foot in a location that will not cause hazardous sampling conditions. Ideally, the sampling site should be on the applicant's property or within the municipality's easement; if not, the field personnel should obtain permission from the owner of the property where the discharge outfall is located. Typical sampling locations may include the discharge at the end of a pipe, a ditch, or a channel.

However, logistical problems with sample locations may arise (e.g., nonpoint discharges, inaccessibility of discharge point, etc.). Logistical problems with sample locations and suggested solutions are described in Exhibit 2-12. In many cases, it may be necessary to locate a sampling point further upstream of the discharge point (e.g., in a manhole or inlet). If the storm water at a selected location is not representative of a facility's total runoff, the facility may have to sample at several locations to best characterize the total runoff from the site. In situations where discharge points are difficult to sample for various reasons, the applicant should take the best sample possible and explain the conditions in the application. A discussion on sampling at retention ponds appears in Section 3.1.2.

2.9 STAFFING CONSIDERATIONS

Staffing needs for sampling must be determined by the applicant. Factors in making the determination include the number of sample locations, the size of the area to be sampled, how far apart the locations are, the type of sampling required, the technique to be used, the number of samples to be taken (depending on how many parameters must be analyzed), and safety considerations.

Training sampling personnel is important to the success of storm water discharge characterization. Training can be done using this manual. Sampling conducted by untrained personnel may result in

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EXHIBIT 2-12. SOLUTIONS TO SAMPLE LOCATION PROBLEMS	
Problem:	**Sampling where storm water commingles with process or non-process water**
Solution:	Attempt to sample the storm water discharge before it mixes with the non-storm water discharge. If this is impossible, sample the discharge both during dry and wet weather and present both sets of data to the permitting authority. This will provide an indication of the contribution of pollutants from each source.
Problem:	**Numerous small point discharges**
Solution:	Impound channel or join together flow by building a weir or digging a ditch to collect discharge at a low point for sampling purposes. This artificial collection point should be lined with plastic to prevent infiltration and/or high levels of sediment. Or, sample at several locations to represent total site runoff.
Problem:	**Inaccessible discharge point [examples include underwater discharges or unreachable discharges (e.g., out of a cliff)]**
Solution:	Go up the pipe to sample (i.e., to the nearest manhole or inspection point). If these are not available, tap into the pipe or sample at several locations to best represent total site runoff.
Problem:	**Managing multiple sampling sites to collect grab samples during the first 30 minutes (industrial facilities only)**
Solution:	Have a sampling crew ready for mobilization when forecasts indicate that a representative storm will occur or sample several different representative events. Also, for most parameters, automatic samplers may be used to collect samples within the first 30 minutes triggered by the amount of rainfall, the depth of flow, flow volume or time.
Problem:	**Commingling of parking lot runoff with discharge associated with industrial activity**
Solution:	The combined runoff must be sampled at the discharge point as near as possible to the receiving water or the parking lot drain inlet if there is one.
Problem:	**Sampling in manholes**
Solution:	Sample in manholes only when necessary. See Chapter 6 for safety information. Sampling in manholes requires training on confined space entry.
Problem:	**Runon from other property**
Solution:	If possible, estimate the volume of offsite runon contributions and offsite runon sources of pollutants to perform a mass balance calculation. Include this information in the permit application. If this estimation is not possible, provide a narrative discussion of the upstream site (e.g., is it developed, if so the type of facility, the types of pollutants that may be present on the site, etc.).

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data that is unrepresentative of the facility's storm water discharge. This data might be rejected by the permitting authority, who would then require another sampling effort.

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3. FUNDAMENTALS OF SAMPLING

Because of the variable nature of storm water flows during a rainfall event and different analytical considerations for certain pollutants, the storm water regulations establish specific requirements for sample collection techniques. The quality of storm water discharges and logistical needs for sampling will be different for industrial applicants and municipal applicants. Therefore, specific sampling requirements vary. After a brief review of sampling fundamentals and special sampling requirements for storm water permit applications, the following sections are intended to teach applicants how to sample to meet these requirements.

The applicant should carefully plan his/her sampling strategy prior to the actual sampling event, e.g., walk the site to determine appropriate sampling locations, become familiarized with local rainfall patterns, train sampling staff in procedures and safety, consult with laboratory, and collect supplies.

3.1 TYPES AND TECHNIQUES OF SAMPLING

There are three basic aspects of sampling:

- Sample type (i.e., grab versus composite)
- Sample technique (i.e., manual versus automatic)
- Flow measurement methods.

These topics will be discussed in relation to requirements of an NPDES storm water discharge permit application. Once these aspects are addressed, step-by-step instructions on sampling procedures are presented. The sections below define and describe the types of storm water samples that must be collected and methods or techniques for collecting them. In addition, special sampling requirements for certain pollutants are discussed.

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3.1.1 SAMPLE TYPE VERSUS SAMPLE TECHNIQUE

It is important to understand the difference between sample type and technique. "Sample type" refers to the kind of sample that must be collected -- either a grab or a composite. "Sample technique" refers to the method by which a grab or composite sample is actually collected -- either manually or by automatic sampler. A generalized relationship between sample type and sample technique is presented in Exhibit 3-1. Sections 3.1.2 and 3.1.3 further explain the significance of these terms as they relate to storm water sampling requirements.

EXHIBIT 3-1. SAMPLE TYPE vs. SAMPLE TECHNIQUE

Sample Type	Sample Technique
Grab	Manual Automatic sampling system
Composite	Manual with manual compositing Automatic system or automatic sampling with manual compositing

3.1.2 SAMPLE TYPE: GRAB AND COMPOSITE SAMPLES

To comply with storm water application requirements, the sample type (grab or composite) must be collected in accordance with 40 CFR 122.21(g)(7) and 40 CFR Part 136. The storm water application requirements clearly specify which pollutants must be analyzed by grab sample, and which by composite sample. Although the requirements in 40 CFR 122.21(g)(7) do not explicitly specify either manual or automatic sampling techniques, the approved analytical methods contained in 40 CFR Part 136 direct that grab samples must be collected manually for certain pollutants. Sections 3.3 and 3.4 clarify which pollutants must be grabbed, which ones must be grabbed manually, and which ones must be flow-weighted composites.

The two types of storm water samples required by the regulations, grab and composite samples, are described below.

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Grab Samples

A grab sample is a discrete individual sample taken within a short period of time (usually less than 15 minutes). Analysis of grab samples characterizes the quality of a storm water discharge at a given time of the discharge.

Composite Samples

A composite sample is a mixed or combined sample that is formed by combining a series of individual and discrete samples of specific volumes at specified intervals. Although these intervals can be time-weighted or flow-weighted, the storm water regulations require the collection of flow-weighted composite samples. This means that discrete aliquots, or samples, are collected and combined in proportion to flow rather than time. Composite samples characterize the quality of a storm water discharge over a longer period of time, such as the duration of a storm event.

Application Requirements

Both types of samples must be collected and analyzed for storm water discharge permit applications. Grab samples must be collected for the following conditions:

- For storm water discharges associated with industrial activity, a grab sample must be obtained during the first 30 minutes of a discharge. This requirement is in addition to the composite sampling requirements. These samples are intended to characterize the maximum concentration of a pollutant that may occur in the discharge and/or may indicate intermingling of non-storm water discharges.

- For storm water discharges from large and medium municipal separate storm sewers, grab samples are required for Part 1 of the application if a discharge is noted during dry weather field screening. Two grab samples must be collected during a 24-hour period with a minimum of 4 hours between samples. These samples are intended to assist in the identification of illicit connections or illegal dumping. In Part 2, grab samples may be required for the analysis of certain pollutants for which municipalities are required to sample.

Flow-weighted composite samples must be collected during the first 3 hours of discharge or the entire discharge (if it is less than 3 hours) for both industrial and municipal applicants.

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Pollutant-specific Requirements

The regulations at 40 CFR 122.21(g)(7) identify certain pollutants for which grab sampling is required:

- Monitoring by grab sample must be conducted for pH, temperature, cyanide, total phenols, residual chlorine, oil and grease (O&G), fecal coliform, and fecal streptococcus. Composite samples are not appropriate for these parameters due to their tendency to transform to different substances or change in concentration after a short period of time. Such transformations may be particularly likely in the presence of other reactive pollutants.

Sampling At Retention Ponds

Retention ponds with greater than a 24-hour holding time for a representative storm event may be sampled by grab sample. Composite sampling is not necessary. The rationale for this is that, because the water is held for at least 24 hours, a thorough mixing occurs within the pond. Therefore, a single grab sample of the effluent from the discharge point of the pond accurately represents a composite of the storm water contained in the pond. If the pond does not thoroughly mix the discharge, thereby compositing the sample, then a regular grab and composite sample should be taken at the inflow to the pond. Since each pond may vary in its capability to "composite" a sample, applicants must carefully evaluate whether the pond is thoroughly mixing the discharge. Such factors as pond design and maintenance are important in making this evaluation. Poor pond design, for example, where the outfall and inflow points are too closely situated, may cause short-circuiting and inadequate mixing. In addition, poor maintenance may lead to excessive re-suspension of any deposited silt and sediment during heavy inflows. Because of factors such as these, the applicant should determine the best location to sample the pond (e.g., at the outfall, at the outfall structure, in the pond) to ensure that a representative composite sample is taken. If adequate compositing is not occurring within the pond, the applicant should conduct routine grab and flow-weighted composite sampling.

A grab sample and a flow-weighted sample must be taken for storm water discharges collected in holding ponds with less than a 24-hour retention period. The applicant must sample the discharge in the same manner as for any storm water discharge [as described in 40 CFR 122.21(g)(7)]. In

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effect, the applicant must take one grab sample within the first 30 minutes of discharge, or as soon as possible. The applicant must also collect a flow-weighted composite sample for at least the first 3 hours of the discharge, or for the event's entire duration (if it is less than 3 hours). The flow-weighted composite sample may be taken using a continuous sampler or as a combination of at least three sample aliquots taken during each hour of the discharge, with a minimum of 15 minutes between each aliquot. If the applicant does not know what retention period the pond is designed for, the design engineer of the pond should be consulted.

3.1.3 SAMPLE TECHNIQUE: MANUAL VERSUS AUTOMATIC SAMPLING

As previously discussed, manual and automatic sampling techniques are methods by which both grab and composite samples can be collected. Manual samples are simply samples collected by hand. Automatic samplers are powered devices that collect samples according to preprogrammed criteria. A typical automatic sampler configuration is shown in Exhibit 3-2.

For most pollutants, either manual or automatic sample collection will conform with 40 CFR Part 136. However, one case in which automatic samplers cannot be used is for the collection of volatile organic compound (VOC) samples because VOCs will likely volatilize as a result of agitation during automatic sampler collection. Samples collected for VOC analysis should be filled until a reverse meniscus is found over the top of the collection bottle and capped immediately to leave no air space. Automatic samplers do not perform this function. Special requirements for VOC sampling are discussed in Section 3.5.2.

Although both collection techniques are available, several other pollutants may not be amenable to collection by an automatic sampler, for example fecal streptococcus, fecal coliform and chlorine have very short holding times (i.e., 6 hours), pH and temperature need to be analyzed immediately and oil and grease requires teflon coated equipment to prevent adherence to the sampling equipment.

Other restrictions on sample collection techniques (such as container type and preservation) should be determined by consulting the approved analytical methods listed in 40 CFR Part 136. Section 3.5 and Technical Appendix C provide additional information on sample handling, holding times, and preservation methods.

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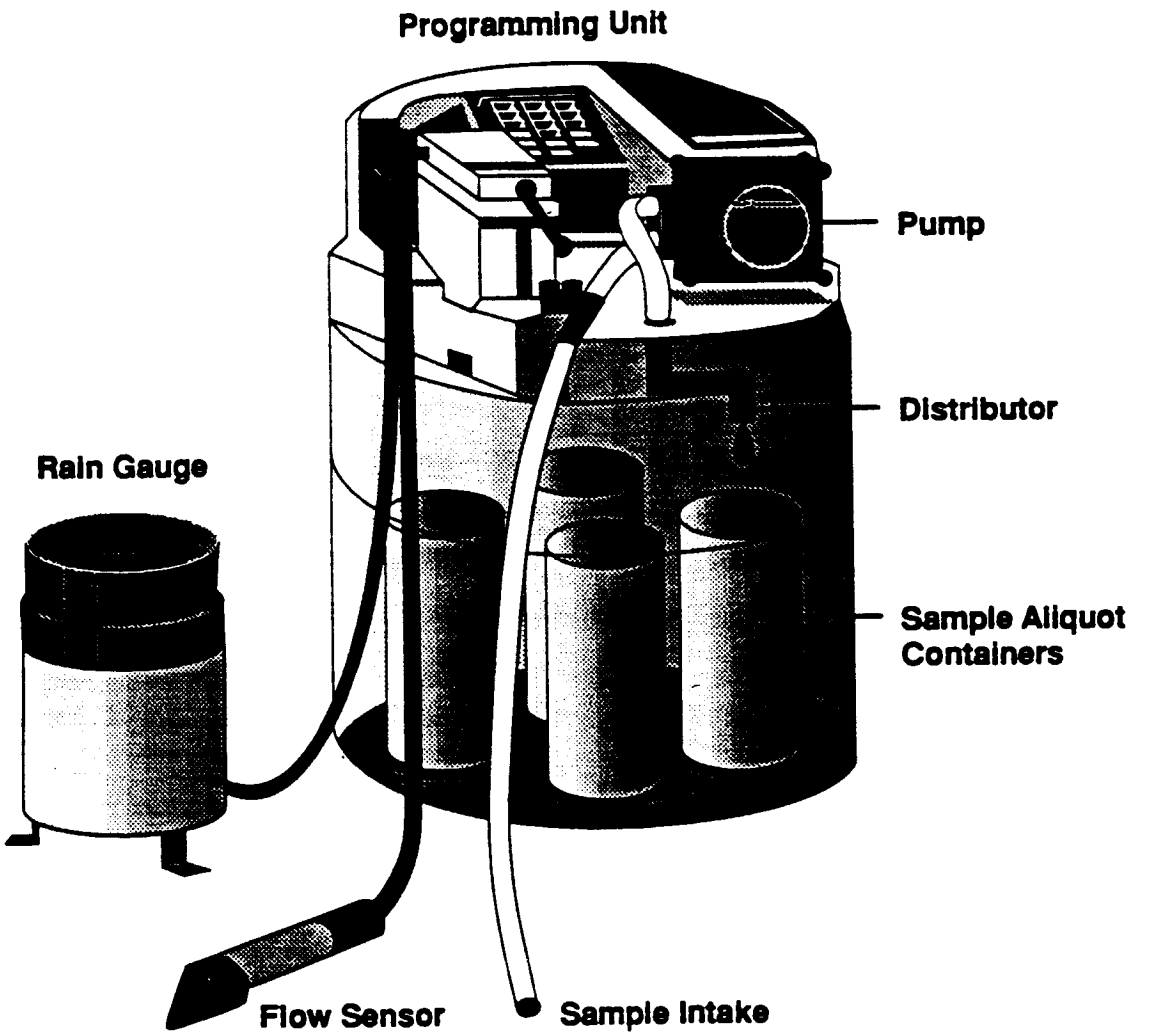
EXHIBIT 3-2. AUTOMATIC SAMPLER



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Manual and automatic techniques have advantages and disadvantages that the applicant should consider in relation to the sampling program. The main advantage of manual sampling is that it can be less costly than purchasing or renting automatic samplers. Automatic samplers, however, can be often more convenient. Exhibit 3-3 presents a matrix of advantages and disadvantages associated with each technique. Ultimately, the best technique to use will depend on each applicant's situation.

3.2 OBTAINING FLOW DATA

In addition to collecting samples of storm water discharges, applicants must collect data characterizing the flow rate and flow volume for each storm water discharge sampled. Flow rate is the quantity of storm water discharged from an outfall per unit of time. Total flow is a measure of the total volume of storm water runoff discharged during a rain event. Flow rates and volumes can either be measured specifically or can be estimated (based on rainfall measurements, velocities, and depth of flows). To collect flow-weighted composite samples, flow rate data is necessary to combine proportional volumes of individually collected aliquots. Applicants must also report the mass of pollutants contained in storm water discharges (see Section 3.2.5). To determine mass loadings of pollutants, applicants must measure both discharge flow rate and pollutant concentration. This section presents methods for obtaining flow data.

3.2.1 MEASURING FLOW RATES

Flow rates for storm water discharges are most accurately measured using either primary or secondary flow measurement devices. Facilities should use these devices to characterize their discharge as precisely as possible. Where flow measurement devices are not already installed, portable devices should be considered. There are many permanent and portable types of flow measurement devices available. This discussion is limited to the most common flow measurement devices. To purchase flow measurement devices and rain gauges, pertinent engineering journals can be consulted for equipment vendor listings. Proper analysis of site discharge conditions must be conducted prior to purchase and installment of flow measurement devices.

Primary Flow Measurement Devices

A primary flow measurement device is a man-made flow control structure which, when inserted into an open channel, creates a geometric relationship between the depth of the flow and the rate of the

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EXHIBIT 3-3. COMPARISON OF MANUAL AND AUTOMATIC SAMPLING TECHNIQUES

Sample Method	Advantages	Disadvantages
Manual Grabs	• Appropriate for all pollutants • Minimum equipment required	• Labor-intensive • Environment possibly dangerous to field personnel • May be difficult to get personnel and equipment to the storm water outfall within the 30 minute requirement • Possible human error
Manual Flow-Weighted Composites (multiple grabs)	• Appropriate for all pollutants • Minimum equipment required	• Labor-intensive • Environment possibly dangerous to field personnel • Human error may have significant impact on sample representativeness • Requires flow measurements taken during sampling
Automatic Grabs	• Minimizes labor requirements • Low risk of human error • Reduced personnel exposure to unsafe conditions • Sampling may be triggered remotely or initiated according to present conditions	• Samples collected for O&G may not be representative • Automatic samplers cannot properly collect samples for VOCs analysis • Costly if numerous sampling sites require the purchase of equipment • Requires equipment installation and maintenance • Requires operator training • May not be appropriate for pH and temperature • May not be appropriate for parameters with short holding times (e.g., fecal streptococcus, fecal coliform, chlorine) • Cross-contamination of aliquot if tubing/bottles not washed
Automatic Flow-Weighted Composites	• Minimizes labor requirements • Low risk of human error • Reduced personnel exposure to unsafe conditions • May eliminate the need for manual compositing of aliquots • Sampling may be triggered remotely or initiated according to on-site conditions	• Not acceptable for VOCs sampling • Costly if numerous sampling sites require the purchase of equipment • Requires equipment installation and maintenance, may malfunction • Requires initial operator training • Requires accurate flow measurement equipment tied to sampler • Cross-contamination of aliquot if tubing/bottles not washed

R0013410

flow. The depth of the flow, referred to as the head (H), can then be measured at the respective reference point/area with a ruler or other staff gauge. When substituted into a formula, which mathematically describes the relationship between depth and discharge for the primary devices, the head measurement can be used to calculate a flow rate (Q). The most common primary flow measurement devices are weirs and flumes. Weirs and flumes are flow structures designed to provide a known, repeatable relationship between flow and depth.

Weirs

Weirs consist of a crest located across the width of an open channel (at a right angle to the direction of the flow). The flow of water is impeded, causing water to overflow the crest. Diagrams and formulas of some typically found weirs are provided in Exhibit 3-4. Weirs are inexpensive and particularly valuable in measuring flow in natural or man-made swales because they are easily installed in irregularly shaped channels.

Weirs can only provide accurate flow measurements when head measurements are appropriately taken. When flow exceeds the capacity of the weir and water overtops the weir crest, flow depth actually diminishes as the water approaches the weir, as shown in Exhibit 3-5. Therefore, measuring the depth at the weir crest will result in an inaccurate measurement of the actual head. Under these circumstances, the head should be measured upstream, at a point determined by the type of weir and the estimated amount of flow. A staff gauge can be installed at a nonturbulent point upstream of the weir crest to provide accurate and convenient measurements.

Flumes

Flumes are structures which force water through a narrow channel. They consist of a converging section, a throat, and a diverging section. Exhibit 3-6 portrays the most common type of flume, the Parshall flume, and also provides formulas for calculating appropriate flow rates.

Parshall flumes have fixed specifications relating to geometric shape. They vary only in throat width. Due to these geometric constraints, Parshall flumes may be expensive to install. They are typically used in permanent flow measurement points and are most commonly placed in concrete-lined channels. However, Parshall flumes can also be used in temporary points. Parshall flumes provide accurate measurements for a relatively wide range of flow rates. The flow rate through the Parshall flume (see Exhibit 3-6) is calculated from the depth (H_a) of flow measured in the converging

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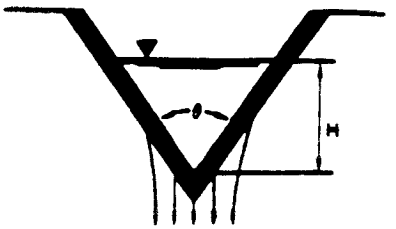
EXHIBIT 3-4. WEIRS

V-Notch



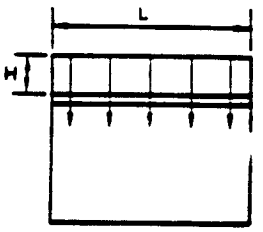
$Q = 2.5\ H^{2.5}$ (90°)
$Q = 1.443\ H^{2.5}$ (60°)
$Q = 1.035\ H^{2.5}$ (45°)
$Q = 0.676\ H^{2.5}$ (30°)
$Q = 0.497\ H^{2.5}$ (22½°)

Q = Flow Rate

H = Depth of flow (Head)

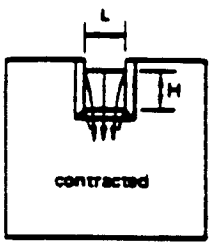
Rectangular (without contractions)

$Q = 3.33\ L\ H^{1.5}$



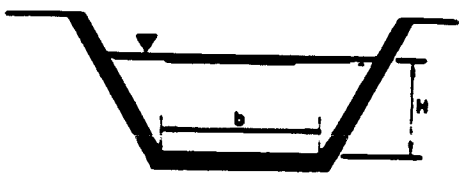
Rectangular (with contractions)

$Q = 3.33\ (L - 0.2\ H)^{1.5}$



Cipolleti (trapezoidal)

$Q = 3.367\ b\ H^{1½}$



Source: Civil Engineering Reference Manual, 5th Edition, by Michael R. Lindeburg, PE, with permission from the publisher, Professional Publications, Inc., Belmont, California, 1989.

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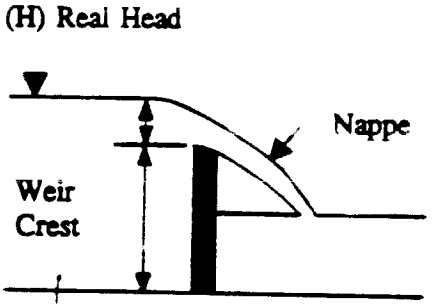
EXHIBIT 3-5. SUPPRESSED FLOW OVER THE WEIR CREST



Source: Civil Engineering Reference Manual, 5th Edition, by Michael R. Lindeburg, PE, with permission from the publisher, Professional Publications, Inc., Belmont, California, 1989.

section of the flume. The exact location of the depth measurement depends on the specific design of the Parshall flume. Exhibit 3-6 indicates the equations used to calculate flow rate through a typical Parshall flume. These equations are accurate only when the submergence ratio (H_b/H_a) is greater than 0.7. The manufacturers' information should be consulted for the flow rate equation and measuring points for a specific Parshall flume.

Palmer-Bowlus flumes, shown in Exhibit 3-7, are also used at some facilities. Palmer-Bowlus flumes are designed to be installed in an existing circular channel (such as a manhole channel) and are available as portable measurement devices. While Palmer-Bowlus flumes are inexpensive, self cleaning, and easy to install, they can only measure flow rates accurately over a narrow range of flow.

The flow from a Palmer-Bowlus flume is calculated using the height between the floor of the flume portion and the water level, not the total head of the water level. Head measurements are taken at

R0013413

EXHIBIT 3-6. FLUMES

Parshall Flume

$Q = 0.338\ H^{1.55}$ (1 inch)

$Q = 0.676\ H^{1.55}$ (2 inches)

$Q = 0.992\ H^{1.567}$ (3 inches)

$Q = 2.09\ H^{1.58}$ (6 inches)

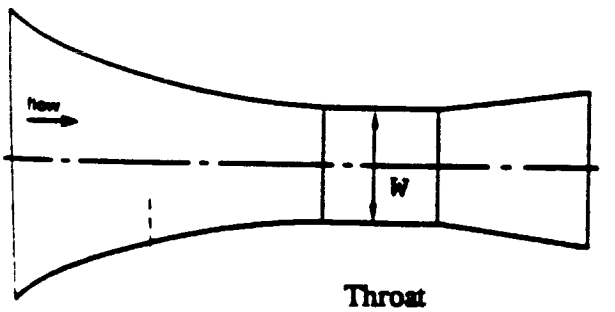
$Q = 3.07\ H^{1.53}$ (9 inches)

$Q = 4\ W\ H^{1.522}\ W^{0.026}$ (1-8 feet)

$Q = (3.6875\ W + 2.5)H^{1.6}$ (10-50 feet)

Q = Flow rate

H = Depth of flow (Head)

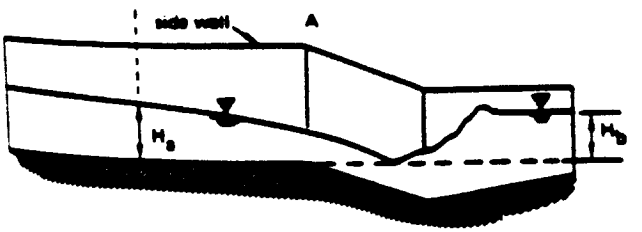


Top View

Throat

Converging Section

Diverging Section



Side View

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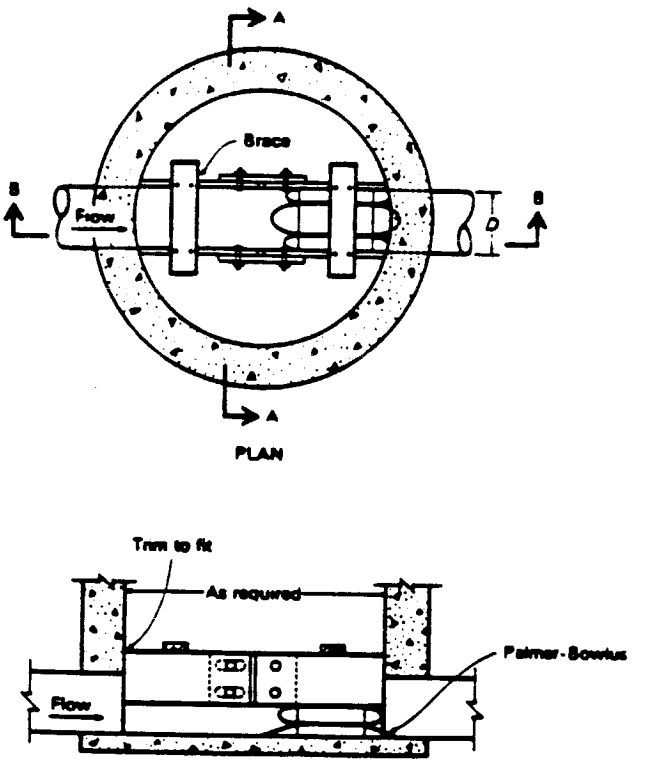
EXHIBIT 3-7. PALMER-BOWLUS FLUME



Source: Wastewater Engineering: Treatment, Disposal, Reuse, 2nd Edition, Metcalf & Eddy, Inc., with permission from the publisher, McGraw-Hill Book Co., New York, 1979.

a distance from the throat equal to one half the width of the flume. The dimensions of a Palmer-Bowlus flume have been standardized in a generic sense, but the flume shape may vary. Therefore, there are no formulas that can be applied to all Palmer-Bowlus flumes. Device-specific head-flow relationships for each device should be obtained from the manufacturer.

There are a number of other, less common, flow measurement devices available which will not be discussed (see Appendix D for additional references).

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Secondary Flow Measurement Devices

Secondary flow measurement devices are automated forms of flow rate and volume measurement Typically, a secondary device is used in conjunction with a primary device to automatically measure the flow depth or head. This value is then processed, using established mathematical relationships to relate the depth measurement to a corresponding flow rate. The device also may have the capacity to convert this flow rate to a volume. Secondary flow measurement devices include floats, ultrasonic transducers, pressure transducers, and bubblers. The output of the secondary device is transmitted to a display, recorder, and/or totalizer to provide flow rate and volume information. The user manuals for these devices should be consulted for proper usage.

Evaluation of Flow Measurement Devices

To ensure accurate results, facilities should evaluate, via visual observation and routine checks, the design, installation, and operation of flow measurement devices. When evaluating design, select a device which:

- Is accurate over the entire range of expected flow rates
- Can be installed in the channel to be monitored
- Is appropriate to the sampling location (i.e., power setup, submersible, etc.).

When evaluating the installation of flow measurement devices, ensure that:

- There are no leaks and/or bypasses of flow around the measuring device
- The primary device is level and squarely installed
- The secondary device is calibrated.

When evaluating the operation of flow measurement devices, look for:

- Excessive flows which submerge the measuring device
- Flows outside the accuracy range of the device
- Leaks and/or bypasses around the measuring device

R0013416

- Turbulent flow through the measuring device
- Corrosion, scaling, or solids accumulation within the measuring device
- Obstructions to the measuring device
- Use of the correct factor or formula to convert head readings to actual flow rate.

Other than ensuring appropriate design and installation, accuracy checks are difficult to accomplish for primary flow measurement devices. Secondary flow measurement devices, on the other hand, may require evaluation of design, installation, and calibration. Applicants should examine the secondary recording devices and their readouts after installation to ensure that they are operating properly. Unusual fluctuations or breaks in flow indicate operational or design flaws.

3.2.2 ESTIMATING FLOW RATES

There are a variety of techniques for estimating flow rates. These methods are not as accurate as the methods described in Section 3.2.1 above, but are suitable for those discharges where primary or secondary devices are not practical or economically feasible. Each of the following methods is suitable for certain types of flow situations, as indicated. For each, the procedure for collecting flow rate data will be given along with a sample calculation.

Float Methods

Float methods can be used for any discharge where the flow is exposed and/or easily accessible. It is particularly useful for overland flows, gutter flows, and open drain or channel flows. The flow rate is calculated in each of the float methods by estimating the velocity of the flow and the cross-sectional area of the discharge and using the standard flow rate equation:

$$\textit{Flow Rate } (cfm) = \textit{Velocity } (ft/min) \times \textit{Area } (ft^2)$$

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The velocity is estimated by measuring the time it takes a float to travel between two points (point A and point B) along the flow path. For most accurate results, the two points should be at least 5 feet apart. The cross-sectional area is estimated by measuring the depth of the water and the width of the flow, and multiplying the depth by the width. This assumes a uniform cross-section in the flow path and a geometric cross-section shape. The float method can also be used for any accessible pipe or ditch where the movement of the float can be traced downstream for at least 5 feet. Subsurface storm water flows can be measured with the float method where there are two accessible manholes.

If the flow is overland, the water will need to be directed into a narrow channel or ditch so that the measurements can be taken. The initial preparation for this method requires that a shallow channel or ditch be dug that is 6 feet long or longer and 4 to 12 inches wide. The channel or ditch should be shallow enough to easily obtain flow depths but should be deep enough to carry the flow that will be diverted to it. Boards or other barriers should be placed on the ground above the channel (so that the flow is diverted into the channel) and along the edges of the channel or ditch (flush with the ground surface so that flow does not seep under them).

The procedure for measuring the flow rate by the float method involves measuring the length of the channel between chosen points A and B (which must be 5 feet apart or more). The depth of the water at point B, in the middle of the channel, must be determined, and the width of the water flow must be measured at point B. A float is then placed in the water and timed as it moves from point A to point B. Exhibit 3-8 provides an example of estimating the flow rate using the float method.

For runoff flows from many directions into a drain in a low or flat area where ponding is evident, the float method can also be used. The total flow rate is calculated by measuring flow rates for several points into the drain and adding these values together. Exhibit 3-9 provides an example of estimating the flow rate using the float method in this situation.

Bucket and Stopwatch Method

The bucket and stopwatch method of estimating flow rate is the easiest of all the flow rate estimation procedures. However, it can only be used under certain conditions. The flow or discharge to be measured must be flowing from a small pipe or ditch, and it must be free-flowing. In other words,

R0013418

EXHIBIT 3-8. EXAMPLE CALCULATION OF FLOAT METHOD FOR UNIMPEDED OPEN CHANNEL FLOW

Step 1: When each sample or aliquot is taken, record the data for the time the sample was taken and the length between points A and B (at least 5 feet apart). See columns A, B, and C.

EXAMPLE DATA:

A	B	C	D	E	F	G
Sample Number	Time in Minutes	Distance Between Points A & B (feet)	Time of Travel (A to B) (min)	Depth of Water at Point B (feet)	Width of Flow at Point B (feet)	Calculated Flow Rate (cfm)
1	0	5.0	0.17	0.12	0.5	1.8
2	20	5.0	0.18	0.25	0.5	3.5
3	40	5.0	0.20	0.29	0.5	3.6
4	60	5.0	0.21	0.33	0.5	3.9
5	80	5.0	0.18	0.29	0.5	4.0
6	100	5.0	0.17	0.25	0.5	3.7
7	120	5.0	0.17	0.12	0.5	1.8
8	140	5.0	0.16	0.12	0.5	1.9
9	160	5.0	0.18	0.12	0.5	1.7

Step 2: Place a float in the water flow at point A and time it as it moves from point A to point B. Record the time in minutes. See column D.

Step 3: Measure the depth of the water and the width of the flow at point B. See columns E and F.

Step 4: Calculate the flow rate for each sample time using the common flow rate formula. See column G.

Formulas:

$$Velocity\ (V) = \frac{Length\ from\ A\ to\ B}{Time\ of\ Travel}$$

$$Area\ (A) = Water\ Depth \times Width\ of\ Flow$$

$$Flow\ Rate\ (Q) = (V) \times (A)$$

Example: For Sample 1

$$V = \frac{5.0\ ft}{0.17\ min} = 29.4\ ft/min$$

$$A = 0.12\ ft \times 0.5\ ft = 0.06\ ft^2$$

$$Q = 29.4\ ft/min \times 0.06\ ft^2 = 1.8\ cfm$$

R0013419

EXHIBIT 3-9. EXAMPLE CALCULATION OF FLOAT METHOD FOR ESTIMATING DRAIN FLOW RATES

Step 1: When each sample or aliquot is taken, record the data for the time the sample was taken. Measure the outer perimeter or edge of the drain where the water flows in. See columns B and C.

Step 2: Designate three evenly spaced points surrounding the drain approximately 3 to 5 feet from the drain. These points will be referred to as points A, B, and C. Record the distance from each point to the edge of the drain. See column D.

EXAMPLE DATA: Assume the drain dimensions are 1 ft x 1 ft square, and flow surrounds drain.

A	B	C	D			E			F			G
Sample Number	Sample Time (min)	Drainage Perimeter (feet)	Distance of Point to Drain (feet)			Time of Travel to Drain (min)			Depth of Water (feet)			Calculated Flow Rate (cfm)
			Pt. A	Pt. B	Pt. C	Pt. A	Pt. B	Pt. C	Pt. A	Pt. B	Pt. C	
1	0	4	3	4	5	0.2	0.3	0.5	0.08	0.08	0.08	4 cfm
2	20	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
3	40	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
4	60	4	3	4	5	0.4	0.5	0.6	0.16	0.17	0.20	6 cfm
5	80	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
6	100	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
7	120	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
8	140	4	3	4	5	0.3	0.4	0.5	0.11	0.12	0.14	5 cfm
9	160	4	3	4	5	0.2	0.3	0.5	0.08	0.08	0.08	4 cfm

Step 3: Place a float at each of the three points and measure the time it takes to reach the drain. Record the times in minutes. See column E.

Step 4: Determine the depth of flow at each place where the float enters the drain from points A, B, and C. Record the depth in feet. See column F.

Step 5: Calculate the flow rate by adding the individual flow rates for points A, B, and C. Record the data in column G.

Formulas:

$$Velocity\ (V) = \frac{Distance\ of\ Point\ from\ Drain}{Time\ of\ Travel}$$

$$Area\ (A) = Water\ Depth \times Drainage\ Perimeter$$

$$Flow\ Rate\ (Q) = 1/n\Sigma A_n V_n,\ where\ n\ equals\ points\ A,\ B,\ and\ C$$

Example: For Sample 1

$$V_A = \frac{3\ Feet}{0.2\ Min} = 15\ ft/min$$

$$A_A = 0.08\ ft \times 4\ ft = 0.32\ ft^2$$

R0013420

EXHIBIT 3-9. EXAMPLE CALCULATION OF FLOAT METHOD FOR ESTIMATING DRAIN FLOW RATES (Continued)

$$Q_{(TOTAL)} = \tfrac{1}{3}(V_A A_A + V_B A_B + V_C A_C)$$

$$= \tfrac{1}{3}[(15\ ft/min)(0.32\ ft^2) + (13\ ft/min)(0.32\ ft^2) + (10\ ft/min)(0.32\ ft^2)]$$

$$= 4\ cfm$$

the pipe or ditch must be raised above the ground. Also, the flow must be small enough to be captured by a bucket or other suitable container without overflowing. If these conditions are not present, another method must be used. The procedure involves recording the time that each sample is taken, the time it takes for the container to be filled, and the volume of discharge collected. The flow rate is then calculated in gallons per minute (gpm) or in cubic feet per minute (cfm). The basis for the bucket and stopwatch method is the collection of a measured amount of flow over a measured amount of time to determine flow per unit of time (or flow rate) as per the formula below.

$$Flow\ Rate\ Q\ (gpm) = \frac{Volume\ of\ Bucket\ (gal)}{Time\ to\ Fill\ (sec)} \times \frac{60\ sec}{1\ min}$$

Exhibit 3-10 provides an example of estimating flow rates with the bucket and stopwatch method.

Slope and Depth Method

The slope and depth method is also a relatively easy method for estimating flow rates in pipes and ditches. This procedure requires that the slope of the pipe or ditch be known. A survey or engineering design data such as sewer or grading plans may provide the slope or grade of the pipe or ditch. In addition, the flow or effluent to be measured should not fully fill the pipe or ditch from which it is flowing. To measure the depth of the flow at the center of the pipe or ditch at the outfall, the outfall should be accessible. If these conditions are not present, another method should be used. The procedure involves recording the time that each sample is taken and measuring the depth of the flow in the middle of the pipe or ditch. If the flow is coming from a pipe, the inside diameter of the pipe should be recorded. If the effluent is coming from a ditch, the width of the flow in the ditch should be measured. Also, the modified slope of the ditch should be calculated. The flow rate is calculated in cfm using the same formulas for both pipes and ditches. Exhibit 3-11 provides an example of estimating the flow rate with the slope and depth method.

R0013421

EXHIBIT 3-10. EXAMPLE CALCULATION OF BUCKET AND STOPWATCH METHOD FOR ESTIMATING FLOWS

Step 1: When each sample or aliquot is taken, record the data for the time the sample was taken. See column B.

EXAMPLE DATA:

A	B	C	D	E	F
Sample Number	Time (minutes)	Time to Fill Bucket (seconds)	Volume of Bucket (gallons)	Calculated Flow Rate (gpm)	Calculated Flow Rate in (cfm)
1	0	40.0	2.0	3.0	0.4
2	20	26.0	2.0	4.6	0.6
3	40	24.0	2.0	5.0	0.7
4	60	32.0	2.0	3.7	0.5
5	80	45.0	2.0	2.7	0.4
6	100	31.0	2.0	3.9	0.5
7	120	50.0	2.0	2.4	0.3
8	140	21.0	2.0	5.7	0.8
9	160	28.0	2.0	4.3	0.6

Step 2: Put a bucket beneath the flow, while measuring with a stopwatch the time it takes to fill the bucket to a certain level. If the water spills over the sides, the process must be redone. Record the time it took to fill the volume of water. See columns C and D.

Step 3: Calculate the flow rate in gpm and cfm.

Formulas:

$$Flow\ Rate,\ Q(gpm) = \frac{Volume\ of\ bucket\ (gal)}{Time\ to\ fill\ (sec)} \times \frac{60\ sec}{1\ min}$$

$$Q(cfm) = Q(gpm) \times 0.1337\ ft^3/gal$$

Example: For Sample 1

$$Q\ (gpm) = \frac{2\ gal}{40.0\ sec} \times \frac{60\ sec}{1\ min} = 3.0\ gpm$$

$$Q\ (cfm) = 3.0\ gpm \times 0.1337\ ft^3/gal = 0.4\ cfm$$

R0013422

EXHIBIT 3-11. EXAMPLE CALCULATION OF SLOPE AND DEPTH METHOD FOR ESTIMATING FLOW RATES

Step 1: Obtain the pipe or ditch channel percent slope from engineering data. Determine the inside diameter if the flow is from a pipe.

EXAMPLE DATA: For purposes of this example, a ditch with a 2 percent slope is assumed.

Step 2: When each sample or aliquot is taken, record the data for the time the sample was taken. See column B.

EXAMPLE DATA:

A	B	C	D	E	F	G
Sample Number	Time (minutes)	Depth of Water (in)	Width of Flow (ditch only) (feet)	"M" Modified Slope (ditch only)	Calculated Flow Rate (cfm Pipe only)	Calculated Flow Rate (cfm ditch only)
1	0	3.6	2.2	3.7	-	246.1
2	20	6.0	3.2	3.2	-	713.6
3	40	7.2	4.0	3.3	-	1,237.3
4	60	8.4	4.2	3.0	-	1,532.9
5	80	7.2	4.0	3.3	-	1,237.3
6	100	6.0	3.2	3.2	-	713.6
7	120	6.0	3.0	3.0	-	624.2
8	140	6.0	2.9	2.9	-	581.8
9	160	4.6	2.5	3.3	-	374.1

Step 3: Measure the depth of the water in the center of the pipe or ditch. Record the data in feet. See column C.

Step 4: Measure the width of the flow only if the flow is in a ditch. Record the data in feet. See column D.

Step 5: Calculate the modified side slope only if the flow is in a ditch (leave column E blank if the flow is in a pipe).

Formula:
$$\textit{Modified slope } (M) = \frac{12.0 \text{ in/ft} \times \textit{flow width (ft)}}{2.0 \times \textit{water depth (in)}}$$

Example: Sample 1:
$$M = \frac{12.0 \text{ in/ft} \times 2.2 \text{ ft}}{2.0 \times 3.6 \text{ in}} = 3.7$$

Step 6: For pipes, calculate the flow rate and record the data in column F.

$$\textit{Flow Rate } (Q) = 0.004 \times (I.D.)^{2.67} \times D \times \sqrt{S}$$

where Q = flow rate in pipe (cfm), I.D. = inside diameter of pipe (in), D = water depth (in), S = pipe slope (%)

Step 7: For ditches or channels, calculate the flow rate in cfm. Record the flow rate in column G.

Formula:
$$\textit{Flow Rate } (Q) = \frac{0.42M \times (M)^{1.67} \times (D)^{2.67} \times \sqrt{S}}{(M^2 + 1)^{0.33}}$$

where Q = flow rate in ditch (cfm), M = modified slope, D = water depth (in), S = ditch slope (%)

Example: For sample 1:
$$Q_1 = \frac{0.42\,(3.7) \times (3.7)^{1.67} \times (3.6)^{2.67} \times \sqrt{2}}{[(3.7)^2+1]^{0.33}}$$

$$Q = 246.1 \text{ cfm}$$

R0013423

Runoff Coefficient Methods

Runoff coefficient methods are the least accurate of all the flow rate estimation methods. These methods should only be used for composite flow-weighted samples if all of the other methods are inappropriate for the site. Although the least accurate, runoff coefficients are the simplest method of estimating runoff rates.

Runoff coefficients represent the fraction of total rainfall that will be transmitted as runoff from the drainage area that flows into the facility outfall. Runoff coefficients consider the ground surface or cover material and determine the amount of storm water flow which may infiltrate or runoff as a discharge. A simple estimate of runoff volume assumes that paved areas and other impervious structures such as roofs have a runoff coefficient of 0.90 (i.e., 90 percent of the rainfall leaves the area as runoff). For unpaved surfaces, a runoff coefficient of 0.50 is normally assumed. A more accurate estimate can be made by using more specific runoff coefficients for different areas of the facility, based on the specific type of ground cover. Commonly used runoff coefficients are listed in Exhibit 3-12.

The average runoff coefficient can be estimated for drainage areas that have both paved and unpaved areas by weighting the coefficients based on their proportion of the total area. An equation for this would be:

$$\textit{Estimated Average Runoff Coef.} = \frac{(\textit{Area A})(\textit{Runoff Coef. A}) + (\textit{Area B})(\textit{Runoff Coef. B})}{\textit{Area A} + \textit{Area B}}$$

The area of the drainage basin can generally be obtained from land surveys conducted at the time of facility purchase or site surveys taken from design documents developed as part of construction planning. If these are not available, the applicant may estimate the drainage areas from a topographic map of the area. The areas used in this calculation should include only those areas drained by the sampled outfall. When determining the basin area that drains through the outfall, some special considerations should be noted: (1) storm water from sources outside an industrial facility's property boundary may contribute to the discharge; and (2) storm water not associated with industrial activity may contribute to the flow volume. Where these conditions occur, the facility should accurately quantify and appropriately address these contributions.

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EXHIBIT 3-12. TYPICAL "c" COEFFICIENTS FOR 5- TO 10-YEAR FREQUENCY DESIGN STORMS

Description of Area	Runoff Coefficients
Business	
• Downtown areas	0.70-0.95
• Neighborhood areas	0.50-0.70
Residential	
• Single-family areas	0.30-0.50
• Multiunits (detached)	0.40-0.60
• Multiunits (attached)	0.60-0.75
Residential (suburban)	0.25-0.40
Apartment dwelling areas	0.50-0.70
Industrial	
• Light areas	0.50-0.80
• Heavy areas	0.60-0.90
Parks and cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets	
• Asphalt	0.70-0.95
• Concrete	0.80-0.95
• Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
Lawns - course textured soil (greater than 85 percent sand)	
• Slope: Flat (2 percent)	0.05-0.10
Average (2-7 percent)	0.10-0.15
Steep (7 percent)	0.15-0.20
Lawns - fine textured soil (greater than 40 percent clay)	
• Slope: Flat (2 percent)	0.13-0.17
Average (2-7 percent)	0.18-0.22
Steep (7 percent)	0.25-0.35

Source: *Design and Construction of Sanitary and Storm Sewers*, with permission from the publisher, American Society of Civil Engineers, *Manual of Practice*, page 37, New York, 1960.

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There are two specific methods to estimate flow rate using runoff coefficients. The first method uses depth of flow in a pipe or ditch and an average runoff rate to estimate each of the sample flow rates where the slope/pitch of the pipe or ditch is unknown. Exhibit 3-13 provides an example calculation of estimating flow rates based on depth and runoff coefficients. The second method uses only rainfall accumulation and runoff coefficients to estimate a flow associated with the time the sample was taken. No actual flows or flow depths are measured. Exhibit 3-14 provides an example of estimating the flow rate based on rainfall depth and runoff coefficients.

3.2.3 MEASURING TOTAL FLOW VOLUMES FOR THE SAMPLED RAIN EVENT

Similar to measuring flow rates, flow volumes may be measured using automatic flowmeters or primary/secondary devices as discussed in Section 3.2.1. Measurement of flow volume with these devices provides a reasonably accurate determination of the total flow volume for the entire storm water discharge. In many cases, however, primary or secondary devices have not been installed for storm water flow measurement. Portable flow measurement devices are often expensive. Many of the automatic samplers that are currently on the market can measure flow volumes as well as perform sampling. Where available and when economically feasible, measuring devices should be used to generate data for calculating flow.

3.2.4 ESTIMATING TOTAL FLOW VOLUMES FOR THE SAMPLED RAIN EVENT

Since accurate measurement of total flow volumes is often impracticable due to lack of equipment, total flow volumes are more commonly estimated. The two methods provided in this section require only simple estimated measurements. The first method is based on rainfall depths and runoff coefficients and the second is based on flow rates that can be either measured or estimated.

Runoff Coefficients Methods

Discharge volumes are most easily estimated using the area of the drainage basin contributing to the outfall, the rainfall accumulation, and a runoff coefficient. The total volume of discharge can be estimated using a simple equation that relates the amount of rainfall to the volume of discharge that will leave the site as runoff. The equation is as follows:

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EXHIBIT 3-13. EXAMPLE CALCULATION OF RUNOFF COEFFICIENT/FLOW DEPTH METHOD FOR ESTIMATING FLOW RATES

Step 1: Estimate the runoff coefficient for the drainage area that contributes flow to the sampled outfall (see Section 3.2.2).

EXAMPLE: Assume the drainage area to the outfall is 3 acres. Two of those acres are paved with a runoff coefficient of .90, and 1 is unpaved with a runoff coefficient of .50. Using the equation for estimated runoff coefficient from the text in Section 2.2.2.2:

$$\textit{Est. Run. Coef.} = \frac{(2\ Ac)\ (0.90) + (1\ Ac)\ (0.50)}{2\ Ac + 1\ Ac} = 0.77$$

The runoff coefficient for the entire drainage area is 0.77.

Step 2: Measure the rainfall depth. Record the total rainfall of the storm or the rainfall that occurred in the first 3 hours (if it lasted more than 3 hours). Also record the duration of the rain event.

EXAMPLE: Assume the rainfall depth to be 1.0 inches in 3 hours.

Step 3: Calculate an average runoff rate.

Formula:

$$\textit{Average Runoff Rate} = \frac{\textit{Drainage Area} \times \textit{Runoff Coef.} \times \textit{Rainfall Depth}}{\textit{Rainfall Duration}}$$

Example:

$$\textit{Average Runoff Rate} = \frac{3\ Ac \times .77 \times 1\ in}{3\ hrs} \times \frac{43{,}560\ ft^2}{Ac} \times \frac{ft}{12\ in} \times \frac{hr}{60\ min} = 47\ cfm$$

When each sample or aliquot is taken, record the data for the time the samples were taken and the depth of the water in the center of the ditch or pipe. Record the data in columns B and C.

EXAMPLE DATA:

A	B	C	D	E
Sample Numbers	Time (minutes)	Channel or Ditch Water Depth (feet)	Calculated Depth-Weighted Flow Factor	Flow Rate (cfm)
1	0	1.0	0.82	39
2	20	1.1	0.90	42
3	40	1.2	0.98	46
4	60	1.25	1.02	48
5	80	1.3	1.06	50
6	100	1.25	1.02	48
7	120	1.2	0.98	46
8	140	1.7	1.39	65
9	160	1.0	0.82	39

Step 4: Sum up all the water depths for each sample taken as indicated above in column C.

Sum = 11.0 feet

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EXHIBIT 3-13. EXAMPLE CALCULATION OF RUNOFF COEFFICIENT/FLOW DEPTH METHOD FOR ESTIMATING FLOW RATES (Continued)

Step 5: Calculate a depth-weight flow factor and record the data in column D.

Formula:

$$Factor = \frac{Measured\ Water\ Depth \times Number\ of\ Flow\ Measurements}{Sum\ of\ all\ Water\ Depths}$$

Example: For Sample 1

$$Factor = \frac{(1\ ft) \times 9}{11.0} = 0.82$$

Step 6: Calculate the flow rate. Record the data in column E.

Formula:

$$Flow\ Rate,\ Q\ (cfm) = Average\ Runoff\ Rate \times Depth\ Factor$$

Example: For Sample 1

$$Q = 47\ cfm \times 0.82 = 39\ cfm$$

$$V_t = R_t \times [(A_{paved} \times C_{runoff}) + (A_{unpaved} \times C_{runoff})]$$

where: V_t = the total runoff volume in cubic feet
R_t = the total rainfall measured in feet
A_{paved} = the area (sq ft) within the drainage basin that is paved or roofed
$A_{unpaved}$ = the area (sq ft) within the drainage basin that is unpaved
C_{runoff} = a specific runoff coefficient (no units) for the drainage area ground cover

Exhibit 3-15 provides an example calculation of total runoff volume from rainfall data.

Discharge Volumes Estimated Based on Measured Flow Rates

Another method of estimating the total volume of a discharge uses a series of measured or estimated flow rates. The total volume of discharge can be estimated by first multiplying each of the flow rates by the time interval in between flow measurements. This time period represents the portion of the total storm duration that can be associated with the flow rate measurement. Adding all such partial volumes results in a total flow volume. A procedure for calculating the total runoff volume from a set of discrete measurements of flow depth and velocity in a ditch during a storm runoff event is presented in Exhibit 3-16.

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EXHIBIT 3-14. EXAMPLE CALCULATION OF RUNOFF COEFFICIENT RAINFALL DEPTH METHOD FOR ESTIMATING FLOW RATES

Step 1: Estimate the runoff coefficient for the drainage area that contributes flows to the sampled outfall.

EXAMPLE: See Step 1 in Exhibit 3-14. The site for this example will be similar so a coefficient of .77 will be used for the same 3-acre drainage area.

Step 2: When each sample or aliquot is taken, record the data for the time the sample was taken. Record the data in column B.

EXAMPLE DATA:

A	B	C	D	E	F
Sample Number	Time (minutes)	Total Rainfall Depth (inches)	Time Since Last Sample	Incremental Rainfall (inches) per 20 minutes	Calculated Flow Rate (cfm)
1	0	0.0	0	0.0	–
2	20	0.2	20	0.2	84
3	40	0.3	20	0.1	42
4	60	0.5	20	0.2	84
5	80	0.6	20	0.1	42
6	100	0.8	20	0.2	84
7	120	0.9	20	0.1	42
8	140	1.0	20	0.1	42
9	160	1.1	20	0.1	42

Step 3: Using a rainfall gauge, measure the total rainfall depth (in inches) and record the data in column C.

EXAMPLE: See sample data above.

Step 4: Calculate the incremental time since the last flow measurement and record the data in column D.

EXAMPLE: Samples were taken 20 minutes apart so this increment will be 20 minutes for every sample.

Step 5: Calculate the additional or incremental rainfall that has occurred since the last measurement. Record the data in column E.

Formula:

$$\textit{Incremental Rainfall} = \textit{Total Rainfall Sample 2} - \textit{Total Rainfall Sample 1}$$

Example: For Sample 2

$$\textit{Incremental Rainfall} = .2 - 0 = .2 \textit{ inches}$$

Step 6: Calculate the flow rate. Record the data in column F.

Formula:

$$\textit{Flow Rate (cfm)} = \frac{(\textit{Drainage area})(\textit{Runoff coefficient})(\textit{Incremental rainfall})}{(\textit{Incremental time})}$$

Example:

$$\textit{Flow Rate} = \frac{(3\ \text{Ac})(0.77)(0.2\ \text{in})}{20\ \text{min}} \times \frac{(43{,}560\ \text{ft}^2)}{\text{Ac}} \times \frac{1\ \text{ft}}{12\ \text{in}} = 84\ \text{cfm}$$

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EXHIBIT 3-15. EXAMPLE CALCULATION OF TOTAL RUNOFF VOLUME FROM RAINFALL DATA

Step 1: Determine the area of drainage contributing to the runoff volume at the outfall and convert it to square feet.

Example: Using a land survey, a facility has determined its site encompasses 0.3 acres (13,068 square feet). The entire site is used for industrial activities, and therefore, any storm water discharges from the site will be associated with industrial activity. A berm surrounds the entire site limiting the drainage area to the site itself and preventing any dilution or contamination from other discharges. (Note: To convert acres to square feet, multiply the number of acres by 43,560, which is the conversion factor).

Step 2: Determine the rainfall depth during the event that was sampled to the nearest one-hundredth of an inch and convert it to feet.

Example: From the rain gauge, the rainfall accumulation is measured at 0.6 inches or 0.05 feet (ft). (Note: To convert inches to feet, divide the inches by 12, which is the conversion factor).

Step 3: Determine the runoff coefficients for each area.

Example: The facility has estimated that ⅛ of the site, or 4,356 square feet, is covered by impervious surfaces (i.e., roofs or paved roadways) and ⅞ of the site, or 8,712 square feet, is unpaved.

Step 4: Calculate the volume of flow using the following formula and convert the volume to liters.

Formula: ***Total runoff volume in cubic feet (cu ft) = total rainfall (ft) x [facility paved area (sq ft) x 0.90 + facility unpaved area (sq ft) x 0.50]***

Example: ***Total runoff volume (cu ft) = 0.05 x [4,356 x 0.90 + 8,712 x 0.50]***

Total runoff volume = 413.8 cu ft or 11,720 liters

(Note: To convert cubic feet to liters, multiply cubic feet by 28.32, which is the conversion factor).

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EXHIBIT 3-16. EXAMPLE CALCULATION OF TOTAL RUNOFF VOLUME FROM FLOW RATE DATA

Step 1: Measure and tabulate flow depths and velocities every 20 minutes (at the same time that the sample is collected) during at least the first 3 hours of the runoff event.

EXAMPLE DATA:

A	B	C	D	E	F
Sample Number	**Time (minutes)**	**Flow Velocity (feet per minute)**	**Flow Depth (feet)**	**Width (feet)**	**Calculated Flow Rate (cfm)**
1	0	-	-	-	-
2	20	4	0.2	5	4
3	40	8	0.4	5	16
4	60	12	0.4	5	24
5	80	8	0.4	5	16
6	100	4	0.2	5	4
7	120	8	0.2	5	8
8	140	4	0.2	5	4
9	160	4	0.2	5	4

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EXHIBIT 3-16. EXAMPLE CALCULATION OF TOTAL RUNOFF VOLUME FROM FLOW RATE DATA (Continued)

Step 2: Calculate and tabulate the cross-sectional area of flow for each of the flow depths measured. Calculate the flow rate for each discrete set of measurements.

Formula: $$\textit{Flow Rate } Q \textit{ (cfm)} = \textit{Velocity (ft/min)} \times \textit{Area (sq ft)}$$
$$\textit{Area} = \textit{Depth} \times \textit{Width}$$

Example. For Sample 1

$$\textit{Area} = 0.2\ \textit{ft} \times 5\ \textit{ft} = 1\ \textit{sq ft}$$
$$\textit{Flow Rate} = 4\ \textit{ft/min} \times 1\ \textit{sq ft} = 4\ \textit{cfm}$$

Step 3: Plot the flow rate, Q, versus time. Also, assume that flow drops uniformly from the last calculated flow rate (Q_9) to zero at the time when Q_{10} would have been taken.

Example: The flow rates calculated in Step 3 are plotted against the time between samples.

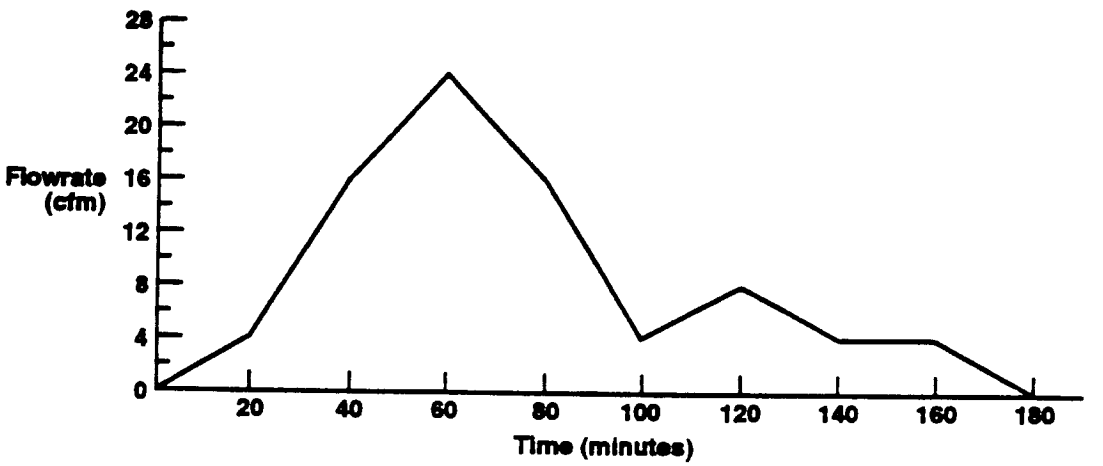

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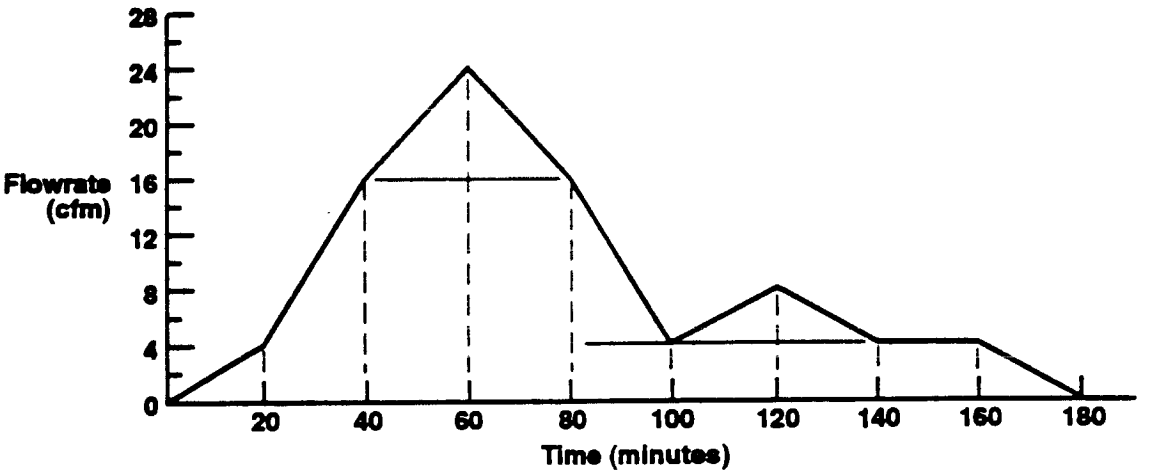
EXHIBIT 3-16. EXAMPLE CALCULATION OF TOTAL RUNOFF VOLUME FROM FLOW RATE DATA (Continued)

Step 4: The total flow volume (V_t) can be calculated by geometrically determining the area under the curve. The summation of the individual volumes per increment of time (V_1 through V_9) is the total flow volume of the event.

Example:



Step 5: Compute the flow volume associated with each observation (V_1, V_2, ..., V_9) by multiplying the measured flow rate by the duration (in this case, 20 minutes). Be sure the units are consistent. For example, if durations are in minutes and flow velocities are in cubic feet per second (cfs), convert the durations to seconds or the velocities to feet per minute.

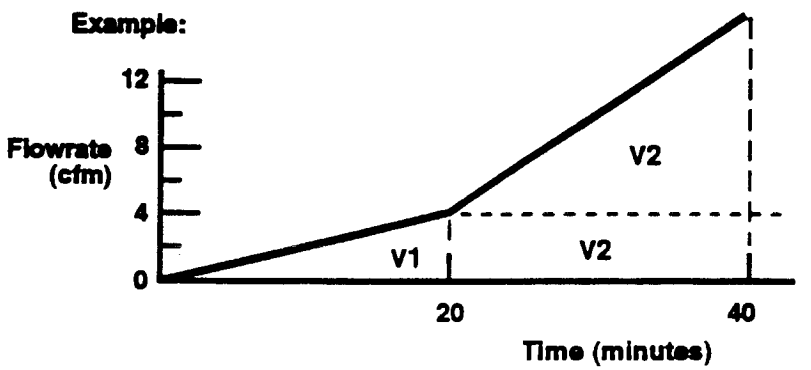


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EXHIBIT 3-16. EXAMPLE CALCULATION OF TOTAL RUNOFF VOLUME FROM FLOW RATE DATA (Continued)

Formula: ***Volume (V) = Flow Rate (cfm) x Duration (minutes)***

Example:

$$V_1 = \frac{1}{2}(Q_1 - Q_0)(t_1 - t_0) = \frac{1}{2}(4-0)(20-0) = 40\ ft^3$$

$$V_2 = \frac{1}{2}(Q_2 - Q_1)(t_2 - t_1) + Q_1(t_2 - t_1)$$

$$= \frac{1}{2}(16-4)(40-20) + 4(20)$$

$$= 120 + 80 = 200\ ft^3$$

$V_1 = 40\ ft^3$
$V_2 = 200\ ft^3$
$V_3 = 400\ ft^3$
$V_4 = 400\ ft^3$
$V_5 = 200\ ft^3$
$V_6 = 120\ ft^3$
$V_7 = 120\ ft^3$
$V_8 = 80\ ft^3$
$V_9 = 40\ ft^3$

Step 6: Total the individual volumes calculated in Step 5 to obtain the total runoff volume.

Example:

Total Storm Runoff = 1,600 ft³

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3.2.5 REPORTING STORM WATER DISCHARGE FLOW RATES AND VOLUMES

Form 2F requires applicants to provide quantitative data (reported both as concentration and as total mass) based on flow-weighted samples collected during storm events. In addition, applicants are required to provide flow estimates or flow measurements, as well as an estimate of the total volume of the discharge. The method of flow estimation or measurement must be described in the application. Although EPA only requires flow estimates in Form 2F, accurate flow measurement is necessary for collecting representative flow-weighted composite samples and reporting pollutant mass loadings.

3.2.6 MEASURING RAINFALL

Many types of instruments have been developed to measure the amount and intensity of precipitation. All forms of precipitation are measured on the basis of the depth of the water that would accumulate on a level surface if precipitation remained where it fell. There are two types of rain gauges - standard and recording gauges. A standard rain gauge collects the rainfall so that the amount of rain can be easily measured. The standard gauge for the NWS has a collector which is 8 inches in diameter. Rain flows from the collector into a cylindrical measuring tube inside the overflow can. The measuring tube has a cross-sectional area one tenth the size of the collector so that 0.1 inch of rainfall will fill 1 inch of the measuring tube. While this standard gauge is both accurate and easy to use, any open receptacle with vertical sides can be an effective rain gauge. Standard rain gauges are simple and inexpensive; however, with a standard gauge, there is no way to record changes in the intensity of the rainfall without making frequent observations of the gauge during the storm.

The second type of gauge is the recording rain gauge, which provides a permanent record of the amount of rainfall which accumulates over time. Three common types of recording gauges are:

- Tipping Bucket Gauge - Water caught in a collector is funneled into a two-compartment bucket; a known quantity of rain fills one compartment, overbalancing the bucket and emptying it into a reservoir. This moves the second bucket into place beneath the funnel. The tipping of the bucket engages an electric circuit, which records the event.
- Weighing Type Gauge - Water is weighed when it falls into a bucket placed on the platform of a spring or lever balance. The weight of the contents is recorded on a chart, showing the accumulation of precipitation.
- Float Recording Gauge - Water is measured by the rise of a float that is placed in the receiver. These gauges may be self-siphoning, or may need to be emptied periodically by hand.

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Recording rain gauges provide a permanent record of rainfall, and they can be used to determine variations in rainfall intensity over time without making frequent observations during the storm. But recording gauges are more complicated mechanically than standard gauges, making them more costly, less durable, and more difficult to operate.

Although all gauges are subject to error, most errors can be minimized. To minimize errors, the gauge should be placed on a level surface that is not windswept and is away from trees or buildings that might interfere with the path of rainfall. When taking measurements, other factors contributing to error should also be considered: mistakes in reading the scale, dents in the collector rim (which changes the receiving area), measuring sticks that may retain some of the water, and water lost to evaporation. In the case of tipping bucket gauges, water may not be collected while the bucket is still tipping. The most common source of inaccuracy is changes in data that are attributable to wind. It is possible to assess wind errors by comparing measurements of gauges that are protected from the wind with those that are not.

3.3 GRAB SAMPLE COLLECTION

Section 3.1.2 discussed both the parameters that must be monitored by grab sample and the conditions under which grab sampling is required. This section explains how to collect grab samples. The entire sample is collected at an uninterrupted interval (i.e., grabbed at one time). A grab sample provides information on the characterization of storm water at a given time and may be collected either manually or automatically as discussed below.

3.3.1 HOW TO MANUALLY COLLECT GRAB SAMPLES

A manual grab is collected by inserting a container under or downcurrent of a discharge with the container opening facing upstream. Generally, simplified equipment and procedures can be used. In most cases, the sample container itself may be used to collect the sample. Less accessible outfalls may require the use of poles and buckets to collect grab samples. To ensure that manual grab samples are representative of the storm water discharged, the procedures set forth in Exhibit 3-17 should be followed.

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EXHIBIT 3-17. RECOMMENDED OPERATING PROCEDURES FOR TAKING GRAB SAMPLES

- Label sample containers before sampling event
- Take a cooler with ice to the sampling point
- Take the grab from the horizontal and vertical center of the channel
- Avoid stirring up bottom sediments in the channel
- Hold the container so the opening faces upstream
- Avoid touching the inside of the container to prevent contamination
- Keep the sample free from uncharacteristic floating debris
- Transfer samples into proper containers (e.g., from bucket to sample container), however, fecal coliform, fecal streptococcus, phenols and O&G should remain in original containers
- If taking numerous grabs, keep the samples separate and labelled clearly
- Use safety precautions (see Chapter 6)

Specialized equipment and procedures may be needed, particularly in situations where storm water discharges are inaccessible or where certain parameters are monitored. For example:

- When sampling for O&G and VOCs, equipment that safely and securely houses O&G bottles or VOC vials should be used. This may be necessary because: (1) O&G will adhere to containers and thus should not be transferred from one container to another; and (2) excessive aeration during sampling may result in the partial escape of VOCs.
- Since facilities sometimes use sample bottles that already contain preservatives (as provided by contract laboratories), extreme care should be taken when filling them to avoid spills, splatters, or washout of the preservatives.

All equipment and containers that come into contact with the sample must be clean to avoid contamination. Additionally, sample collection equipment and container materials should be totally unreactive to prevent leaching of pollutants. Cleaning procedures are discussed in detail in Section 3.5.

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3.3.2 HOW TO COLLECT GRAB SAMPLES BY AUTOMATIC SAMPLER

Grab samples can also be collected using programmed automatic samplers. Automatic samplers come equipped with computers that can be programmed to collect grab samples. Programming for grabs is specific to the type of automatic sampler. Some samplers are portable and have been developed specifically to sample for storm water discharges. These samplers are frequently attached to a rain gauge and/or a flow sensor. Such samplers can be programmed to initiate sample collection by one or more of the following conditions: (1) depth of flow in a channel; (2) rainfall in inches; (3) flow rate; (4) time; (5) external signal; and (6) combinations of the first three conditions. For example, an automatic sampler could be used to collect a sample at 15-minute intervals after its sensors indicate that rainfall has begun.

When using an automatic sampler, planning is very important. First, all equipment must be properly cleaned, particularly the tubing and the sample containers. There are several different types of tubing available, including rubber and Tygon tubing. Tygon tubing is commonly used since it generally does not leach contaminants. Deionized water should be drawn through the sampler to remove any remaining pollutant residuals prior to taking samples. Tubing should also be replaced periodically to avoid algae or bacterial growth.

Sampling personnel should also use adequate and appropriate containers and ensure they are properly cleaned. Section 3.5 contains information on cleaning procedures which should be followed for all equipment. Additionally, the utilization of blanks (a control used to verify the accuracy of analytical results) is recommended to determine if cross-contamination of sampling equipment has occurred. Samplers should also be programmed, set up, and supplied with a source of power. Properly charged batteries should be readily available for portable samplers in advance of a storm event and, as a backup power supply in case of power failure. Finally, although automatic samplers may be useful in some situations, several parameters are not amenable to collection by automatic sampler. These pollutants include fecal streptococcus, fecal coliforms, oil and grease and VOCs which should be collected manually, not automatically, as discussed in Section 3.1.2.

3.4 FLOW-WEIGHTED COMPOSITE SAMPLE COLLECTION

Composite samples are samples simply comprised of a series of individual sample aliquots that have been combined to reflect average pollutant concentrations of the storm water discharge during the

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sampling period. Composite samples can be developed based on time or flow rate. There are four different types of composite samples, as follows:

- Constant Time - Constant Volume - Samples of equal volume are taken at equal increments of time and composited to make an average sample (similar to Exhibit 3-18). This method is not acceptable for samples taken for compliance with the storm water permit application regulations.

- Constant Time - Volume Proportional to Flow Increment - Samples are taken at equal increments of time and are composited proportional to the volume of flow since the last sample was taken (see Exhibit 3-19).

- Constant Time - Volume Proportional to Flow Rate - Samples are taken at equal increments of time and are composited proportional to the flow rate at the time each sample was taken (see Exhibit 3-20).

- Constant Volume - Time Proportional to Flow Volume Increment - Samples of equal volume are taken at equal increments of flow volume and composited (see Exhibit 3-21).

Generally, flow-weighted composite samples must be collected for most parameters. The methods for generating flow-weighted composite samples are discussed in the following sections.

For storm water discharge permit applications, the aliquots for flow-weighted composite samples must be collected during a representative storm for the first 3 hours, or for the duration of the storm event if it is less than 3 hours long. The storm water application regulations allow for flow-weighted composite samples to be collected manually or automatically. For both methods, equal volume aliquots may be collected at the time of sampling and then flow-proportioned and composited in the laboratory, or the aliquot may be collected based on the flow rate at the time of sample collection and composited in the field. When composite samples are collected, the regulations require that each aliquot collection be separated by a minimum of 15 minutes and that a minimum of three sample aliquots be taken within each hour of the discharge. See Exhibit 3-22 for an example of how this requirement may be fulfilled.

The provisions set forth in 40 CFR 122.21(g)(7) for collecting flow-weighted composite samples establish specific requirements for minimum time duration between sample aliquots. Where these conditions cannot be met, the permitting authority may allow alternate protocols with respect to the time duration between sample aliquots (see Chapter 5). However, permission from the permitting

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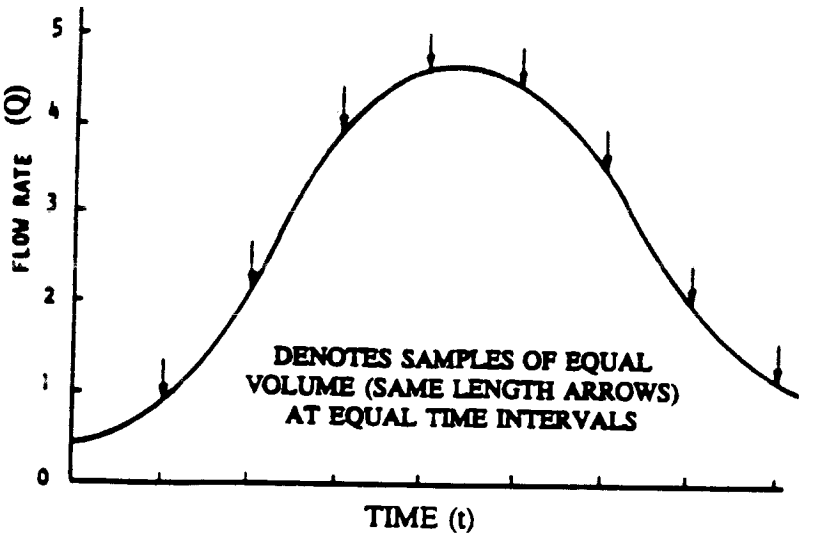
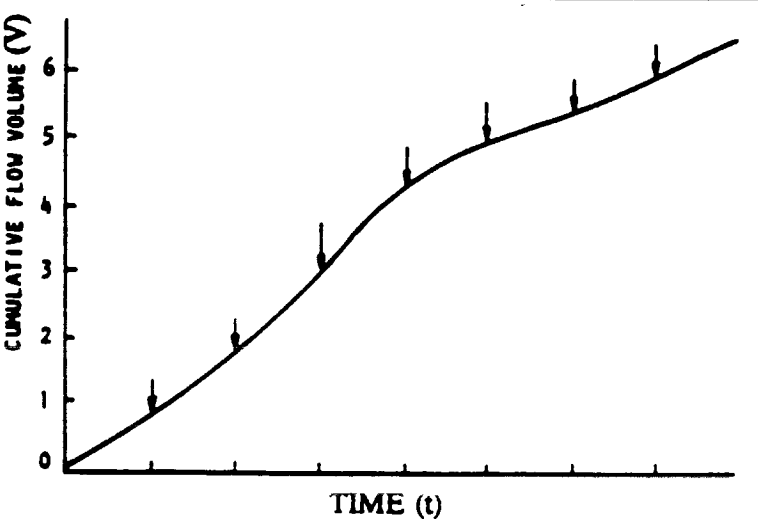
EXHIBIT 3-18. CONSTANT TIME - CONSTANT VOLUME



Method of compositing samples on a fixed volume-fixed time interval basis

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

EXHIBIT 3-19. CONSTANT TIME - VOLUME PROPORTIONAL TO FLOW INCREMENT



Method of compositing samples proportional to flow volume at constant time interval

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

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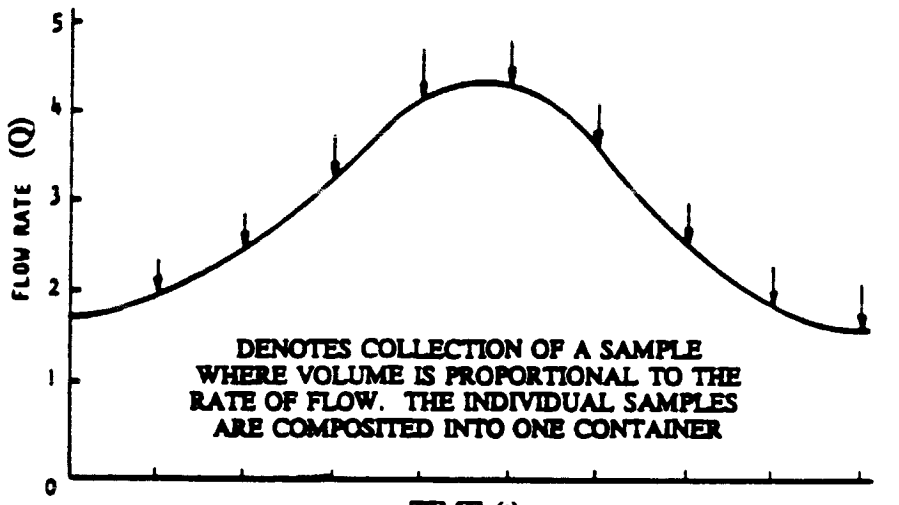
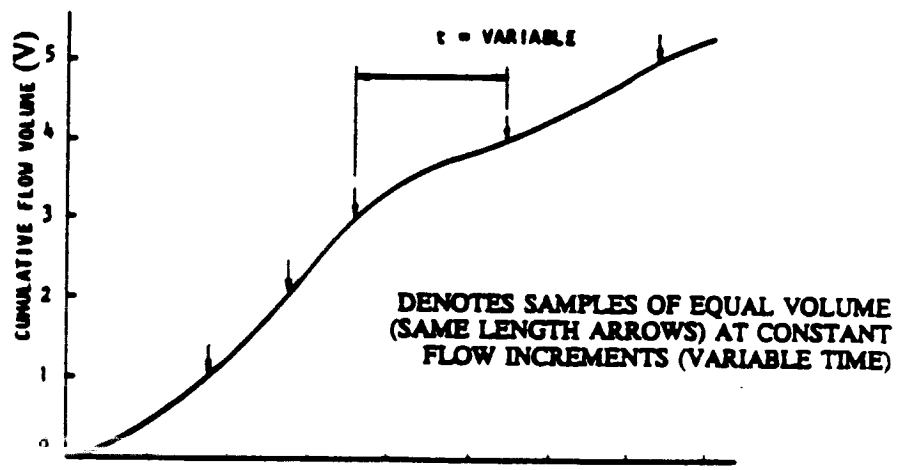
EXHIBIT 3-20. CONSTANT TIME - VOLUME PROPORTIONAL TO FLOW RATE



Method of compositing samples proportional to flow rate

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

EXHIBIT 3-21. CONSTANT VOLUME - TIME PROPORTIONAL TO FLOW VOLUME INCREMENT



Method of compositing samples of equal volume at equal increments of flow

Source: Methodology for the Study of Urban Storm Generated Pollution and Control, U.S. EPA 600/2-76-145, August 1976.

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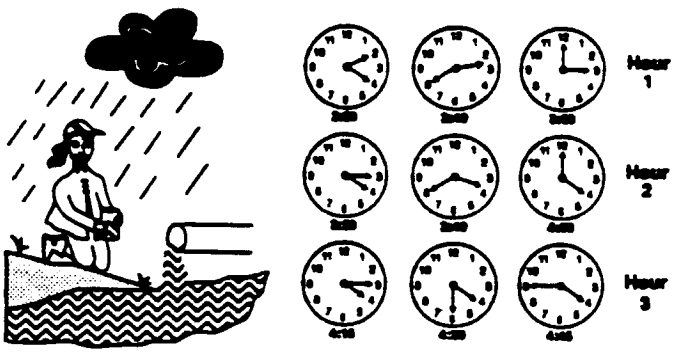
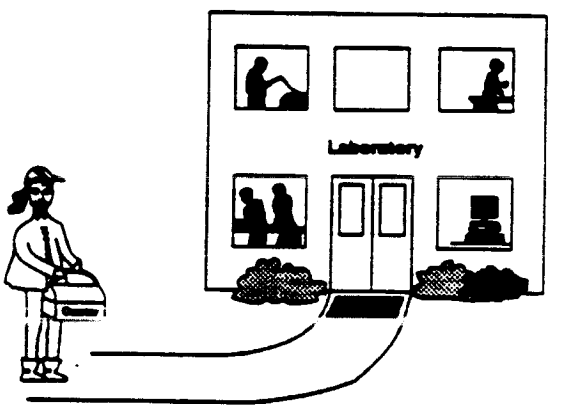
EXHIBIT 3-22. EXAMPLE OF SAMPLING INTERVALS

Suppose that a storm water discharge began at 2:15 p.m. and lasted until 5:15 p.m. on a Friday. The field staff person wants to collect the samples at regular intervals, so s/he plans to collect an aliquot with a volume that is proportional to the flow every 20 minutes. After the third hour of collection, the field staff person must deliver the samples to the laboratory (which is 10 minutes away). The laboratory closes at 5:00 p.m. So, s/he should take the last sample at 4:45 p.m. One way of doing this would be to collect samples (in hour three) at 4:15, 4:30, and 4:45 p.m. This would comply with the three-sample minimum in hour three (4:15-5:15 p.m.) and the required 15-minute minimum interval between collections. It would also allow the field staff person to get the samples to the lab before it closes for the weekend. On the other hand, if s/he missed the sample collection at 4:15 p.m. and instead, collected the sample at 4:20 p.m., then s/he would have to collect the next sample at 4:35 p.m. and the last sample at 4:50 p.m., and the field staff person would not be able to deliver the sample until Monday (by which time the required maximum holding time would be exceeded), and the sampling would need to be repeated.





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authority must be obtained before changes are initiated. Considerations applicable to the collection of flow-weighted composites by automatic and manual techniques are discussed in the following sections.

3.4.1 HOW TO MANUALLY COLLECT FLOW-WEIGHTED COMPOSITE SAMPLES

Manually collected, flow-weighted composite samples may be appropriate for a facility that prefers not to invest in automatic equipment. This technique is cost-effective for short-term monitoring programs and for facilities where few outfalls are being sampled. The fundamental requirement for facilities that use these methodologies is that they should have personnel available to perform the sampling when needed. Those facilities where VOCs analysis of storm water discharges are required should manually collect composite samples since these parameters may not be amenable to sampling by automatic samplers. Compositing of VOC samples should be conducted in the laboratory as discussed in Section 3.5.2.

The manual collection of a flow-weighted sample is performed in the same manner as taking manual grab samples (see Section 3.3.1). The only difference is that a series of samples (or aliquots) will be collected. As discussed in the previous section, there are two ways to manually collect and combine the aliquots for a flow-weighted sample:

- Collect sample aliquot volumes based on the flow at the time of sampling which can immediately be combined to make the composite sample in the field (see Exhibit 3-23)
- Collect equal volume sample aliquots at the time of sampling and then flow-proportion and composite the aliquots in the laboratory (see Exhibit 3-24).

When uniform time intervals are used between the collection of the sample aliquots, the volumes of each aliquot used in the composite sample can be determined based on either volumes of flow or the flow rate, as they will result in similar proportions. However, when there are different time intervals between the sample aliquots, the individual sample aliquot volumes should be based on the runoff volume (calculated from the individual flow rates and durations) associated with each sample aliquot.
Generally, 1,000 ml for each aliquot collected should provide enough sample volume, when composited, for pollutant analyses of the required parameters contained in Section VII.A of Form 2F (see Section 3.6). More aliquot volume may be required if sampling is conducted for additional parameters. The laboratory conducting the analyses should always be contacted prior to a sampling event to determine how much sample volume they will require.

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EXHIBIT 3.23 EXAMPLE OF HOW TO COLLECT SAMPLE ALIQUOT VOLUMES BASED ON FLOW, AND PROPORTION AND COMPOSITE IN THE FIELD

Step 1: Determine the necessary volume for compositing purposes.

Example: To fulfill analyses for all parameters in Section VII.A of Form 2F for which composite samples are required [Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN), nitrate plus nitrite, and phosphorous] a total composite sample volume of 5,000 ml is needed by the contract laboratory.

Step 2: Determine an appropriate interval for collection of samples.

Example: Manually collected flow-weighted composite samples must consist of at least three sample aliquots collected per hour and must be gathered at least 15 minutes apart. For this example, sample aliquots will be collected exactly 20 minutes apart.

Step 3: Estimate or measure the volume of discharge for each sampling event.

Example: A discharge flow volume of 4.8 cubic feet will be used here.

Step 4: Convert the discharge flow volume to liters.

Example: To convert cubic feet to liters, use the conversion factor of 28.32 liters per 1 cubic foot as set forth in the following formula:

$$\textit{Volume (liters)} = \textit{Volume (cubic feet)} \times \frac{\textit{28.32 liters}}{\textit{1 cubic foot}}$$

$$\textit{Volume} = \textit{4.8 cubic feet} \times \frac{\textit{28.32 liters}}{\textit{1 cubic foot}} = \textit{136 liters}$$

Step 5: Using Steps 3 and 4, volumes that have been discharged between the collection of each aliquot can be calculated.

(Note that the discharge volumes provided for aliquot numbers 2-9 have already been given for the purposes of this exhibit.)

Example: The procedures set forth in Section 3.2 may be used to calculate discharge volumes. The following table presents aliquot numbers, time of aliquot collection, and discharge volumes.

Aliquot Number	Time of Aliquot Collection	Discharged Volume
1	2:15 p.m.	136 liters
2	2:35 p.m.	200 liters
3	2:55 p.m.	122 liters
4	3:15 p.m.	178 liters
5	3:35 p.m.	156 liters
6	3:55 p.m.	117 liters
7	4:15 p.m.	94 liters
8	4:30 p.m.	21 liters
9	4:45 p.m.	12 liters

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EXHIBIT 3-23. EXAMPLE OF HOW TO COLLECT SAMPLE ALIQUOT VOLUMES BASED ON FLOW, AND PROPORTION AND COMPOSITE IN THE FIELD (Continued)

Step 6: Determine the appropriate minimum aliquot volume as the basis for collecting other aliquot samples which together will provide adequate volume to fulfill the analytic requirements.

Example: In Step 1, it was determined that at least 5,000 ml of sample were required for flow-weighted composite sample analytical testing. As discussed in Section 3.4.1, basing the sample collection on a minimum aliquot volume of 1,000 ml gathered every interval (i.e., every 15 minutes) should result in adequate sample volume.

Step 7: Calculate the volume of the sample aliquot which must be collected during each aliquot sample period using the following formula:

$$\textit{Aliquot volume (ml)} = \textit{Minimum aliquot volume (ml)} \times \frac{\textit{Aliquot's discharge volume (liters)}}{\textit{Initial discharge volume (liters)}}$$

Step 6 shows that the minimum aliquot volume is 1,000 ml.

$$\textit{Aliquot \#1 volume (ml)} = 1{,}000 \text{ ml} \times \frac{136 \text{ liters}}{136 \text{ liters}} = 1{,}000 \text{ ml}$$

$$\textit{Aliquot \#2 volume (ml)} = 1{,}000 \text{ ml} \times \frac{200 \text{ liters}}{136 \text{ liters}} = 1471 \text{ ml}$$

$$\textit{Aliquot \#3 volume (ml)} = 1{,}000 \text{ ml} \times \frac{122 \text{ liters}}{136 \text{ liters}} = 897 \text{ ml}$$

$$\textit{Aliquot \#4 volume (ml)} = 1{,}000 \text{ ml} \times \frac{178 \text{ liters}}{136 \text{ liters}} = 1{,}309 \text{ ml}$$

$$\textit{Aliquot \#5 volume (ml)} = 1{,}000 \text{ ml} \times \frac{156 \text{ liters}}{136 \text{ liters}} = 1{,}147 \text{ ml}$$

$$\textit{Aliquot \#6 volume (ml)} = 1{,}000 \text{ ml} \times \frac{117 \text{ liters}}{136 \text{ liters}} = 860 \text{ ml}$$

$$\textit{Aliquot \#7 volume (ml)} = 1{,}000 \text{ ml} \times \frac{94 \text{ liters}}{136 \text{ liters}} = 691 \text{ ml}$$

$$\textit{Aliquot \#8 volume (ml)} = 1{,}000 \text{ ml} \times \frac{21 \text{ liters}}{136 \text{ liters}} = 154 \text{ ml}$$

$$\textit{Aliquot \#9 volume (ml)} = 1{,}000 \text{ ml} \times \frac{12 \text{ liters}}{136 \text{ liters}} = 88 \text{ ml}$$

A table of these calculations follows:

Aliquot Number	Discharged Volume	Aliquot Volume
1	136 liters	1,000 ml
2	200 liters	1,471 ml
3	122 liters	897 ml
4	178 liters	1,309 ml
5	156 liters	1,147 ml
6	117 liters	860 ml
7	94 liters	691 ml
8	21 liters	154 ml
9	12 liters	88 ml

In conclusion, a combination of the above sample aliquots result in a composite of 7,617 ml.

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EXHIBIT 3-24 EXAMPLE OF HOW TO MANUALLY COLLECT EQUAL SAMPLE ALIQUOTS WHICH ARE LATER FLOW PROPORTIONED AND COMPOSITED IN THE LABORATORY

Step 1: Determine the necessary volume for compositing purposes.

Example: To fulfill analyses for all parameters in Section VII.A of Form 2F for which composite samples are required (BOD_5, COD, TSS, TKN, nitrate plus nitrite, and phosphorous) a total composite sample volume of 5,000 ml is needed by the contract laboratory.

Step 2: Determine an appropriate interval for collection of samples.

Example: Manually collected flow-weighted composite samples must consist of at least nine sample aliquots and must be gathered at least 15 minutes apart; only three or four samples per hour may be taken. For convenience, the minimum number of three is chosen. Sample aliquots will be collected every 20 minutes.

Step 3: Determine the aliquot which should be taken during each sampling event.

Example: At least 5,000 ml of sample is required for flow-weighted composite sample analytical testing. As discussed in Section 3.4.1, a minimum aliquot volume of 1,000 ml gathered every interval (i.e., every 15 minutes) should result in adequate sample volume to be used for later flow-weighted compositing.

Step 4: Estimate or measure the volume of discharge for each sampling event while collecting a discrete 1,000-ml aliquot, as discussed in Step 3, for later compositing.

Example: Section 3.2 discusses methods to calculate total discharge volumes. A discharge flow volume of 4.8 cubic feet will be used here.

Step 5: Convert the discharge flow volume to liters.

Example: To convert cubic feet to liters, use the conversion factor of 28.32 liters per 1 cubic foot as set forth in the following formula:

$$\textit{Volume (liters)} = \textit{Volume (cubic feet)} \times \frac{\textit{28.32 liters}}{\textit{1 cubic foot}}$$

$$\textit{Volume} = \textit{4.8 cubic feet} \times \frac{\textit{28.32 liters}}{\textit{1 cubic foot}} = \textit{136 liters}$$

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EXHIBIT 3-24. EXAMPLE OF HOW TO MANUALLY COLLECT EQUAL SAMPLE ALIQUOTS WHICH ARE LATER FLOW-PROPORTIONED AND COMPOSITED IN THE LABORATORY (Continued)

Step 6: Using Steps 3 and 4, calculate the volumes that have been discharged between the collection of each aliquot.

Example: The procedures set forth in Section 3.2 may be used to calculate discharge volumes. The following table presents aliquot numbers, time of aliquot collection, and discharge volumes (note that the discharge volumes provided for aliquot numbers 2-9 were chosen for purposes of this exhibit).

Aliquot Number	Time of Aliquot Collection	Discharged Volume
1	2:15 p.m.	136 liters
2	2:35 p.m.	200 liters
3	2:55 p.m.	122 liters
4	3:15 p.m.	178 liters
5	3:35 p.m.	156 liters
6	3:55 p.m.	117 liters
7	4:15 p.m.	94 liters
8	4:30 p.m.	21 liters
9	4:45 p.m.	12 liters

Step 7: Determine the aliquot sample which is associated with the greatest discharge volume.

Example: Aliquot number 2 was taken when the volume was 200 liters. This is the largest discharge volume.

Step 8: Calculate the volume of sample aliquot which must be used subsequent to the sample event to comprise a flow-weighted composite sample. The following formula should be used:

$$\textit{Aliquot volume (ml)} = \textit{Minimum aliquot volume (ml)} \times \frac{\textit{Aliquot's discharge volume (liters)}}{\textit{Largest discharge volume (liters)}}$$

Step 3 shows that the minimum aliquot volume is 1,000 ml. Using this value and the data determined as part of Steps 6 and 7, the following can be calculated:

$$\textit{Aliquot \#1 volume (ml)} = 1{,}000 \text{ ml} \times \frac{136 \text{ liters}}{200 \text{ liters}} = 680 \text{ ml}$$

$$\textit{Aliquot \#2 volume (ml)} = 1{,}000 \text{ ml} \times \frac{200 \text{ liters}}{200 \text{ liters}} = 1{,}000 \text{ ml}$$

$$\textit{Aliquot \#3 volume (ml)} = 1{,}000 \text{ ml} \times \frac{122 \text{ liters}}{200 \text{ liters}} = 610 \text{ ml}$$

$$\textit{Aliquot \#4 volume (ml)} = 1{,}000 \text{ ml} \times \frac{178 \text{ liters}}{200 \text{ liters}} = 890 \text{ ml}$$

$$\textit{Aliquot \#5 volume (ml)} = 1{,}000 \text{ ml} \times \frac{156 \text{ liters}}{200 \text{ liters}} = 780 \text{ ml}$$

$$\textit{Aliquot \#6 volume (ml)} = 1{,}000 \text{ ml} \times \frac{117 \text{ liters}}{200 \text{ liters}} = 585 \text{ ml}$$

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EXHIBIT 3-24. EXAMPLE OF HOW TO MANUALLY COLLECT EQUAL SAMPLE ALIQUOTS WHICH ARE LATER FLOW-PROPORTIONED AND COMPOSITED IN THE LABORATORY (Continued)

Aliquot #7 volume (ml) = 1,000 ml x $\frac{94 \text{ liters}}{200 \text{ liters}}$ = 470 ml

Aliquot #8 volume (ml) = 1,000 ml x $\frac{21 \text{ liters}}{200 \text{ liters}}$ = 105 ml

Aliquot #9 volume (ml) = 1,000 ml x $\frac{12 \text{ liters}}{200 \text{ liters}}$ = 60 ml

A table of these calculations follows

Aliquot Number	Discharged Volume	Aliquot Volume
1	136 liters	680 ml
2	200 liters	1,000 ml
3	122 liters	610 ml
4	178 liters	890 ml
5	156 liters	780 ml
6	117 liters	585 ml
7	94 liters	470 ml
8	21 liters	105 ml
9	12 liters	60 ml

In conclusion, a combination of the above sample aliquots results in a composite sample of 5,100 ml.

Manually collected flow-weighted composite samples can also be prepared by collecting sample aliquots of equal volume where the collection times are related to the volume of discharge which has passed since the last sample aliquot collection. However, this method is subject to fluctuating flow rates and volumes which may dictate that samples be taken prior to the 15-minute interval required by the regulations. In that case, the alternative sampling protocol would have to be approved by the permitting authority.

3.4.2 HOW TO COLLECT FLOW-WEIGHTED COMPOSITE SAMPLES BY AUTOMATIC SAMPLER

The typical automatic sampler collects sample aliquots after a specific interval. These aliquots can be flow-weight composited by the automatic sampler; or by hand in the laboratory. The automatic

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sampler may be programmed in one of three ways: (1) to collect a sample at equal time intervals and varying aliquot volumes commensurate with the flow (either rate or volume) that has passed; (2) to collect equal volume aliquots at varying time intervals commensurate with the flow volume that has passed; or (3) to collect equal volume aliquots of sample at equal time intervals.

The first two methods automatically composite the sample but require that the sampler be connected to a flow meter such that the sampler determines either the flow rate or the amount of volume that passes. Since these methods automatically composite samples, one main sample container may be used to receive all aliquots. The third method automatically collects the sample aliquots but does not automatically flow-weight composite the sample. As such, discrete sample containers must be used, and manual flow-weighted compositing must be conducted after the aliquots are collected. Exhibits 3-23 and 3-24 in Section 3.4.1 describe the manual compositing procedures that should be followed.

Manufacturers' instructions for the use of an automatic sampler provide the best explanation of programming options and should be consulted for information on programming samplers for storm water collection. Some of the points regarding automatic samplers discussed in Section 3.3.2 should also be considered.

3.5 SAMPLE HANDLING AND PRESERVATION

Samples must be handled and preserved in accordance with 40 CFR Part 136. This section describes acceptable analytical methods, including requirements regarding sample holding times, containers, sizes, and preservation requirements. For each pollutant or parameter that may have to be analyzed, 40 CFR Part 136 includes information on:

- Container types to be used to store the samples after collection
- Procedures to correctly preserve the samples
- The maximum holding time allowed for each parameter.

The following sections present a detailed discussion of preservation techniques and sample handling procedures. Technical Appendix C presents a matrix of required containers, preservation techniques,

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and holding times for each parameter. Most laboratories can provide clean sample containers, preservatives, sealing, chain-of-custody forms and can advise further on sample handling and preservation.

3.5.1 DECONTAMINATION OF SAMPLE EQUIPMENT CONTAINERS

Storm water sample containers should be cleaned and prepared for field use according to the procedures set forth in 40 CFR Part 136. A summary of the procedures is presented below for plastic containers, any or all of which may be performed by the laboratory or container distributor:

- Nonphosphate detergent and tap water wash
- Tap water rinse
- 10 percent nitric acid rinse (only if the sample is to be analyzed for metals)
- Distilled/deionized water rinse
- Total air dry.

To clean glass containers, the same steps should be taken; but, after the distilled/deionized water rinse, the containers should be rinsed with solvent if appropriate prior to total air drying. After the decontamination procedures have been accomplished, the sample containers should be capped or sealed with foil, and the sampling device should be protected and kept clean. It is a good idea to label sample containers after cleaning. The laboratory should keep a record of the technician performing the cleaning procedure as well as the date and time. This begins the required chain-of-custody procedure for legal custody (see Section 3.10 for more information). A chain-of-custody record accompanies each sample to track all personnel handling the sample. This record is essential to trace the sample integrity in the event that quality control checks reveal problems. For this reason, as well as to avoid problems if contamination issues arise, it is suggested that the laboratory performing the analysis perform the cleaning.

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3.5.2 SAMPLE PRESERVATION AND HOLDING TIMES

Preservation techniques ensure that the sample remains representative of the storm water discharge at the time of collection. Since many pollutants in the samples collected are unstable (at least to some extent), the sample should be analyzed immediately or preserved or fixed to minimize changes between the time of collection and analysis. Because immediate analysis is not always possible, most samples are preserved regardless of the time of analysis.

Problems may be encountered when flow-weighted composite samples are collected. Since sample deterioration can take place during the compositing process, it is necessary to preserve or stabilize the samples during compositing in addition to preserving aggregate samples before shipment to the laboratory. Preservation techniques vary depending on the pollutant parameter to be measured; therefore, familiarity with 40 CFR Part 136 (see Technical Appendix C) is essential to ensure effective preservation. It is important to verify that the preservation techniques for one parameter do not affect the analytical results of another in the same sample. If this is the case, two discrete samples should be collected and preserved accordingly.

Sample preservation techniques consist of refrigeration, pH adjustment, and chemical fixation. pH adjustment is necessary to stabilize the target analyte (e.g., addition of NaOH stabilizes cyanide); acidification of total metal samples ensures that metal salts do not precipitate. Refrigeration is the most widely used technique because it has no detrimental effect on the sample composition (i.e., it does not alter the chemistry of the sample), and it does not interfere with most analytical methods. Refrigeration requires the sample to be quickly chilled to a temperature of 4°C. This technique is used at the beginning of sample collection in the field, and is continued during sample shipment, and while the sample is in the laboratory. Even though samples taken for compositing purposes are taken over time each individual sample must be refrigerated. If taken manually, the samples can be placed in an ice box. If taken by a automatic sampler, the sampler unit should have refrigeration capabilities. The analytical laboratory may provide chemicals necessary for fixation, or may tell sampling personnel where they can be purchased.

In addition to preservation techniques, 40 CFR Part 136 indicates maximum holding times. A detailed list of holding times appears in Technical Appendix C. The holding time is the maximum

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amount of time that samples may be held before analysis and still be considered valid. Samples exceeding these holding times are considered suspect and sample collection may have to be repeated.

Although Technical Appendix C provides required sample containers, preservation techniques, and holding times, some of the more commonly monitored parameters warrant additional discussion. The following provides a more detailed discussion of considerations pertaining to cyanide, VOCs, organics and pesticides, O&G, pH, total residual chlorine, fecal coliform, fecal streptococcus, and 5-day Biochemical Oxygen Demand (BOD_5).

Cyanide

Cyanide is very reactive and unstable. If the sample cannot be analyzed immediately, it must be preserved by pH adjustment after collection. However, prior to pH adjustment, procedures to eliminate residual chlorine and sulfides must be followed immediately.

Where chlorine has the possibility of being present, the sample should be tested for residual chlorine by using potassium iodide-starch test paper previously moistened with acetate buffer. If the sample contains residual chlorine (a blue color indicates the need for treatment), ascorbic acid must be added 0.6 gram (g) at a time until the tests produce a negative result; then, an additional 0.6 g of ascorbic acid should be added to the sample.

Samples containing sulfides may be removed, in which case the holding time is extended to 14 days. Sulfides must be removed as follows:

- Use lead acetate paper moistened with an acetic acid buffer solution to test for the presence of sulfide. Darkening of the lead acetate paper indicates sulfide is present in the sample.
- Add cadmium nitrate to be added to the sample in a manner similar to the ascorbic acid until the test is negative.
- Filter with a 0.45 micrometer (μm) filter and prefilter combination immediately after.

After chlorine and sulfide residuals have been eliminated, the pH must be adjusted to greater than 12.0 standard units (s.u.) and chilled to 4°C.

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If cyanide is suspected to be present, the sampling personnel should bring all materials mentioned above to the sampling location.

VOCs

Sampling for VOCs requires the use of a glass vial. The vial should contain a teflon-coated septum seal. Volatiles will escape from the water to the air if any air is entrapped in the container. Therefore, the sample should be collected so that there are no air bubbles in the container after the screw cap and septum seal are applied. To ensure that air bubbles are not trapped in the vial, the following procedures should be followed:

- Fill the vial until a reverse meniscus forms above the top of the vial
- Screw on the cap (the excess sample will overflow)
- Invert the vial to check for the presence of air bubbles
- If air bubbles are observed, the vial should be opened, emptied, then completely refilled, and the first three actions should be repeated.

VOC samples should not be composited in the field. To composite a sample, the sampling personnel would have to mix it thoroughly. This mixing action would aerate the sample and cause volatiles to be lost. Therefore, VOC samples should be sent to the laboratory where they can be immediately, and carefully, composited and analyzed with minimal volatilization as per method Nos. 502.1, 502.2, 524.1, and 524.2 as described at 40 CFR 141.24(f)(14)(iv) and (v). There are two ways flow-weighted compositing of VOCs can be accomplished—mathematical compositing or procedural compositing as discussed below.

Mathematical Compositing

In this method, the grab samples are analyzed separately. The sampling personnel collect the requisite number of samples and send them to the laboratory. The laboratory performs the individual analyses on each sample. Five ml (or 25 ml if greater sensitivity is required) of each grab sample are placed into the purge vessel of the GC or GC/MS for analysis. Special precautions must be made to maintain zero headspace in the syringe used to transfer the VOC sample into the purge vessel of the GC or GC/MS. These analytical results are mathematically flow-weight composited

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using the calculation in Exhibit 3-24. The concentrations (C) should be adjusted by using the following formula:

$$Adjusted\ Concentration = \frac{Individual\ Aliquot\ Volume}{Total\ Composite\ Sample} \times C$$

Each sample concentration should be adjusted, and all adjusted concentrations added, to obtain the flow-weighted VOC composite using this method

Procedural Compositing

For the second method, sampling personnel collect the requisite number of samples and provide the laboratory with flow-weighted values for each sample using the calculation in Exhibit 3-24. The laboratory technician then draws the necessary volume from each aliquot into an adequately sized syringe, physically combining the samples to result in a flow-weighted composite sample for VOC analysis. Necessary volumes are drawn into the syringe with a volume control fitting. The samples are thus composited directly in the syringe and then placed in the purge vessel of the GC or GC/MS. The advantage of this procedure is that only one analysis on the GC or GC/MS has to be performed.

Although the applicant is required to report only flow-weighted composite concentrations, the mathematical compositing method may provide more information, as it will indicate the concentrations of each separate grab sample. For example, if the procedural compositing method is employed and one of the samples has a high concentration and the other three have non-detectable concentrations, the result will be an average which does not represent the concentration in any of the separate grab samples. In certain cases it may be important to know the concentration of each grab as well as the composite concentration. The mathematical compositing method would be the most appropriate compositing method in these cases.

Organics and Pesticides

The procedures affecting organics and pesticides [base/neutral/acids and pesticide polychlorinated biphenyls (PCBs)] are less complex than VOC procedures. Glass containers must be used for sample collection purposes, amber glass should be used to eliminate the potential for reactivity caused by light. These samples should be maintained at 4°C during storage and shipment. A preservative in

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the form of 0.008 percent sodium thiosulfate ($Na_2S_2O_3$) must be added to organic samples if residual chlorine is present. To determine if chlorine is present, a small color indicator test kit can be used. Eighty ml of $Na_2S_2O_3$ per liter of sample must then be added and mixed well until chlorine tests indicate a negative result as per methods 604 and 625 of 40 CFR Part 136 Appendix A. The pH of pesticide samples must be adjusted to between 5 and 9 s.u.

Oil and Grease

O&G tends to adhere to the surfaces that it contacts. Therefore, it should not be transferred from one container to another; rather, a 1-liter container should be used to take the sample. The container used for O&G must be made of glass. A teflon insert should be included in the glass container's lid. However, if teflon is not available, aluminum foil extending out from under the lid may be used. Samples for O&G must be preserved by adding sulfuric acid (H_2SO_4) or hydrochloric acid (HCl) to a pH of less than 2 s.u. and then stored at 4°C.

Additional Considerations

Some pollutants have specific analysis requirements due to short holding times that the applicant must consider. For example:

- Requirements to analyze immediately (pH, total residual chlorine, temperature, sulfite, and dissolved oxygen)
- Requirements to preserve immediately and analyze within 6 hours (fecal coliform and fecal streptococcus)
- Requirements to analyze within 48 hours (BOD_5).

Because of these requirements, field testing equipment may need to be purchased, borrowed, or rented for those parameters that may require field analysis. If the laboratory is located nearby, analysis in the field may not be required.

Laboratories do not always operate in the evenings or on weekends. As a result, holding times for samples taken in the late afternoon or on a Friday may be exceeded. To prevent this from occurring, close coordination with laboratories is necessary. The latest date and time of delivery should be

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established to avoid taking samples, only to discover they cannot be accepted by the laboratory and analyzed in accordance with 40 CFR Part 136 requirements.

3.6 SAMPLE VOLUMES

Exhibit 3-25 presents minimal suggested sample volumes for specific parameters. This exhibit should be consulted so that the proper volume is collected for analysis of each pollutant of concern. This exhibit may not include all parameters; if a particular parameter is not listed, refer to 40 CFR Part 136.

3.7 SAMPLE DOCUMENTATION

Information should be submitted to the laboratory with the sample to ensure proper handling by the laboratory. Exhibit 3-26 is an example form which can be used to document the following information.

- Unique Sample or Log Number - All samples should be assigned a unique identification number. If there is a serial number on the transportation case, the sampling personnel should add this number to the field records.
- Date and Time of Sample Collection - Date and time of sample collection (including notation of a.m. or p.m.) must be recorded. In the case of composite samples, the sequence of times and aliquot size should be noted.
- Source of Sample, Including Facility Name and Address - Use the outfall identification number from the site map with a narrative description; a diagram referring to the particular site where the sample was taken should be included.
- Name of Sampling Personnel - The names and initials of the persons taking the sample must be indicated. For a composite sample, the names of the persons installing the sampler and the names of the persons retrieving the sample should be included.
- Sample Type - Each sample should indicate whether it is a grab or composite sample. If the sample is a composite, the volume and frequency of individual aliquots should be noted.
- Preservation Used - Any preservatives (and the amount) added to the sample should be recorded. The method of preservation (e.g., refrigeration at 4°C) should be indicated.
- Analysis Required - All parameters for which the sample must be analyzed at the laboratory should be specified.

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EXHIBIT 3-25. VOLUME OF SAMPLE REQUIRED FOR DETERMINATION OF THE VARIOUS CONSTITUENTS OF INDUSTRIAL WASTEWATER

Tests	Volume of Sample, ml*
Physical	
Color and odor**	100 to 500
Corrosivity**	flowing sample
Electrical conductivity**	100
pH, electrometric**	100
Radioactivity	100 to 1,000
Specific gravity**	100
Temperature**	flowing sample
Toxicity**	1,000 to 20,000
Turbidity**	100 to 1,000
Chemical	
VOCs	100
Dissolved Gases	
Ammonia,*** NH_3	500
Carbon Dioxide,*** free CO_2	200
Chlorine,*** free Cl_2	200
Hydrogen,*** H_2	1,000
Hydrogen sulfide,*** H_2S	500
Oxygen,*** O_2	500 to 1,000
Sulfur dioxide,*** free SO_2	100
Miscellaneous	
Acidity and alkalinity	100
Bacteria (fecal coliform)	500
Bacteria (fecal streptococcus)	100
Biochemical oxygen demand (BOD)	100 to 500
Carbon dioxide, total CO_2 (including CO_3^{-}, HCO_3^{-}, and free)	200
Chemical oxygen demand (dichromate)	50 to 100
Chlorine requirement	2,000 to 4,000
Chlorine, total residual Cl_2 (including OCl^-, HOCl, NH_2Cl, $NHCl_2$, and free)	200
Chloroform-extractable matter	1,000
Detergents	100 to 200
Hardness	50 to 100
Hydrazine	50 to 100

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EXHIBIT 3-25. VOLUME OF SAMPLE REQUIRED FOR DETERMINATION OF THE VARIOUS CONSTITUENTS OF INDUSTRIAL WASTEWATER (Continued)

Tests	Volume of Sample, ml*
Miscellaneous (Continued)	
Micro-organisms	100 to 200
Volatile and filming amines	500 to 1,000
Oily matter	3,000 to 5,000
Organic nitrogen	500 to 1,000
Phenolic compounds	800 to 4,000
Polyphosphates	100 to 200
Silica	50 to 100
Solids, dissolved	100 to 20,000
Solids, suspended	50 to 1,000
Tannin and lignin	100 to 200
Cations	
Aluminum, Al+++	100 to 1,000
Ammonium,**** NH_4+	500
Antimony, Sb+++ to Sb+++++	100 to 1,000
Arsenic, As+++ to As+++++	100 to 1,000
Barium, Ba++	100 to 1,000
Cadmium, Cd++	100 to 1,000
Calcium, Ca++	100 to 1,000
Chromium, Cr+++ to Cr++++++	100 to 1,000
Copper, Cu++	200 to 4,000
Iron,**** Fe++ and Fe+++	100 to 1,000
Lead, Pb++	100 to 4,000
Magnesium, Mg++	100 to 1,000
Manganese, Mn++ to Mn+++++++	100 to 1,000
Mercury, Hg+ and Hg++	100 to 1,000
Potassium, Ni++	100 to 1,000
Nickel, Ni++	100 to 1,000
Silver, Ag+	100 to 1,000
Sodium, NA+	100 to 1,000
Strontium, Sr++	100 to 1,000
Tin, Sn++ and Sn++++	100 to 1,000
Zinc, Zn++	100 to 1,000

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EXHIBIT 3-25. VOLUME OF SAMPLE REQUIRED FOR DETERMINATION OF THE VARIOUS CONSTITUENTS OF INDUSTRIAL WASTEWATER (Continued)

Tests	Volume of Sample, ml*
Anions	
Bicarbonate, HCO_3^-	100 to 200
Bromide, Br^-	100
Carbonate, CO_3^{--}	100 to 200
Chloride, Cl^-	25 to 100
Cyanide, Cn^-	25 to 100
Fluoride, Fl^-	200
Hydroxide, OH^-	50 to 100
Iodide, I^-	100
Nitrate, NO_3^-	10 to 100
Nitrite, NO_2^-	50 to 100
Phosphate, Ortho, PO_4^{--}, HPO_4^{--}, $H_2PO_4^-$	50 to 100
Sulfate, SO_4^{--}, HSO_4^-	100 to 1,000
Sulfide, S^{--}, HS^-	100 to 500
Sulfite, SO_3^{--}, HSO_3^-	50 to 100

*Volumes specified in this table should be considered as guides for the approximate quantity of sample necessary for a particular analysis. The exact quantity used should be consistent with the volume prescribed in the standard method of analysis, whenever a volume is specified.
**Aliquot may be used for other determinations.
***Samples for unstable constituents must be obtained in separate containers, preserved as prescribed, completely filled, and sealed against all exposure.

Source: Associated Water and Air Resource Engineers, Inc., 1973, *Handbook for Monitoring Industrial Wastewater*, EPA Technology Transfer.

- Flow - If flow is measured at the time of sampling, the measurement must be recorded and accompanied by a description of the flow measurement method and calculations.

- Date, Time, and Documentation of Sample Shipment - The shipment method (e.g., air, rail, or bus) as well as the shipping papers or manifest number should be noted.

- Comments - All relevant information pertaining to the sample or the sampling site should be recorded. Such comments could include the condition of the sample site, observed characteristics of the sample environmental conditions that may affect the sample and problems encountered during sampling.

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EXHIBIT 3-26. FIELD SHEET FOR SAMPLE DOCUMENTATION

Sample Source	Sample ID #	Date: XX/XX/XX
Facility Name		Time: XX:XX a.m./p.m.
Address	Person Performing Sampling	
Outfall ID #	Signature	
Description	Preservation Method	
Diagram of Site	Comments	
Flow Description	Ship Via: Stable Shipping Paper/Manifest	
Flow Calculations	Analysis Required	

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3.8 SAMPLE IDENTIFICATION AND LABELING

Prior to collection of the sample, a waterproof, gummed sample identification label or tag should be attached to the sample container. This label should contain relevant information for sample analysis, such as:

- Facility name
- Name of the sample collector
- Sample identification number
- Date and time of sample collection
- Type of analysis required
- Location of sample collection
- Preservatives used
- Type of sample (grab or composite).

Sample lids should be used to protect the sample's integrity from the time it is collected to the time it is opened in the laboratory. The lid should contain the collector's name, the date and time the sample was collected, and a sample identification number. Information on the seal must be identical to the information on the label. In addition, the lid should be taped shut so that the seal must be broken to open the sample container. Caution should be taken to ensure that glue from tape and label tag wires do not contaminate samples, particularly those containing volatile organics and metals. Also, waterproof ink should be used to avoid smearing on the label from melted ice used for cooling.

3.9 SAMPLE PACKAGING AND SHIPPING

If the samples are not hand-delivered to the laboratory or analyzed in an onsite laboratory, they should be placed in a transportation case (e.g., a cooler) along with the chain-of-custody record form, pertinent field records, and analysis request forms and shipped to the laboratory. Glass bottles should be wrapped in foam rubber, plastic bubble wrap, or other material to prevent breakage during shipment. The wrapping can be secured around the bottle with tape. The container lid should also be sealed with tape. Samples should be placed in ice or a synthetic ice substitute that

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will maintain the sample temperature at 4°C throughout shipment. Ice should be placed in double-wrapped watertight bags so the water will not leak from the shipping case. Metal or heavy plastic ice chests make good sample transportation cases. Filament tape wrapped around each end of the ice chest ensures that it will not open during transport. Sampling records (preferably laminated or waterproof) can be placed in a waterproof envelope and taped to the inside of the transportation case to avoid getting them wet in case a sample container or an ice bag leaks. Shipping containers should also be sealed to prevent tampering. A copy of all sampling records should be kept onsite in case they are requested by the permitting authority

Most samples will not require any special transportation precautions except careful packaging to prevent breakage and/or spillage. If the sample is shipped by common carrier or sent through the U.S. mail, it must comply with Department of Transportation Hazardous Materials Regulations (49 CFR Parts 171-177). Air shipment of hazardous materials samples may also be covered by requirements of the International Air Transport Association (IATA). Before shipping a sample, the facility should be aware of, and follow, any special shipping requirements. Special packing and shipping rules apply to substances considered hazardous materials as defined by IATA rules. Storm water samples are not generally considered hazardous materials, but in the event of a spill, leakage, etc., at the collection site hazardous materials may be present in the samples. Be aware, before sampling, of what hazardous materials may be in the discharge drainage area. If the presence of hazardous materials is suspected, do not sample unless properly trained.

3.10 CHAIN-OF-CUSTODY PROCEDURES

Once samples have been obtained and collection procedures are properly documented, a written record of the chain of custody of that sample should be made. This is recommended so the applicant can be confident that the samples have not been tampered with and that the sample once analyzed is representative of the storm water discharge. "Chain-of-custody" refers to the documented account of changes in possession that occur for a particular sample or set of samples. The chain-of-custody record allows an accurate step-by-step recreation of the sampling path, from origin through analysis. Information necessary in chain-of-custody is:

- Name of the persons collecting the sample
- Sample ID numbers

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- Date and time of sample collection
- Location of sample collection
- Names and signatures of all persons handling the samples in the field and in the laboratory.

To ensure that all necessary information is documented, a chain-of-custody form should be developed. An example of such a form is found in Exhibit 3-27. Chain-of-custody forms should be printed on carbonless, multipart paper so all personnel handling the sample receive a copy. All sample shipments should be accompanied by the chain-of-custody record and a copy of these forms should be retained by the originator. In addition, all receipts associated with the shipment should be retained. Carriers typically will not sign for samples; therefore, seals must be used to verify that tampering has not occurred during shipment.

When transferring possession of samples, the transferee should sign and record the date and time on the chain-of-custody record. In general, custody transfers are made for each sample, although samples may be transferred as a group. Each person who takes custody should fill in the appropriate section of the chain-of-custody record.

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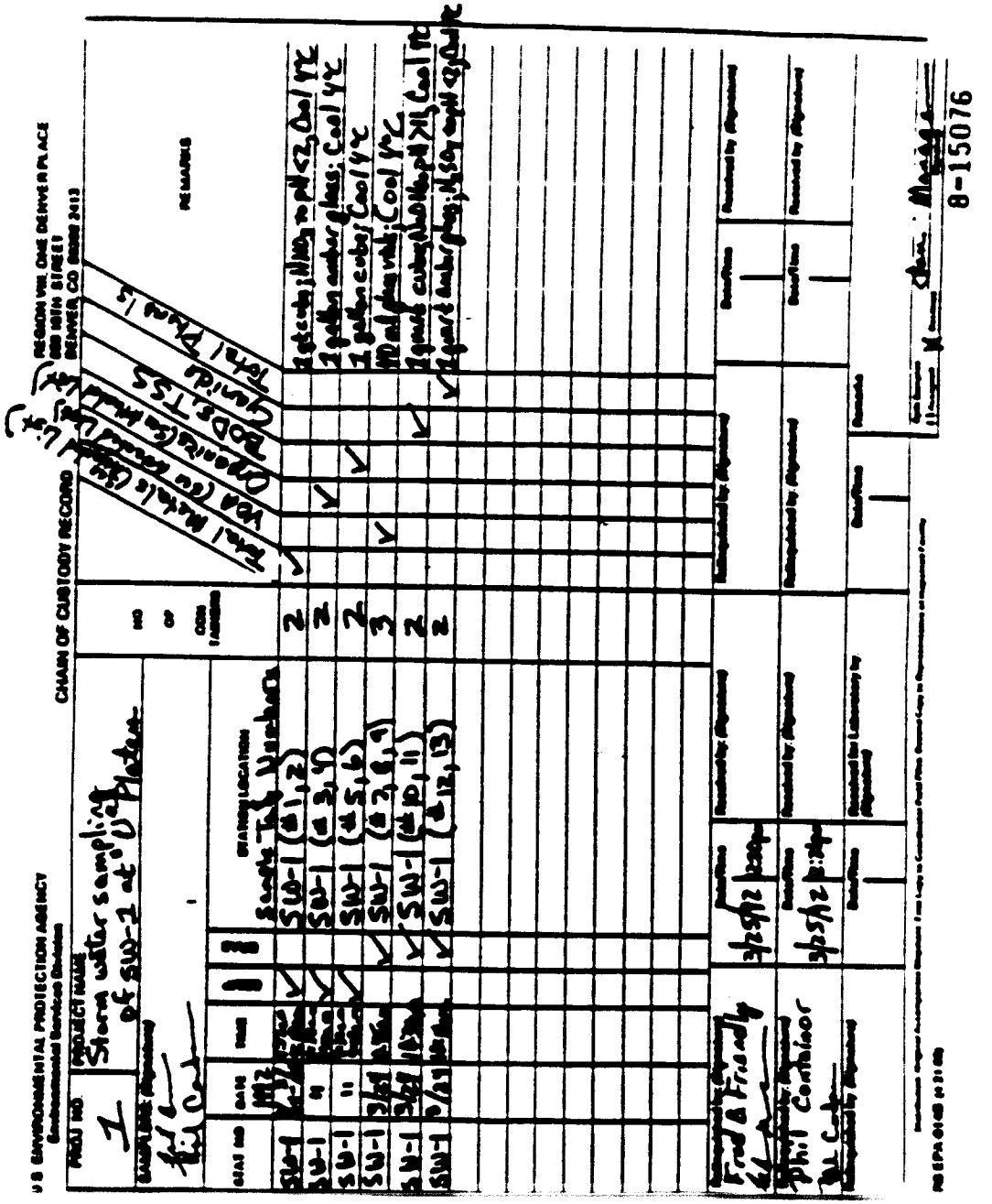
EXHIBIT 3-27. EXAMPLE OF CHAIN-OF-CUSTODY FORM



Source: U.S. EPA, Region 8

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4. ANALYTICAL CONSIDERATIONS

All storm water discharges must be sampled and analyzed in accordance with the test procedures provided in 40 CFR Part 136. This section discusses pollutant parameters which must be analyzed by storm water permit applicants. If the applicant wants to use an alternative test method, the facility must apply for approval (by submitting a description of the method to the permitting authority for approval) prior to application submission [see 40 CFR 136.4(d)(3)]. Section 5.4 elaborates on how to obtain approval for an analytical method for a parameter that is not included in 40 CFR Part 136. EPA-approved analytical methods at 40 CFR 136.3, Tables IB and IC are shown in Appendix C of this document.

When choosing the appropriate 40 CFR Part 136 analytical method, the applicant should consider sample interferences and potential field sampling error. Most method detection levels are established under ideal sample conditions (e.g., with little or no sample matrix interferences or sampling error). Thus, for storm water samples, the method chosen should account for sampling error and interferences.

4.1 INDUSTRIAL REQUIREMENTS

Industrial dischargers must provide information on the following parameters, as required in 40 CFR 122.26(c)(1)(i)(E):

- Any pollutant limited in an effluent guideline to which the facility is subject
- Any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility has an existing NPDES permit)
- O&G, pH, BOD_5, COD, TSS, total phosphorus, TKN, and nitrate plus nitrite nitrogen
- Any pollutant known or believed to be present [as required in 40 CFR 122.21(g)(7)]
- Flow measurements or estimates of the flow rate, the total amount of discharge for the storm events sampled, and the method of flow measurement or estimation
- The date and duration (in hours) of the storm events sampled, rainfall measurements or estimates of the storm event (in inches) which generated the sampled runoff, and the time between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event (in hours).

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4.1.1 INDIVIDUAL APPLICANTS

Industrial facilities submitting an individual permit application must provide sampling data in three parts of the Form 2F application form as discussed below. (Form 2F restates requirements listed in 40 CFR 122.21 and 122.26).

Section VII.A Parameters

Section VII.A of Form 2F requires the facility to sample (grab and flow-weighted samples) for O&G, BOD_5, COD, TSS, TKN, nitrate plus nitrite nitrogen, total phosphorus, and pH. These parameters are to be monitored by every facility applying for a storm water discharge permit, regardless of the type of operations that exist at the site. Sampling for additional parameters may be required, depending on the type of facility applying for the permit or the pollutants expected to be present in the discharge. These additional requirements are discussed in detail below.

Section VII.B Parameters

Section VII-B of Form 2F requires the applicant to identify all pollutants that are limited in an effluent guideline to which the facility is subject, as well as other toxic and nonconventional pollutants listed in the facility's NPDES permit for its process wastewater. EPA interprets that for pollutants listed in NPDES process wastewater permits, at a minimum, facilities must sample their storm water discharge for those pollutants specifically limited in their process wastewater permit. States can be more stringent, however, and may interpret this requirement to mean all pollutants listed in the permit. Once these parameters are identified, the applicant will be required to sample for these parameters by both grab and flow-weighted composite samples, except for the specified pollutants which must be grab sampled only. Form 2F requires the applicant to submit maximum values. The average values column is not compulsory, but should be completed if data are available. Applicable effluent guidelines appear in 40 CFR Parts 405-471. A listing of the Subchapter N—Effluent Guidelines and Standards by which the applicant may be regulated appears in Exhibit 4-1. The applicant must refer to the effluent guidelines and standards for the particular industry, and should determine which guidelines apply and which parameters should be listed in Section VII.B of Form 2F.

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EXHIBIT 4-1. SUBCHAPTER N-EFFLUENT GUIDELINES AND STANDARDS

Part	Effluent Guidelines and Standards	Part	Effluent Guidelines and Standards
405	Dairy Products Processing Point Source Category	431	Builder's Paper and Board Mills Point Source Category
406	Grain Mils Point Source Category	432	Meat Products Point Source Category
407	Canned and Preserved Fruits and Vegetables Point Source Category	433	Metal Finishing Point Source Category
408	Canned and Preserved Seafood Point Source Category	434	Coal Mining Point Source Category
409	Sugar Processing Point Source Category	435	Oil and Gas Extraction Point Source Category
410	Textile Mills Point Source Category	436	Mineral Mining and Processing Point Source Category
411	Cement Manufacturing Point Source Category	439	Pharmaceutical Manufacturing Point Source Category
412	Feedlots Point Source Category	440	Ore Mining and Dressing Point Source Category
413	Electroplating Point Source Category	443	Paving and Roofing Point Source Category
414	Organic Chemicals, Plastics, and Synthetic Fibers Point Source Category	446	Paint Formulating Point Source Category
415	Inorganic Chemicals Manufacturing Point Source Category	447	Ink Formulating Point Source Category
416	(Reserved)	454	Gum and Wood Chemicals Manufacturing Point Source Category
417	Soap and Detergent Manufacturing Point Source Category	455	Pesticide Chemicals Manufacturing Point Source Category
418	Fertilizer Manufacturing Point Source Category	457	Explosives Manufacturing Point Source Category
419	Petroleum Refining Manufacturing Point Source Category	458	Carbon Black Manufacturing Point Source Category
420	Iron and Steel Manufacturing Point Source Category	459	Photographic Point Source Category
421	Nonferrous Metals Manufacturing Point Source Category	460	Hospital Point Source Category
422	Phosphate Manufacturing Point Source Category	461	Battery Manufacturing Point Source Category
423	Steam Electric Power Generating Point Source Category	463	Plastics Molding and Forming Point Source Category
424	Ferroalloy Manufacturing Point Source Category	464	Metal Molding and Casting Point Source Category
425	Leather Tanning and Finishing Point Source Category	465	Coil Coating Point Source Category
426	Glass Manufacturing Point Source Category	466	Porcelain Enameling Point Source Category
427	Asbestos Manufacturing Point Source Category	467	Aluminum Forming Point Source Category
428	Rubber Manufacturing Point Source Category	468	Copper Forming Point Source Category
429	Timber Products Processing Point Source Category	469	Electrical and Electronic Components Point Source Category
430	Pulp, Paper and Paperboard Point Source Category	471	Nonferrous Metals Forming and Metal Powders Point Source Category

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Section VII.C Parameters

Section VII.C requires the applicant to list, for each outfall, each pollutant described in 40 CFR Part 122, Appendix D, Tables II, III, IV, and V (Tables 2F-2, 2F-3, and 2F-4 of application Form 2F) that it knows, or has reason to believe, may be present in the storm water discharge. These pollutants consist of conventional and nonconventional pollutants, toxic pollutants and total phenol, Gas Chromatography/Mass Spectrometry (GC/MS) fraction volatile compounds, acid compounds, base/neutral compounds, pesticides, and hazardous substances. These tables are also provided on the back of Form 2F. Tables II and III of 40 CFR Part 122 Appendix D have been combined in Table 2F-3 of application Form 2F. Table IV of 40 CFR Part 122 Appendix D is listed as Table 2F-2 of application Form 2F and Table V of 40 CFR Part 122 Appendix D is listed as Table 2F-4 of application Form 2F. There are specific requirements associated with each table. If pollutants in Table IV of 40 CFR Part 122 Appendix D (Table 2F-2 of application Form 2F), are directly or indirectly limited by an effluent guideline limitation, the applicant must analyze for it and report the data. For other pollutants listed in Table IV of 40 CFR Part 122 Appendix D (Table 2F-2 of the application form), the applicant must either report quantitative data, if available, or briefly describe the reasons the pollutant is expected to be in the discharge.

For every pollutant in Tables II and III of 40 CFR Part 122 Appendix D (Table 2F-3 of application Form 2F) expected to be discharged in concentrations of 10 parts per billion (ppb) or greater, the applicant must submit quantitative data. For acrolein, acrylonitrile, 2,4-dinitrophenol, and 2-methyl-4,6-dinitrophenol, the applicant must submit quantitative data if any of these four pollutants is expected to be discharged in concentrations of 100 ppb or greater. For every pollutant expected to be discharged with a concentration less than 10 ppb (or 100 ppb for the four parameters mentioned above), the applicant must either submit quantitative data or briefly explain why the pollutant is expected to be discharged.

For the parameters identified in Table V of 40 CFR Part 122 Appendix D (Table 2F-4 of application Form 2F) that the applicant believes to be present in the discharge, no sampling is required. If previous analyses of these parameters were conducted, the results must be reported. Otherwise, the applicant is required to explain why these pollutants are believed to be present.

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Small Business Exemption

Small businesses are exempted from the reporting requirements for the organic toxic pollutants presented in 40 CFR Part 122, Table II of Appendix D. Applicants can claim a small business exemption if:

- The facility is a coal mine and the probable annual production is less than 100,000 tons per year. The applicant may submit past production data or estimate future production data instead of conducting analyses for the organic toxic pollutants listed in Table 2F-3 of application Form 2F.
- The facility is not a coal mine, and the gross total annual sales for the most recent 3 years is, on average, less than $100,000 per year (reflected in second quarter 1980 dollars). The applicant may submit sales data for those years instead of conducting analyses for the organic toxic pollutants listed in Table 2F-3 of application Form 2F.

Section VIII

Section VIII of Form 2F requires the applicant to provide biological toxicity testing data for storm water discharges associated with industrial activity. Applicants are required to perform biological toxicity testing for the storm water application if the facility's NPDES permit for its process wastewater lists biological toxicity (EPA interprets "listed" as limited). For example, if a facility's NPDES process wastewater permit has an acute toxicity limit of a lethal concentration (LC_{50}), equal to 75 percent effluent using ceriodaphnia, then that facility must also test its storm water discharges associated with industrial activity and report the results of the tests in Section VIII of Form 2F.

Until whole effluent toxicity methods are promulgated by EPA in 40 CFR Part 136, toxicity testing should be conducted using the most appropriate methods and species as determined by the permitting authority. In the absence of State acute toxicity testing protocols, EPA recommends using the methods described in Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Fresh Water and Marine Organisms. EPA/600/4-90-027 (Rev. September 1991)

4.1.2 GROUP APPLICANTS

Industrial facilities submitting a group application must also provide sampling data (from the sampling subgroup) which is required to be submitted in Sections VII, VIII, and IX along with the certification in Section X of Form 2F. At a minimum, these parameters include O&G, BOD_5, COD,

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TSS, TKN, nitrate plus nitrite nitrogen, total phosphorous, and pH. Furthermore, all pollutants listed in an effluent guideline or limited in an NPDES permit applicable to the sampling facilities within the group must be sampled, as well as pollutants suspected of being present based on significant materials and industrial activities present onsite.

4.2 MUNICIPAL REQUIREMENTS

For Part 1 of the municipal permit application, municipalities must submit samples from the field screening effort for pH, total chlorine, total copper, phenol, and detergents (or surfactants). A narrative description of the color, odor, turbidity, and presence of oil sheen and surface scum must be included. For Part 2 of the permit application, municipalities must provide quantitative data for the organic pollutants listed in Table II of 40 CFR Part 122 Appendix D, and the pollutants listed in 40 CFR Part 122, Appendix D, Table III, as well as some additional pollutants. These pollutants are listed in Exhibit 4-2.

Furthermore, 40 CFR 122.26(d)(2)(iii)(A)(5) requires that estimates be provided of the annual pollutant load of the cumulative discharges to waters of the U.S. from all identified municipal outfalls, and the event mean concentration of the cumulative discharges to waters of the U.S. from all identified municipal outfalls during storm events for the parameters listed in Exhibit 4-2. Estimates of the parameters must be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modelling, data analysis, and calculation methods.

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EXHIBIT 4-2. PARAMETERS WHICH MUST BE ANALYZED BY MUNICIPAL APPLICANTS

Pollutants Contained in Table III of 40 CFR Part 122, Appendix D				
Total antimony	Total cadmium	Total lead	Total selenium	Total zinc
Total arsenic	Total chromium	Total mercury	Total silver	Total cyanide
Total beryllium	Total copper	Total nickel	Total thallium	Total phenols

Pollutants Contained in Table II of 40 CFR Part 122, Appendix D				
Acrolein	Toluene	Benzo(a)pyrene	2,6-dinitrotoluene	Gamma-BHC
Acrylonitrile	1,2-trans-dichloroethylene	3,4-benzofluoranthene	Di-n-octyl phthalate	Delta-BHC
Benzene	1,1,1-trichloroethane	Benzo(ghi)perylene	1,2-diphenylhydrazine	Chlordane
Bromoform	1,1,2-trichloroethane	Benzo(k)fluoranthene	Fluoranthene	4,4'-DDT
Carbon Tetrachloride	Trichloroethylene	Bis(2-chloroethoxy)methane	Fluorene	4,4'-DDE
Chlorobenzene	Vinyl chloride	Bis(2-chloroethyl)ether	Hexachlorobenzene	4,4'-DDD
Chlorodibromo-methane	2-chlorophenol	Bis(2-chloroisopropyl)ether	Hexachlorobutadiene	Dieldrin
Chloroethane	2,4-dichlorophenol	Bis(2-ethylhexyl)phthalate	Hexachlorocyclopen-tadiene	Alpha-endosulfan
2-Chloroethylvinyl ether	2,4-dimethylphenol	4-bromophenyl phenyl ether	Hexachloroethane	Beta-endosulfan
Chloroform	4,6-dinitro-o-cresol	Butylbenzyl phthalate	Indeno(1,2,3-cd)pyrene	Endosulfan sulfate
Dichlorobromo-methane	2,4-dinitrophenol	2-chloronaphthalene	Isophorone	Endrin
1,1-dichloroethane	2-nitrophenol	4-chlorophenyl phenyl ether	Naphthalene	Endrin aldehyde
1,2-dichloroethane	4-nitrophenol	Chrysene	Nitrobenzene	Heptachlor
1,1-dichloroethylene	p-chloro-m-cresol	Dibenzo(a,h)anthracene	N-nitrosodimethylamine	Heptachlor epoxide
1,2-dichloropropane	Pentachlorophenol	1,2-dichlorobenzene	N-nitrosodi-n-propylamine	PCB-1242
1,3-dichloropropylene	Phenol	1,3-dichlorobenzene	N-nitrosodiphenylamine	PCB-1254
Ethylbenzene	2,4,6-trichlorophenol	1,4-dichlorobenzene	Phenanthrene	PCB-1221
Methyl bromide	Acenaphthene	3,3-dichlorobenzidine	Pyrene	PCB-1232
Methyl chloride	Acenaphthylene	Diethyl phthalate	1,2,4-trichlorobenzene	PCB-1248
Methylene chloride	Anthracene	Dimethyl phthalate	Aldrin	PCB-1260
1,1,2,2-tetrachloroethane	Benzidine	Di-n-butyl phthalate	Alpha-BHC	PCB-1016
Tetrachloroethylene	Benzo(a)anthracene	2,4-dinitrotoluene	Beta-BHC	Toxaphene

Additional Pollutants Which Must be Analyzed		
TSS	O&G	TKN
TDS	Fecal coliform	Nitrate plus nitrite nitrogen
COD	Fecal streptococcus	Total and dissolved phosphorus
BOD_5	pH	
	Total residual chlorine	

Source: 40 CFR Part 122, Appendix D

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5. FLEXIBILITY IN SAMPLING

The requirements for storm water sampling for permit applications offer some flexibility by the permitting authority. The areas of flexibility are discussed below.

5.1 PROTOCOL MODIFICATIONS

The permitting authority may allow sampling protocol modifications for specific requirements on a case-by-case basis. For example, the permitting authority may accept application forms with incomplete sampling data if there was no rainfall at the applicant's facility prior to the submission deadline. However, the permitting authority will require that sampling data be submitted as soon as possible. The reason for not submitting data must be certified by a corporate official (for industrial facilities) or the principal executive officer or ranking official (for municipalities).

Another area where permitting authorities may allow flexibility in storm water sampling is acceptance of quantitative data from a storm event that does not meet the representative rainfall criteria of within 50 percent of the volume and duration for the average storm event for the area. The permitting authority may decide that the discharge data provided is better than no data at all.

In addition, the permitting authority may establish appropriate site-specific sampling procedures or requirements, including sampling locations; the season in which the sampling takes place; the minimum duration between the previous measurable storm event and the storm event sampled; the minimum or maximum level of precipitation required for an appropriate storm event; the form of precipitation sampled (snow melt or rainfall); protocols for collecting samples under 40 CFR Part 136; and additional time for submitting data on a case-by-case basis. The permitting authority should be contacted for preapproval of any necessary protocol modifications. In the case of group applications, EPA Headquarters should be contacted.

5.2 PETITION FOR SUBSTITUTING SUBSTANTIALLY IDENTICAL EFFLUENTS

As described at 40 CFR 122.21(g)(7), when an industrial applicant has two or more outfalls with substantially identical effluents, the permitting authority may allow the applicant to test only one outfall and to report that the quantitative data also apply to the substantially identical outfalls. In the case of group applications, the petition must be submitted to EPA Headquarters.

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For facilities seeking to demonstrate that storm water outfalls are substantially identical, a variety of methods can be used as determined by the permitting authority. Three possible petition options are discussed here: (1) submission of a narrative description and a site map; (2) submission of matrices; or (3) submission of model matrices. Detailed guidance on each of the three options for demonstrating substantially identical outfalls is provided below. An owner/operator certification should be submitted with each option. See Section 5.2.3 for an example of this certification.

5.2.1 OPTION ONE: NARRATIVE DESCRIPTION/SITE MAP

Facilities demonstrating that storm water outfalls are substantially identical may submit a narrative description of the facility and a site map to the permitting authority . The narrative portion must include a description of why the outfalls are substantially identical. Petitioners may demonstrate that these outfalls contain storm water discharges associated with:

- Substantially identical industrial activities and processes;
- Substantially identical significant materials that may be exposed to storm water [including, but not limited to, raw materials, fuels, materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under Section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); any chemical the facility is required to report pursuant to Section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA); fertilizers; pesticides; and waste products such as ashes, slag, and sludge that have the potential to be released with storm water discharges as per 40 CFR 122.26(b)(12)];
- Substantially identical storm water management practices (such as retention ponds, enclosed areas, diversion dikes, gutters, and swales) and material management practices (such as protective coverings and secondary containment); and
- Substantially identical flows, as determined by the estimated runoff coefficient and approximate drainage area at each outfall.

The site map should include an indication of the facility's topography; each of the drainage and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area for each storm water outfall; all past or present areas used for outdoor storage or disposal of significant materials; identification of the significant materials in each drainage area; and identification of each existing structural control measures used to reduce pollutants in storm water

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runoff, materials loading and access areas, and areas where pesticides, herbicides, soil conditioners, and fertilizers are applied.

Exhibit 5-1 offers an example of a narrative description/site map petition that sufficiently demonstrates identical outfalls. A demonstration of how to determine runoff coefficient estimates was presented in Section 3.2.2. Exhibit 5-2 presents an example of a site map to be included with the narrative description.

5.2.2 OPTION TWO: USE OF MATRICES TO INDICATE IDENTICAL OUTFALLS

Facilities attempting to demonstrate that storm water outfalls are substantially identical may submit matrices and an owner/operator certification describing specific information associated with each outfall to the permitting authority. Matrix information is required only for those outfalls that the permit applicant is attempting to demonstrate are identical, not for all outfalls. Petitioners must demonstrate, using the matrices, that the outfalls have storm water discharges that meet the criteria listed in Section 5.2.1. Refer to Exhibit 5-3 for examples of matrices that demonstrate substantially identical outfalls and Section 3.2.2 for guidance on determining runoff coefficient estimates.

5.2.3 OPTION THREE: MODEL MATRICES

Facilities attempting to demonstrate that storm water outfalls are substantially identical may submit model matrices and an owner/operator certification to the permitting authority. This option is particularly appropriate for facilities with a large number of storm water outfalls and the potential for numerous groupings of identical outfalls. In addition, this option may be useful in group applications that have a large sampling subgroup.

Model matrices should contain information for one grouping of substantially identical outfalls. For example, if a facility has 150 outfalls and several groupings of identical outfalls, the facility would choose one of the groupings of identical outfalls to provide information in the model matrices. The petitioner must demonstrate, using these matrices, that all outfalls within this grouping have storm water discharges that meet the criteria listed in Section 5.2.1.

The facility should provide an owner certification that all other groupings of outfalls have been examined and certified as substantially identical outfalls according to the criteria established in the

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EXHIBIT 5-1. PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP)

Examples

I. The Pepper Company of Philadelphia, Pennsylvania, is primarily engaged in manufacturing paperboard, including paperboard coated on the paperboard machine (from wood pulp and other fiber pulp). This establishment is classified under SIC code 2631. Pursuant to the November 16, 1990, NPDES storm water permit application regulations, this facility is considered to be "engaging in industrial activity" for the purposes of storm water permit application requirements in 40 CFR 122.26(b)(14)(i) and (ii).

II. "When an applicant has two or more outfalls with substantially identical effluents, the Director may allow the applicant to test only one outfall and report that the quantitative data also apply to the substantially identical outfalls." [40 CFR 122.21(g)(7)]

In accordance with 40 CFR 122.21(g)(7) of the NPDES regulations, The Pepper Company hereby petitions the State of Pennsylvania (the permitting authority) for approval to sample certain representative storm water outfalls in groupings of storm water outfalls that are substantially identical. The Pepper Company will demonstrate that of the ten (10) outfalls discharging storm water from our paperboard manufacturing plant, there are two pairs of substantially identical outfalls. Outfalls 3 and 4 are substantially identical and should be grouped together. Outfalls 8 and 9 are substantially identical and should be grouped together. Outfalls 1, 2, 5, 6, 7, and 10 have distinct characteristics and, therefore, will not be grouped together with other outfalls for the purposes of storm water discharge sampling.

III. The Pepper Company will demonstrate that the substantially identical outfalls that have been grouped together contain storm water discharges associated with: (1) substantially identical industrial activities and processes that are occurring outdoors; (2) substantially identical significant materials (including raw materials, fuels, finished materials, waste products, and material handling equipment) that may be exposed to storm water; (3) substantially identical material management practices (such as runoff diversions, gutters and swales, protective coverings, and structural enclosures); and (4) substantially identical flows, as determined by the estimated runoff coefficient and approximate drainage area at each outfall.

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EXHIBIT 5-1. PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

1. Industrial Activities

A. Description of Industrial Activities at the Pepper Company

The Pepper Company receives wastepaper in bales. This baled wastepaper is sent through a hydropulper and converted to pulp. The fiber material is concentrated, stored, and then drawn through refiners to the paper machines. Wires, plastics, and miscellaneous material are removed during the pulping.

Three systems are used to produce top liner, back paper, and filler. The highest quality fiber is used for the top liner, the medium quality is used for the back paper, and the poorest quality is used for the filler paper. Wireforming or conventional boxboard processes are employed to produce clay-coated boxboard, using a water-based clay-coating material. Additional materials may be used as binders. These are stored indoors and are not exposed to precipitation. Ammonia is used in the clay-coating process. Off-grade fiber and trim material are ground up and returned to the liquid process stream. Slime control agents, consisting of bactericides, are used in association with this process. These agents are organic materials used to prevent souring of mill operations. They are received in drums and stored indoors. Empty drums are returned to the supplier to reuse. In addition, the Pepper Company operates an onsite landfill for the disposal of miscellaneous waste materials removed during pulping and paper cuttings operations.

B. Demonstration of Why Outfalls Are Substantially Identical in Terms of Industrial Activities Conducted Outdoors.

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of industrial activities conducted outdoors. Both outfalls contain storm water discharges associated with the outdoor storage of baled wastepaper. The wastepaper, which consists of old corrugated containers, mixed paper, and other types of wastepaper, is received weekly and stored for up to 3 weeks in Storage Areas #1 and #2. These uncovered storage areas are enclosed by chain-link fencing.

Outfalls 8 and 9

Outfalls 8 and 9 drain storm water runoff from areas where all industrial activities occur indoors. The industrial activities occurring under roof cover at these two outfalls include hydropulping, storage of concentrated fiber material, refining, and paperboard production. These industrial processes have no potential for contact with precipitation.

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EXHIBIT 5-1. PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

2. Significant Materials

A. Description of Significant Materials at the Pepper Company

The significant materials listed below are used by the Pepper Company to manufacture paperboard. These materials are stored indoors, unless otherwise indicated.

(i) Raw materials, including baled wastepaper (off-spec damaged paper stock or recycled paper) [wastepaper is stored outdoors at Storage Areas #1 and #2]; clays, ammonias, sizings, and slime control agents (chlorine dioxide); caustic; ammonia, which is stored in two tanks. [See Storage Area #3].

(ii) Waste Materials, including miscellaneous materials removed during pulping and paper cuttings (such as staples, rubber bands, styrofoam, etc.). These waste materials are stored indoors in open dumpsters. However, prior to disposing of the waste in the onsite landfill, these dumpsters are moved outdoors where they are potentially exposed to precipitation for 12 hours or less. [See Storage Area #3].

(iii) Finished Products, including paperboard and molded fiber products. These are always stored indoors.

(iv) Others, including wood pallets (which are used to transport and haul raw materials, waste materials, and finished products) are stored both indoors and outdoors. [See Storage Area #3]. The Pepper Company has an above-ground fuel tank with a pump. [See Storage Area #3].

B. Demonstration of Why Outfalls are Substantially Identical in Terms of Significant Materials that Potentially May be Exposed to Storm Water

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of significant materials that may be exposed to storm water. Both outfalls contain storm water discharges associated with the outdoor storage of baled wastepaper. The wastepaper, which consists of old corrugated containers, mixed paper, and other types of wastepaper, is received weekly and stored for up to 3 weeks in Storage Areas #1 and #2. These uncovered storage areas are enclosed by chain-link fencing.

Outfalls 8 and 9

Outfalls 8 and 9 are substantially identical in terms of significant materials. Both outfalls contain storm water runoff from areas that have no significant materials potentially exposed to storm water. All industrial activities occurring in the areas drained by Outfalls 8 and 9 occur completely indoors.

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EXHIBIT 5-1 PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

3. Material Management Practices

A. Description of Material Management Practices at the Pepper Company

The Pepper Company uses a wide range of storm water management practices and material management practices to limit the contact of significant materials with precipitation. Non-structural storm water management practices include employee training, spill reporting and clean-up, and spill prevention techniques. Structural storm water management practices include:

(i) Diversion Devices (both above-ground trenches and subterranean drains) are used to divert surface water from entering a potentially contaminated area.

(ii) Gutters/Swales (constructed of concrete or grass) channel storm water runoff to drainage systems leading to separate storm sewers.

(iv) Overland Flow (which is the flow of storm water over vegetative areas prior to entrance into a storm water conveyance) allows much of the storm water to infiltrate into the ground. The remainder is naturally filtered prior to reaching the storm water conveyance. This is not considered sheet flow since natural drainage channels may be carved out during a heavy storm event.

B. Demonstration of Why Outfalls Are Substantially Identical in Terms of Storm Water Management Practices Used

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of storm water management practices used. Both outfalls contain storm water discharges associated with the outdoor storage of baled wastepaper, located in Storage Areas #1 and #2. Concrete gutters at both sites channel storm water away from the storage areas down to the respective outfalls.

Outfalls 8 and 9

Outfalls 8 and 9 are substantially identical in terms of storm water management practices used. Both outfalls contain storm water runoff from areas that have no significant materials potentially exposed to storm water. All industrial activities occurring in the areas drained by Outfalls 8 and 9 occur completely indoors. Both outfalls receive overland flow storm water. From roof drains, the storm water in both drainage areas is then conveyed over similarly graded vegetative areas prior to entrance into the respective outfalls.

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EXHIBIT 5-1. PETITION TO SAMPLE SUBSTANTIALLY IDENTICAL OUTFALLS (NARRATIVE DESCRIPTION/SITE MAP) (Continued)

4. **Flow Characteristics**

A. Demonstration of Why Outfalls Are Substantially Identical in Terms of Flow, as Determined by The Estimated Runoff Coefficient and Approximate Drainage Area at Each Outfall

Outfalls 3 and 4

Outfalls 3 and 4 are substantially identical in terms of flow. Both drainage areas have a 2 to 7 percent grade and contain fine textured soil (greater than 40 percent clay) with a vegetative cover. The estimated runoff coefficient for both outfalls is .2. The approximate drainage area for each outfall is similar. Outfall 3 has an approximate drainage area of 3,500 square feet. Outfall 4 has an approximate drainage area of 2,900 square feet.

Outfalls 8 and 9

Outfalls 8 and 9 are substantially identical in terms of flow. Both drainage areas have a 2 to 7 percent grade and contain fine textured soil (greater than 40 percent clay) with a vegetative cover. The estimated runoff coefficient for both outfalls is .2. The approximate drainage area for each outfall is similar. Outfall 8 has an approximate drainage area of 7,600 square feet. Outfall 9 has an approximate drainage area of 8,700 square feet.

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EXHIBIT 5-2. SITE MAP

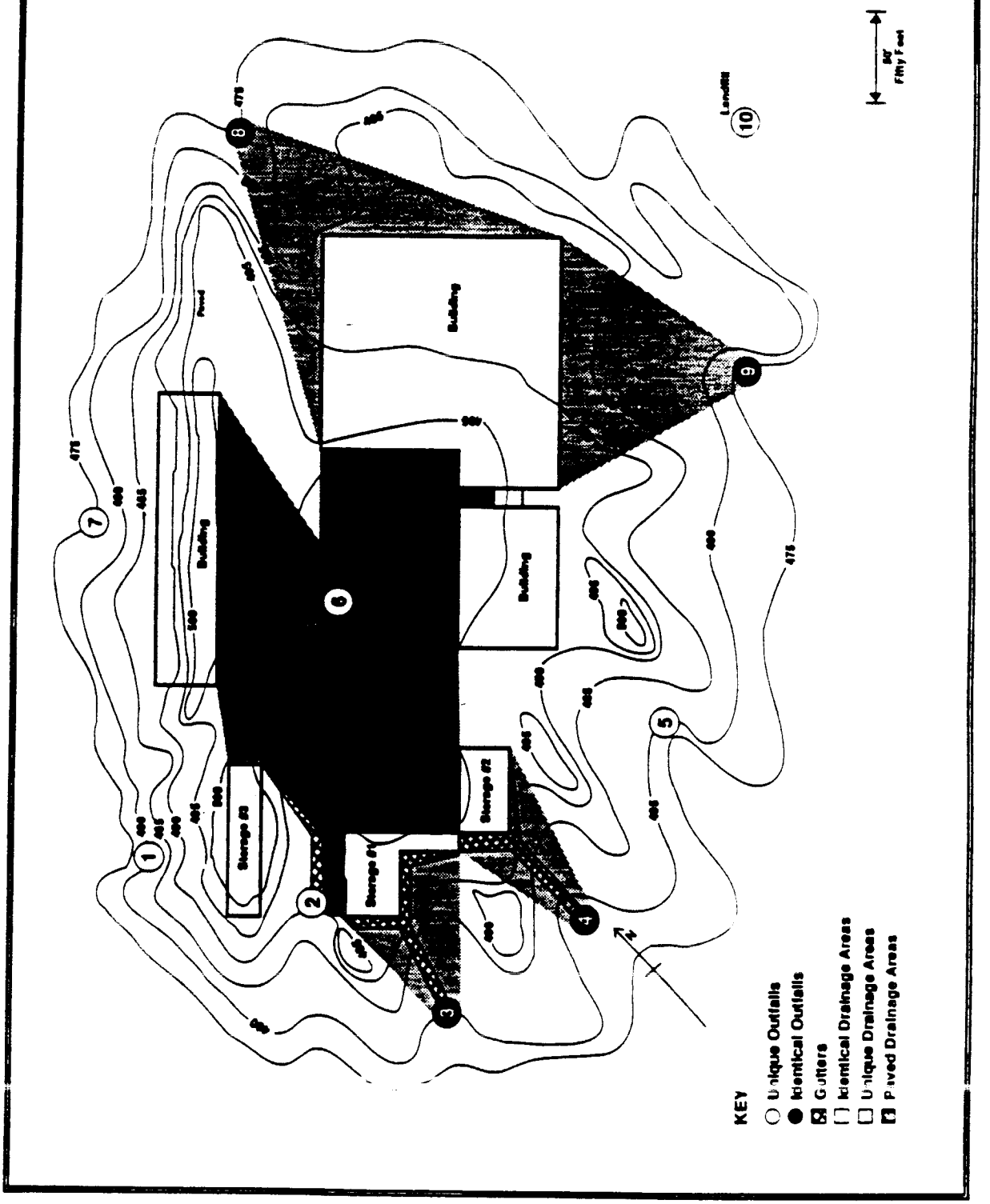

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EXHIBIT 5.3 MATRICES DEMONSTRATING SUBSTANTIALLY IDENTICAL OUTFALLS

Industrial Activities

OUTFALL	A	B	C	D	E
3	X	–	–	X	–
4	X	–	–	X	–
8	–	–	–	–	–
9	–	–	–	–	–

Key:

A = Outdoor storage of raw materials and material-handling equipment
B = Fueling
C = Waste materials storage (dumpster)
D = Loading/unloading of raw materials, intermediate products, and final products
E = Landfill activity

Significant Materials That May Be Exposed to Storm Water

OUTFALL	A	B	C	D	E	F
3	-	–	–	–	X	–
4	–	–	–	–	X	–
8	–	–	–	–	–	–
9	–	–	–	–	–	–

Key:

A = Outdoor ammonia tank
B = Wood pallets
C = Above ground gas tank
D = Waste materials
E = Baled wastepaper
F = Finished products

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EXHIBIT 5.3 MATRICES DEMONSTRATING SUBSTANTIALLY IDENTICAL OUTFALLS (Continued)

Storm Water Management Practices

OUTFALL	A	B	C
3	–	X	–
4	–	X	–
8	–	–	X
9	–	–	X

Key:

A = Runoff diversions
B = Gutters/swales
C = Overland flow (not sheet flow; flow through vegetative areas)

Flow Characteristics

OUTFALL	A	B
3	0.2	3,500
4	0.2	2,900
8	0.2	7,600
9	0.2	8,700

Key:

A = Estimated runoff coefficient
B = Approximate drainage area of outfall (square feet)

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model matrices described in Exhibit 5-3. The owner/operator who signs documents in this section should include the following certification:

> "I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations" [as per 40 CFR 122.22(d)].

5.3 ALTERNATE 40 CFR PART 136 METHOD

As required in 40 CFR 136.4, the applicant must request the approval of an alternate test procedure in writing (in triplicate) prior to testing. The request must be submitted to the Regional Administrator through the Director of the State agency responsible for issuing NPDES permits. The applicant must:

- Provide the name and address of the responsible person or firm making the discharge (if not the applicant), the applicable identification number of the existing or pending permit, the issuing agency, the type of permit for which the alternate test procedure is requested, and the discharge serial number;
- Identify the pollutant or parameter for which approval of an alternate testing procedure is being requested;
- Provide justification for using testing procedures other than those specified in 40 CFR Part 136;
- Provide a detailed description of the proposed alternate test procedure, together with references to published studies of the applicability of the alternate test procedure to the effluents in question;
- Provide comparability data (for applicants applying for nation wide approval of an alternative test procedures).

The permitting authority will notify the applicant within 90 days regarding the approval of the alternate method.

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5.4 LACK OF METHOD IN 40 CFR PART 136

If a specific pollutant that must be tested does not have a corresponding analytical method listed in 40 CFR Part 136, the applicant must submit information on an appropriate method to be used. The permitting authority must approve its use prior to collection and analysis of sampling data. The laboratory should be consulted for suggestions and information about analytical methods that can be used. All information justifying the alternative method should be sent to the permitting authority prior to use.

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6. HEALTH AND SAFETY

Storm water sampling activities may occur when the sampling environment and/or storm water discharges create hazardous conditions. Hazardous conditions associated with sampling include:

- Hazardous weather conditions (e.g., wind, lightning, flooding, etc.)
- Sampling in confined spaces (e.g., manholes)
- Hazards associated with chemicals
- Biological hazards (e.g., rodents and snakes)
- Physical hazards (e.g., traffic, falling objects, sharp edges, slippery footing, and the potential for lifting injuries from opening or removing access panels and manhole covers, etc.)

It is essential that sampling personnel be aware of these hazards. Sampling personnel should be trained to evaluate potentially hazardous situations and develop ways for handling them. Since sampling hazards can be life threatening, safety must be the highest priority for all personnel. This chapter outlines general health and safety issues and concerns. Additional references discussed below should be consulted for more specific guidance to avoid adverse health and safety situations.

6.1 GENERAL TRAINING REQUIREMENTS

Preparation and training of all sampling personnel should be completed before beginning any sampling task. Extreme care should be taken to allow for safety precautions including proper equipment and appropriate operational techniques, sufficient time to accomplish the task, training on potential hazards, and emergency procedures. EPA's Order 1440.2 sets out the policy, responsibilities, and mandatory requirements for the safety of personnel who are involved in sampling activities. This order, which is found within the EPA NPDES Compliance Monitoring Inspector Training: Sampling manual, provides further guidance to applicants' storm water sampling personnel. Basic emergency precautions include having access to both local emergency phone numbers and communication equipment (i.e., phones or radios), and ensuring that personnel are trained in first aid and carry first aid equipment.

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6.2 NECESSARY SAFETY EQUIPMENT

Exhibit 6-1 contains a list of safety equipment that may be appropriate depending on the characteristics of the sampling site.

EXHIBIT 6-1. LIST OF SAFETY EQUIPMENT	
Flashlight	18-inch traffic cones
Meters (for oxygen, explosivity, toxic gases)	Insect/rodent repellant
Ladder	Ventilation equipment
Safety harness	50 feet of 1/2-inch nylon rope
Hard hat	Safety shoes
Safety goggles	Rain wear
Coveralls	Gloves (rubber)
Respirator	First aid kit
Reflective vests	Self-contained breathing apparatus
Source: Adapted from NPDES Compliance Monitoring Inspector Training: Sampling, U.S. EPA, August 1990.	

6.3 HAZARDOUS WEATHER CONDITIONS

Common sense should dictate whether sampling be conducted during adverse weather conditions. No sampling personnel should place themselves in danger during high winds, lightning storms, or flooding conditions which might be unsafe. Under extreme conditions, a less hazardous storm event should be sampled.

6.4 SAMPLING IN CONFINED SPACES

Confined spaces encountered by storm water sampling personnel typically include manholes and deep, unventilated ditches. A confined space is generally defined as a space that is somewhat enclosed with limited access and inadequate ventilation.

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The National Institute of Occupational Safety and Health (NIOSH) has developed a manual entitled "Working in Confined Spaces" which should be consulted prior to confined space entry. Also, several States have developed specific procedures which should also be consulted. Unless they have been trained for confined space entry, sampling personnel should avoid entry under all circumstances.

6.4.1 HAZARDOUS CONDITIONS IN CONFINED SPACES

Confined spaces pose a safety threat to sampling personnel because of low oxygen, explosivity, and toxic gases. When entering a confined space, a qualified person should ensure that the atmosphere is safe by sampling to test for oxygen levels, potential flammable hazards, and toxic materials known or suspected to be present. If atmospheric conditions are detected, the confined space should be ventilated or sampling personnel should use a self-contained air supply and wear a life line. At least one person should remain outside of the confined space in the event that problems arise. If atmospheric testing has not been properly conducted, the confined space should not be entered. Manholes can also pose a threat to safety because of the small confined area, slippery surfaces, sharp objects, unsafe ladders, etc.

6.4.2 SPECIAL TRAINING REQUIREMENTS

Personnel should not enter into a confined space unless trained in confined space entry techniques. Such training covers hazard recognition, the use of respiratory equipment and atmospheric testing devices, use of special equipment and tools, and emergency and rescue procedures. In addition, at least one member of the sampling crew should be certified in basic first aid and Cardiopulmonary Resuscitation (CPR). Sampling personnel should, on an annual basis, practice confined space rescues.

6.4.3 PERMIT SYSTEM

If entry into a confined space is necessary, an entry permit system should be developed which includes a written procedure. This permit should include, at a minimum:

- Description of type of work to be done
- Hazards that may be encountered

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- Location and description of the confined space
- Information on atmospheric conditions at confined space
- Personnel training and emergency procedures
- Names of sampling personnel.

The manual developed by NIOSH discusses this permit system in more detail. Furthermore, the Occupational Safety and Health Administration (OSHA) proposed a rule on June 5, 1989 (54 FR 24080) that would implement a permit system. The rule is expected to be finalized and published late in 1992.

6.5 CHEMICAL HAZARDS

Sampling personnel can also be at risk of exposure to hazardous chemicals—either chemicals in the actual storm water discharge or the chemicals that have been placed in the sample collection containers for sample preservation. Therefore, direct contact with the preservatives and the storm water (if hazardous chemicals are suspected to be present) should be avoided. Sampling personnel should wear gloves and safety glasses to avoid skin and eye exposure to harmful chemicals. Sampling personnel should be trained to avoid exposure and instructed as to what to do if exposure occurs (e.g., flush the eyes, rinse the skin, ventilate the area, etc.).

6.6 BIOLOGICAL HAZARDS

Storm water sampling personnel may also encounter biological hazards such as rodents, snakes, and insects. The sampling crew should remain alert to these hazards. As mentioned in Section 6.2, necessary sampling equipment, for certain locations, should include insect/rodent repellant and a first aid kit.

6.7 PHYSICAL HAZARDS

The sampling crew should be aware of a number of physical hazards that could cause accidents at the sampling site. These hazards include traffic hazards, sharp edges, falling objects, slippery footing, and lifting injuries from removing manhole covers. Sampling personnel should pay close attention in order to prevent these safety hazards at all times.

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If the sample point is in a manhole, a street gutter, or ditch near the street, particular attention must be given to marking off the work area to warn oncoming traffic of the presence of the sampling crew. Traffic cones, warning signs, and barricades should be placed in appropriate places around the sampling point.

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TECHNICAL APPENDIX A

FORMS 2F AND 1

Please print or type in the unshaded areas only

EPA ID Number *(copy from item I of Form 1)*

Form Approved. OMB No. 2040-0086
Approval expires 5-31-92

Form 2F NPDES

EPA

United States Environmental Protection Agency
Washington, DC 20460

Application for Permit to Discharge Storm Water Discharges Associated with Industrial Activity

Paperwork Reduction Act Notice

Public reporting burden for this application is estimated to average 28.6 hours per application, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate, any other aspect of this collection of information, or suggestions for improving this form, including suggestions which may increase or reduce this burden to: Chief, Information Policy Branch, PM-223, U.S. Environmental Protection Agency, 401 M St., SW, Washington, DC 20460, or Director, Office of Information and Regulatory Affairs, Office of Management and Budget, Washington, DC 20503.

I. Outfall Location

For each outfall, list the latitude and longitude of its location to the nearest 15 seconds and the name of the receiving water.

A. Outfall Number *(list)*	B. Latitude	C. Longitude	D. Receiving Water *(name)*

II. Improvements

A. Are you now required by any Federal, State, or local authority to meet any implementation schedule for the construction, upgrading or operation of wastewater treatment equipment or practices or any other environmental programs which may affect the discharges described in this application? This includes, but is not limited to, permit conditions, administrative or enforcement orders, enforcement compliance schedule letters, stipulations, court orders, and grant or loan conditions.

1. Identification of Conditions, Agreements, Etc.	2. Affected Outfalls		3. Brief Description of Project	4. Final Compliance Date	
	number	source of discharge		a. req.	b. proj.

B. You may attach additional sheets describing any additional water pollution (or other environmental projects which may affect your discharges) you now have under way or which you plan. Indicate whether each program is now under way or planned, and indicate your actual or planned schedules for construction.

III. Site Drainage Map

Attach a site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including: each of its intake and discharge structures; the drainage area of each storm water outfall; paved areas and buildings within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied; each of its hazardous waste treatment, storage or disposal units (including each area not required to have a RCRA permit which is used for accumulating hazardous waste under 40 CFR 262.34); each well where fluids from the facility are injected underground; springs, and other surface water bodies which receive storm water discharges from the facility.

Continued from the Front

IV. Narrative Description of Pollutant Sources

A. For each outfall, provide an estimate of the area (include units) of impervious surfaces (including paved areas and building roofs) drained to the outfall, and an estimate of the total surface area drained by the outfall.

Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)	Outfall Number	Area of Impervious Surface (provide units)	Total Area Drained (provide units)

B. Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored or disposed in a manner to allow exposure to storm water; method of treatment, storage, or disposal; past and present materials management practices employed to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner, and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied.

C. For each outfall, provide the location and a description of existing structural and nonstructural control measures to reduce pollutants in storm water runoff; and a description of the treatment the storm water receives, including the schedule and type of maintenance for control and treatment measures and the ultimate disposal of any solid or fluid wastes other than by discharge.

Outfall Number	Treatment	List Codes from Table 2F-1

V. Nonstormwater Discharges

A. I certify under penalty of law that the outfall(s) covered by this application have been tested or evaluated for the presence of nonstormwater discharges, and that all nonstormwater discharges from these outfall(s) are identified in either an accompanying Form 2C or Form 2E application for the outfall.

Name and Official Title (type or print)	Signature	Date Signed

B. Provide a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test.

VI. Significant Leaks or Spills

Provide existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years, including the approximate date and location of the spill or leak, and the type and amount of material released.

EPA ID Number (copy from item I of Form 1)

Continued from Page 2

VII. Discharge Information

A,B,C, & D: See instructions before proceeding. Complete one set of tables for each outfall. Annotate the outfall number in the space provided. Tables VII-A, VII-B, and VII-C are included on separate sheets numbered VII-1 and VII-2.

E. Potential discharges not covered by analyses - is any toxic pollutant listed in table 2F-2, 2F-3 or 2F-4, a substance or a component of a substance which you currently use or manufacture as an intermediate or final product or byproduct?

☐ Yes (list all such pollutants below) ☐ No (go to Section G)

VIII. Biological Toxicity Testing Data

Do you have any knowledge or reason to believe that any biological test for acute or chronic toxicity has been made on any of your discharges or on a receiving water in relation to your discharge within the last 3 years?

☐ Yes (list all such pollutants below) ☐ No (go to Section IX)

IX. Contract Analysis Information

Were any of the analyses reported in item VII performed by a contract laboratory or consulting firm?

☐ Yes (list the name, address, and telephone number of, and pollutants analyzed by, each such laboratory or firm below) ☐ No (go to Section X)

A. Name	B. Address	C. Area Code & Phone No.	D. Pollutants Analyzed

X. Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

A. Name & Official Title (type or print)	B. Area Code and Phone No.
C. Signature	D. Date Signed

EPA Form 3510-2F (Rev. 1-92) Page 3 of 3

EPA ID number (copy from item 1 of Form 1) Form Approved OMB No. 2040-0086
Approval expires 5-31-92

VII. Discharge Information *(Continued from page 3 of Form 2F)*

Part A - You must provide the results of at least one analysis for every pollutant in this table. Complete one table for each outfall. See instructions for additional details.

Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Samples Taken During First 30 Minutes	Flow-weighted Composite	Grab Samples Taken During First 30 Minutes	Flow-weighted Composite		
Oil and Grease						
Biological Oxygen Demand (BOD5)						
Chemical Oxygen Demand (COD)						
Total Suspended Solids (TSS)						
Total Kjeldahl Nitrogen						
Nitrate plus Nitrite Nitrogen						
Total Phosphorus						
pH	Minimum	Maximum	Minimum	Maximum		

Part B - List each pollutant that is limited in an effluent guideline which the facility is subject to or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See the instructions for additional details and requirements.

Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Samples Taken During First 30 Minutes	Flow-weighted Composite	Grab Samples Taken During First 30 Minutes	Flow-weighted Composite		

Continued from the Front

Part C - List each pollutant shown in Tables 2F-2, 2F-3, and 2F-4 that you know or have reason to believe is present. See the instructions for additional details and requirements. Complete one table for each outfall.

Pollutant and CAS Number (if available)	Maximum Values (include units)		Average Values (include units)		Number of Storm Events Sampled	Sources of Pollutants
	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite	Grab Sample Taken During First 30 Minutes	Flow-weighted Composite		

Part D - Provide data for the storm event(s) which resulted in the maximum values for the flow weighted composite sample.

1. Date of Storm Event	2. Duration of Storm Event (in minutes)	3. Total rainfall during storm event (in inches)	4. Number of hours between beginning of storm measured and end of previous measurable rain event	5. Maximum flow rate during rain event (gallons/minute or specify units	6. Total flow from rain event (gallons or specify units)

7. Provide a description of the method of flow measurement or estimate.

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Instructions - Form 2F
Application for Permit to Discharge Storm Water Associated with Industrial Activity

Who Must File Form 2F

Form 2F must be completed by operators of facilities which discharge storm water associated with industrial activity or by operators of storm water discharges that EPA is evaluating for designation as a significant contributor of pollutants to waters of the United States, or as contributing to a violation of a water quality standard.

Operators of discharges which are composed entirely of storm water must complete Form 2F (EPA Form 3510-2F) in conjunction with Form 1 (EPA Form 3510-1).

Operators of discharges of storm water which are combined with process wastewater (process wastewater is water that comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, byproduct, waste product, or wastewater) must complete and submit Form 2F, Form 1, and Form 2C (EPA Form 3510-2C).

Operators of discharges of storm water which are combined with nonprocess wastewater (nonprocess wastewater includes noncontact cooling water and sanitary wastes which are not regulated by effluent guidelines or a new source performance standard, except discharges by educational, medical, or commercial chemical laboratories) must complete Form 1, Form 2F, and Form 2E (EPA Form 3510-2E).

Operators of new sources or new discharges of storm water associated with industrial activity which will be combined with other nonstormwater new sources or new discharges must submit Form 1, Form 2F, and Form 2D (EPA Form 3510-2D).

Where to File Applications

The application forms should be sent to the EPA Regional Office which covers the State in which the facility is located. Form 2F must be used only when applying for permits in States where the NPDES permits program is administered by EPA. For facilities located in States which are approved to administer the NPDES permits program, the State environmental agency should be contacted for proper permit application forms and instructions.

Information on whether a particular program is administered by EPA or by a State agency can be obtained from your EPA Regional Office. Form 1, Table 1 of the "General Instructions" lists the addresses of EPA Regional Offices and the States within the jurisdiction of each Office.

Completeness

Your application will not be considered complete unless you answer every question on this form and on Form 1. If an item does not apply to you, enter "NA" (for not applicable) to show that you considered the question.

Public Availability of Submitted Information

You may not claim as confidential any information required by this form or Form 1, whether the information is reported on the forms or in an attachment. Section 402(j) of the Clean Water Act requires that all permit applications will be available to the public. This information will be made available to the public upon request.

Any information you submit to EPA which goes beyond that required by this form, Form 1, or Form 2C you may claim as confidential, but claims for information which are effluent data will be denied.

If you do not assert a claim of confidentiality at the time of submitting the information, EPA may make the information public without further notice to you. Claims of confidentiality will be handled in accordance with EPA's business confidentiality regulations at 40 CFR Part 2.

Definitions

All significant terms used in these instructions and in the form are defined in the glossary found in the General Instructions which accompany Form 1.

EPA ID Number

Fill in your EPA Identification Number at the top of each odd-numbered page of Form 2F. You may copy this number directly from item I of Form 1.

Item I

You may use the map you provided for item XI of Form 1 to determine the latitude and longitude of each of your outfalls and the name of the receiving water.

Item II-A

If you check "yes" to this question, complete all parts of the chart, or attach a copy of any previous submission you have made to EPA containing the same information.

Item II-B

You are not required to submit a description of future pollution control projects if you do not wish to or if none is planned.

Item III

Attach a site map showing topography (or indicating the outline of drainage areas served by the outfall(s) covered in the application if a topographic map is unavailable) depicting the facility including:

each of its drainage and discharge structures;

the drainage area of each storm water outfall;

paved areas and building within the drainage area of each storm water outfall, each known past or present areas used for outdoor storage or disposal of significant materials, each existing structural control measure to reduce pollutants in storm water runoff, materials loading and access areas, areas where pesticides, herbicides, soil conditioners and fertilizers are applied;

each of its hazardous waste treatment, storage or disposal facilities (including each area not required to have a RCRA permit which is used for accumulating hazardous waste for less than 90 days under 40 CFR 262.34);

each well where fluids from the facility are injected underground; and

springs, and other surface water bodies which receive storm water discharges from the facility;

Item IV-A

For each outfall, provide an estimate of the area drained by the outfall which is covered by impervious surfaces. For the purpose of this application, impervious surfaces are surfaces where storm water runs off at rates that are significantly higher than background rates (e.g., predevelopment levels) and include paved areas, building roofs, parking lots, and roadways. Include an estimate of the total area (including all impervious and pervious areas) drained by each outfall. The site map required under item III can be used to estimate the total area drained by each outfall.

Item IV-B

Provide a narrative description of significant materials that are currently or in the past three years have been treated, stored, or disposed in a manner to allow exposure to storm water; method of treatment, storage or disposal of these materials; past and present materials management practices employed, in the last three years, to minimize contact by these materials with storm water runoff; materials loading and access areas; and the location, manner, and frequency in which pesticides, herbicides, soil conditioners, and fertilizers are applied. Significant materials should be identified by chemical name, form (e.g., powder, liquid, etc.), and type of container or treatment unit. Indicate any materials treated, stored, or disposed of together. "Significant materials" includes, but is not limited to: raw materials; fuels; materials such as solvents, detergents, and plastic pellets; finished materials such as metallic products; raw materials used in food processing or production; hazardous substances designated under Section 101(14) of CERCLA; any chemical the facility is required to report pursuant to Section 313 of Title III of SARA; fertilizers; pesticides; and waste products such as ashes, slag and sludge that have the potential to be released with storm water discharges.

Item IV-C

For each outfall, structural controls include structures which enclose material handling or storage areas, covering materials, berms, dikes, or diversion ditches around manufacturing, production, storage or treatment units, retention ponds, etc. Nonstructural controls include practices such as spill prevention plans, employee training, visual inspections, preventive maintenance, and housekeeping measures that are used to prevent or minimize the potential for releases of pollutants.

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Item V

Provide a certification that all outfalls that should contain storm water discharges associated with industrial activity have been tested or evaluated for the presence of non-storm water discharges which are not covered by an NPDES permit. Tests for such non-storm water discharges may include smoke tests, fluorometric dye tests, analysis of accurate schematics, as well as other appropriate tests. Part B must include a description of the method used, the date of any testing, and the onsite drainage points that were directly observed during a test. All non-storm water discharges must be identified in a Form 2C or Form 2E which must accompany this application (see beginning of instructions under section titled "Who Must File Form 2F" for a description of when Form 2C and Form 2E must be submitted).

Item VI

Provide a description of existing information regarding the history of significant leaks or spills of toxic or hazardous pollutants at the facility in the last three years.

Item VII-A, B, and C

These items require you to collect and report data on the pollutants discharged for each of your outfalls. Each part of this item addresses a different set of pollutants and must be completed in accordance with the specific instructions for that part. The following general instructions apply to the entire item.

General Instructions

Part A requires you to report at least one analysis for each pollutant listed. Parts B and C require you to report analytical data in two ways. For some pollutants addressed in Parts B and C, if you know or have reason to know that the pollutant is present in your discharge, you may be required to list the pollutant and test (sample and analyze) and report the levels of the pollutants in your discharge. For all other pollutants addressed in Parts B and C, you must list the pollutant if you know or have reason to know that the pollutant is present in the discharge, and either report quantitative data for the pollutant or briefly describe the reasons the pollutant is expected to be discharged. (See specific instructions on the form and below for Parts A through C.) Base your determination that a pollutant is present in or absent from your discharge on your knowledge of your raw materials, material management practices, maintenance chemicals, history of spills and releases, intermediate and final products and byproducts, and any previous analyses known to you of your effluent or similar effluent.

A. **Sampling:** The collection of the samples for the reported analyses should be supervised by a person experienced in performing sampling of industrial wastewater or storm water discharges. You may contact EPA or your State permitting authority for detailed guidance on sampling techniques and for answers to specific questions. Any specific requirements contained in the applicable analytical methods should be followed for sample containers, sample preservation, holding times, the collection of duplicate samples, etc. The time when you sample should be representative, to the extent feasible, of your treatment system operating properly with no system upsets. Samples should be collected from the center of the flow channel, where turbulence is at a maximum, at a site specified in your present permit, or at any site adequate for the collection of a representative sample.

   For pH, temperature, cyanide, total phenols, residual chlorine, oil and grease, and fecal coliform, grab samples taken during the first 30 minutes (or as soon thereafter as practicable) of the discharge must be used (you are not required to analyze a flow-weighted composite for these parameters). For all other pollutants both a grab sample collected during the first 30 minutes (or as soon thereafter as practicable) of the discharge and a flow-weighted composite sample must be analyzed. However, a minimum of one grab sample may be taken for effluents from holding ponds or other impoundments with a retention period of greater than 24 hours.

   All samples shall be collected from the discharge resulting from a storm event that is greater than 0.1 inches and at least 72 hours from the previously measurable (greater than 0.1 inch rainfall) storm event. Where feasible, the variance in the duration of the event and the total rainfall of the event should not exceed 50 percent from the average or median rainfall event in that area.

   A grab sample shall be taken during the first thirty minutes of the discharge (or as soon thereafter as practicable), and a flow-weighted composite shall be taken for the entire event or for the first three hours of the event.

   Grab and composite samples are defined as follows:

Grab sample: An individual sample of at least 100 milliliters collected during the first thirty minutes (or as soon thereafter as practicable) of the discharge. This sample is to be analyzed separately from the composite sample.

Flow-Weighted Composite sample: A flow-weighted composite sample may be taken with a continuous sampler that proportions the amount of sample collected with the flow rate or as a combination of a minimum of three sample aliquots taken in each hour of discharge for the entire event or for the first three hours of the event, with each aliquot being at least 100 milliliters and collected with a minimum period of fifteen minutes between aliquot collections. The composite must be flow proportional; either the time interval between each aliquot or the volume of each aliquot must be proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot. Aliquots may be collected manually or automatically. Where GC/MS Volatile Organic Analysis (VOA) is required, aliquots must be combined in the laboratory immediately before analysis. Only one analysis for the composite sample is required.

Data from samples taken in the past may be used, provided that:

All data requirements are met;

Sampling was done no more than three years before submission; and

All data are representative of the present discharge.

Among the factors which would cause the data to be unrepresentative are significant changes in production level, changes in raw materials, processes, or final products, and changes in storm water treatment. When the Agency promulgates new analytical methods in 40 CFR Part 136, EPA will provide information as to when you should use the new methods to generate data on your discharges. Of course, the Director may request additional information, including current quantitative data, if they determine it to be necessary to assess your discharges. The Director may allow or establish appropriate site-specific sampling procedures or requirements, including sampling locations, the season in which the sampling takes place, the minimum duration between the previous measurable storm event and the storm event sampled, the minimum or maximum level of precipitation required for an appropriate storm event, the form of precipitation sampled (snow melt or rainfall), protocols for collecting samples under 40 CFR Part 136, and additional time for submitting data on a case-by-case basis.

B. **Reporting:** All levels must be reported as concentration and mass (note: grab samples are reported in terms of concentration). You may report some or all of the required data by attaching separate sheets of paper instead of filling out pages VII-1 and VII-2 if the separate sheets contain all the required information in a format which is constant with pages VII-1 and VII-2 in spacing and identification of pollutants and columns. Use the following abbreviations in the columns headed "Units."

Concentration		Mass	
ppm	parts per million	lbs	pounds
mg/1	milligrams per liter	ton	tons (English tons)
ppb	parts per billion	mg	milligrams
ug/1	micrograms per liter	g	grams
kg	kilograms	T	tonnes (metric tons)

All reporting of values for metals must be in terms of "total recoverable metal," unless:

(1) An applicable, promulgated effluent limitation or standard specifies the limitation for the metal in dissolved, valent, or total form; or

(2) All approved analytical methods for the metal inherently measure only its dissolved form (e.g., hexavalent chromium); or

(3) The permitting authority has determined that in establishing case-by-case limitations it is necessary to express the limitations on the metal in dissolved, valent, or total form to carry out the provisions of the CWA. If you measure only one grab sample and one flow-weighted composite sample for a given outfall, complete only the "Maximum Values" columns and insert "1" into the "Number of Storm Events Sampled" column. The permitting authority may require you to conduct additional analyses to further characterize your discharges.

If you measure more than one value for a grab sample or a flow-weighted composite sample for a given outfall and those values are representative of your discharge, you must report them. You must describe your method of testing and data analysis. You also must determine the average of all values within the last year and report the concentration and mass under the "Average Values" columns, and the total number of storm events sampled under the "Number of Storm Events Sampled " columns.

C. **Analysis:** You must use test methods promulgated in 40 CFR Part 136; however, if none has been promulgated for a particular pollutant, you may use any suitable method for measuring the level of the pollutant in your discharge provided that you submit a description of the method or a reference to a published method. Your description should include the sample holding time, preservation techniques, and the quality control measures which you used. If you have two or more substantially identical outfalls, you may request permission from your permitting authority to sample and analyze only one outfall and submit the results of the analysis for other substantially identical outfalls. If your request is granted by the permitting authority, on a separate sheet attached to the application form, identify which outfall you did test, and describe why the outfalls which you did not test are substantially identical to the outfall which you did test.

Part VII-A

Part VII-A must be completed by all applicants for all outfalls who must complete Form 2F.

Analyze a grab sample collected during the first thirty minutes (or as soon thereafter as practicable) of the discharge and flow-weighted composite samples for all pollutants in this Part, and report the results except use only grab samples for pH and oil and grease. See discussion in General Instructions to Item VII for definitions of grab sample collected during the first thirty minutes of discharge and flow-weighted composite sample. The "Average Values" column is not compulsory but should be filled out if data are available.

Part VII-B

List all pollutants that are limited in an effluent guideline which the facility is subject to (see 40 CFR Subchapter N to determine which pollutants are limited in effluent guidelines) or any pollutant listed in the facility's NPDES permit for its process wastewater (if the facility is operating under an existing NPDES permit). Complete one table for each outfall. See discussion in General instructions to item VII for definitions of grab sample collected during the first thirty minutes (or as soon thereafter as practicable) of discharge and flow-weighted composite sample. The "Average Values" column is not compulsory but should be filled out if data are available.

Analyze a grab sample collected during the first thirty minutes of the discharge and flow-weighted composite samples for all pollutants in this Part, and report the results, except as provided in the General Instructions.

Part VII-C

Part VII-C must be completed by all applicants for all outfalls which discharge storm water associated with industrial activity, or that EPA is evaluating for designation as a significant contributor of pollutants to waters of the United States, or as contributing to a violation of a water quality standard. Use both a grab sample and a composite sample for all pollutants you analyze for in this part except use grab samples for residual chlorine and fecal coliform. The "Average Values" column is not compulsory but should be filled out if data are available. Part C requires you to address the pollutants in Table 2F-2, 2F-3, and 2F-4 for each outfall. Pollutants in each of these Tables are addressed differently.

Table 2F-2: For each outfall, list all pollutants in Table 2F-2 that you know or have reason to believe are discharged (except pollutants previously listed in Part VII-B). If a pollutant is limited in an effluent guideline limitation which the facility is subject to, the pollutant must be analyzed and reported in Part VII-B. If a pollutant in Table 2F-2 is indirectly limited by an effluent guideline limitation through an indicator (e.g., use of TSS as an indicator to control the discharge of iron and aluminum), you must analyze for it and report the data in Part VII-B. For other pollutants listed in Table 2F-2 (those not limited directly or indirectly by an effluent limitation guideline), that you know or have reason to believe are discharged, you must either report quantitative data or briefly describe the reasons the pollutant is expected to be discharged.

Table 2F-3: For each outfall, list all pollutants in Table 2F-3 that you know or have reason to believe are discharged. For every pollutant in Table 2F-3 expected to be discharged in concentrations of 10 ppb or greater, you must submit quantitative data. For acrolein, acrylonitrile, 2,4 dinitrophenol, and 2-methyl-4,6 dinitrophenol, you must submit quantitative data if any of these four pollutants is expected to be discharged

in concentrations of 100 ppb or greater. For every pollutant expected to be discharged in concentrations less than 10 ppb (or 100 ppb for the four pollutants listed above), then you must either submit quantitative data or briefly describe the reasons the pollutant is expected to be discharged.

Small Business Exemption - If you are a "small business," you are exempt from the reporting requirements for the organic toxic pollutants listed in Table 2F-3. There are two ways in which you can qualify as a "small business". If your facility is a coal mine, and if your probable total annual production is less than 100,000 tons per year, you may submit past production data or estimated future production (such as a schedule of estimated total production under 30 CFR 795.14(c)) instead of conducting analyses for the organic toxic pollutants. If your facility is not a coal mine, and if your gross total annual sales for the most recent three years average less than $100,000 per year (in second quarter 1980 dollars), you may submit sales data for those years instead of conducting analyses for the organic toxic pollutants. The production or sales data must be for the facility which is the source of the discharge. The data should not be limited to production or sales for the process or processes which contribute to the discharge, unless those are the only processes at your facility. For sales data, in situations involving intracorporate transfer of goods and services, the transfer price per unit should approximate market prices for those goods and services as closely as possible. Sales figures for years after 1980 should be indexed to the second quarter of 1980 by using the gross national product price deflator (second quarter of 1980 = 100). This index is available in National Income and Product Accounts of the United States (Department of Commerce, Bureau of Economic Analysis).

Table 2F-4: For each outfall, list any pollutant in Table 2F-4 that you know or believe to be present in the discharge and explain why you believe it to be present. No analysis is required, but if you have analytical data, you must report them. **Note:** Under 40 CFR 117.12(a)(2), certain discharges of hazardous substances (listed at 40 CFR 177.21 or 40 CFR 302.4) may be exempted from the requirements of section 311 of CWA, which establishes reporting requirements, civil penalties, and liability for cleanup costs for spills of oil and hazardous substances. A discharge of a particular substance may be exempted if the origin, source, and amount of the discharged substances are identified in the NPDES permit application or in the permit, if the permit contains a requirement for treatment of the discharge, and if the treatment is in place. To apply for an exclusion of the discharge of any hazardous substance from the requirements of section 311, attach additional sheets of paper to your form, setting forth the following information:

1. The substance and the amount of each substance which may be discharged.
2. The origin and source of the discharge of the substance.
3. The treatment which is to be provided for the discharge by:
    a. An onsite treatment system separate from any treatment system treating your normal discharge;
    b. A treatment system designed to treat your normal discharge and which is additionally capable of treating the amount of the substance identified under paragraph 1 above; or
    c. Any combination of the above.

See 40 CFR 117.12(a)(2) and (c), published on August 29, 1979, in 44 FR 50766, or contact your Regional Office (Table 1 on Form 1, Instructions), for further information on exclusions from section 311.

Part VII-D

If sampling is conducted during more than one storm event, you only need to report the information requested in Part VII-D for the storm event(s) which resulted in any maximum pollutant concentration reported in Part VII-A, VII-B, or VII-C.

Provide flow measurements or estimates of the flow rate, and the total amount of discharge for the storm event(s) sampled, the method of flow measurement, or estimation. Provide the data and duration of the storm event(s) sampled, rainfall measurements, or estimates of the storm event which generated the sampled runoff and the duration between the storm event sampled and the end of the previous measurable (greater than 0.1 inch rainfall) storm event.

Part VII-E

List any toxic pollutant listed in Tables 2F-2, 2F-3, or 2F-4 which you currently use or manufacture as an intermediate or final product or byproduct. In addition, if you know or have reason to believe that 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is discharged or if you use or manufacture 2,4,5-trichlorophenoxy acetic

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acid (2,4,5,-T); 2-(2,4,5-trichlorophenoxy) propanoic acid (Silvex, 2,4,5,-TP); 2-(2,4,5-trichlorophenoxy) ethyl 2,2-dichloropropionate (Erbon); O,O-dimethyl O-(2,4,5-trichlorphenyl) phosphorothioate (Ronnel); 2,4,5-trichlorophenol (TCP); or hexachlorophene (HCP); then list TCDD. The Director may waive or modify the requirement if you demonstrate that it would be unduly burdensome to identify each toxic pollutant and the Director has adequate information to issue your permit. You may not claim this information as confidential; however, you do not have to distinguish between use or production of the pollutants or list the amounts.

Item VIII

Self explanatory. The permitting authority may ask you to provide additional details after your application is received.

Item X

The Clean Water Act provides for severe penalties for submitting false information on this application form.

Section 309(c)(4) of the Clean Water Act provides that "Any person who knowingly makes any false material statement, representation, or certification in any application, . . . shall upon conviction, be punished by a fine of not more than $10,000 or by imprisonment for not more than 2 years, or by both. If a conviction of such person is for a violation committed after a first conviction of such person under this paragraph, punishment shall be by a fine of not more than $20,000 per day of violation, or by imprisonment of not more than 4 years, or by both." 40 CFR Part 122.22 requires the certification to be signed as follows:

> (A) **For a corporation:** by a responsible corporate official. For purposes of this section, a responsible corporate official means (i) a president, secretary, treasurer, or vice-president of the corporation in charge of a principal business function, or any other person who performs similar policy- or decision-making functions for the corporation, or (ii) the manager of one or more manufacturing, production, or operating facilities employing more than 250 persons or having gross annual sales or expenditures exceeding $25,000,000 (in second-quarter 1980 dollars), if authority to sign documents has been assigned or delegated to the manager in accordance with corporate procedures.
>
> **Note:** EPA does not require specific assignments or delegation of authority to responsible corporate officers identified in 122.22(a)(1)(i). The Agency will presume that these responsible corporate officers have the requisite authority to sign permit applications unless the corporation has notified the Director to the contrary. Corporate procedures governing authority to sign permit applications may provide for assignment or delegation to applicable corporate position under 122.22(a)(1)(ii) rather than to specific individuals.
>
> (B) **For a partnership or sole proprietorship:** by a general partner or the proprietor, respectively; or
>
> (C) **For a municipality, State, Federal, or other public agency:** by either a principal executive officer or ranking elected official. For purposes of this section, a principal executive officer of a Federal agency includes (i) the chief executive officer of the agency, or (ii) a senior executive officer having responsibility for the overall operations of a principal geographic unit of the agency (e.g., Regional Administrators of EPA).

Table 2F-1
Codes for Treatment Units

	Physical Treatment Processes		
1-A	Ammonia Stripping	1-M	Grit Removal
1-B	Dialysis	1-N	Microstraining
1-C	Diatomaceous Earth Filtration	1-O	Mixing
1-D	Distillation	1-P	Moving Bed Filters
1-E	Electrodialysis	1-Q	Multimedia Filtration
1-F	Evaporation	1-R	Rapid Sand Filtration
1-G	Flocculation	1-S	Reverse Osmosis (Hyperfiltration)
1-H	Flotation	1-T	Screening
1-I	Foam Fractionation	1-U	Sedimentation (Setting)
1-J	Freezing	1-V	Slow Sand Filtration
1-K	Gas-Phase Separation	1-W	Solvent Extraction
1-L	Grinding (Comminutors)	1-X	Sorption
	Chemical Treatment Processes		
2-A	Carbon Adsorption	2-G	Disinfection (Ozone)
2-B	Chemical Oxidation	2-H	Disinfection (Other)
2-C	Chemical Precipitation	2-I	Electrochemical Treatment
2-D	Coagulation	2-J	Ion Exchange
2-E	Dechlorination	2-K	Neutralization
2-F	Disinfection (Chlorine)	2-L	Reduction
	Biological Treatment Processes		
3-A	Activated Sludge	3-E	Pre-Aeration
3-B	Aerated Lagoons	3-F	Spray Irrigation/Land Application
3-C	Anaerobic Treatment	3-G	Stabilization Ponds
3-D	Nitrification-Denitrification	3-H	Trickling Filtration
	Other Processes		
4-A	Discharge to Surface Water	4-C	Reuse/Recycle of Treated Effluent
4-B	Ocean Discharge Through Outfall	4-D	Underground Injection
	Sludge Treatment and Disposal Processes		
5-A	Aerobic Digestion	5-M	Heat Drying
5-B	Anaerobic Digestion	5-N	Heat Treatment
5-C	Belt Filtration	5-O	Incineration
5-D	Centrifugation	5-P	Land Application
5-E	Chemical Conditioning	5-Q	Landfill
5-F	Chlorine Treatment	5-R	Pressure Filtration
5-G	Composting	5-S	Pyrolysis
5-H	Drying Beds	5-T	Sludge Lagoons
5-I	Elutriation	5-U	Vacuum Filtration
5-J	Flotation Thickening	5-V	Vibration
5-K	Freezing	5-W	Wet Oxidation
5-L	Gravity Thickening		

Table 2F-2

Conventional and Nonconventional Pollutants

Bromide
Chlorine, Total Residual
Color
Fecal Coliform
Fluoride
Nitrate-Nitrite
Nitrogen, Total Organic
Oil and Grease
Phosphorus, Total
Radioactivity
Sulfate
Sulfite
Surfactants
Aluminum, Total
Barium, Total
Boron, Total
Cobalt, Total
Iron, Total
Magnesium, Total
Molybdenum, Total
Manganese, Total
Tin, Total
Titanium, Total

Table 2F-3

Toxic Pollutants

Toxic Pollutants and Total Phenol

Antimony, Total	Copper, Total	Silver, Total
Arsenic, Total	Lead, Total	Thallium, Total
Beryllium, Total	Mercury, Total	Zinc, Total
Cadmium, Total	Nickel, Total	Cyanide, Total
Chromium, Total	Selenium, Total	Phenols, Total

GC/MS Fraction Volatiles Compounds

Acrolein	Dichlorobromomethane	1,1,2,2,-Tetrachloroethane
Acrylonitrile	1,1-Dichloroethane	Tetrachloroethylene
Benzene	1,2-Dichloroethane	Toluene
Bromoform	1,1-Dichloroethylene	1,2-Trans-Dichloroethylene
Carbon Tetrachloride	1,2-Dichloropropane	1,1,1-Trichloroethane
Chlorobenzene	1,3-Dichloropropylene	1,1,2-Trichloroethane
Chlorodibromomethane	Ethylbenzene	Trichloroethylene
Chloroethane	Methyl Bromide	Vinyl Chloride
2-Chloroethylvinyl Ether	Methyl Chloride	
Chloroform	Methylene Chloride	

Acid Compounds

2-Chlorophenol	2,4-Dinitrophenol	Pentachlorophenol
2,4-Dichlorophenol	2-Nitrophenol	Phenol
2,4-Dimethylphenol	4-Nitrophenol	2,4,6-Trichlorophenol
4,6-Dinitro-O-Cresol	p-Chloro-M-Cresol	2-methyl-4,6 dinitrophenol

Base/Neutral

Acenaphthene	2-Chloronaphthalene	Fluoranthene
Acenaphthylene	4-Chlorophenyl Phenyl Ether	Fluorene
Anthracene	Chrysene	Hexachlorobenzene
Benzidine	Dibenzo(a,h)anthracene	Hexachlorobutadiene
Benzo(a)anthracene	1,2-Dichlorobenzene	Hexachloroethane
Benzo(a)pyrene	1,3-Dichlorobenzene	Indeno(1,2,3-cd)pyrene
3,4-Benzofluoranthene	1,4-Dichlorobenzene	Isophorone
Benzo(ghi)perylene	3,3'-Dichlorobenzidine	Naphthalene
Benzo(k)fluoranthene	Diethyl Phthalate	Nitrobenzene
Bis(2-chloroethoxy)methane	Dimethyl Phthalate	N-Nitrosodimethylamine
Bis(2-chloroethyl)ether	Di-N-Butyl Phthalate	N-Nitrosodi-N-Propylamine
Bis(2-chloroisopropyl)ether	2,4-Dinitrotoluene	N-Nitrosodiphenylamine
Bis(2-ethylhexyl)phthalate	2,6-Dinitrotoluene	Phenanthrene
4-Bromophenyl Phenyl Ether	Di-N-Octylphthalate	Pyrene
Butylbenzyl Phthalate	1,2-Diphenylhydrazine (as Azobenzene)	1,2,4-Trichlorobenzene

Pesticides

Aldrin	Dieldrin	PCB-1254
Alpha-BHC	Alpha-Endosulfan	PCB-1221
Beta-BHC	Beta-Endosulfan	PCB-1232
Gamma-BHC	Endosulfan Sulfate	PCB-1248
Delta-BHC	Endrin	PCB-1260
Chlordane	Endrin Aldehyde	PCB-1016
4,4'-DDT	Heptachlor	Toxaphene
4,4'-DDE	[illegible]	
4,4'-DDD	PCB-1242	

Table 2F-4
Hazardous Substances

Toxic Pollutant

Asbestos

Hazardous Substances

Acetaldehyde
Allyl alcohol
Allyl chloride
Amyl acetate
Aniline
Benzonitrile
Benzyl chloride
Butyl acetate
Butylamine
Carbaryl
Carbofuran
Carbon disulfide
Chlorpyrifos
Coumaphos

Cresol
Crotonaldehyde

Cyclohexane
2,4-D (2,4-Dichlorophenoxyacetic acid)
Diazinon
Dicamba
Dichlobenil
Dichlone
2,2-Dichloropropionic acid
Dichlorvos
Diethyl amine
Dimethyl amine
Dinitrobenzene
Diquat
Disulfoton
Diuron
Epichloromydrin
Ethion
Ethylene diamine
Ethylene dibromide
Formaldehyde
Furfural
Guthion
Isoprene
Isopropanolamine
Kelthane

Kepone
Malathion

Mercaptodimethur
Methoxychlor

Methyl mercaptan
Methyl methacrylate
Methyl parathion
Mevinphos
Mexacarbate
Monoethyl amine
Monomethyl amine
Naled
Napthenic acid
Nitrotoluene
Parathion
Phenolsulfonate
Phosgene
Propargite
Propylene oxide
Pyrethrins
Quinoline
Resorcinol
Strontium
Strychnine
Styrene
2,4,5-T (2,4,5-Trichlorophenoxyacetic acid)
TDE (Tetrachlorodiphenyl ethane)
2,4,5-TP [2-(2,4,5-Trichlorophenoxy) propanoic acid]
Trichlorofan
Triethylamine

Trimethylamine
Uranium
Vanadium
Vinyl acetate
Xylene
Xylenol
Zirconium

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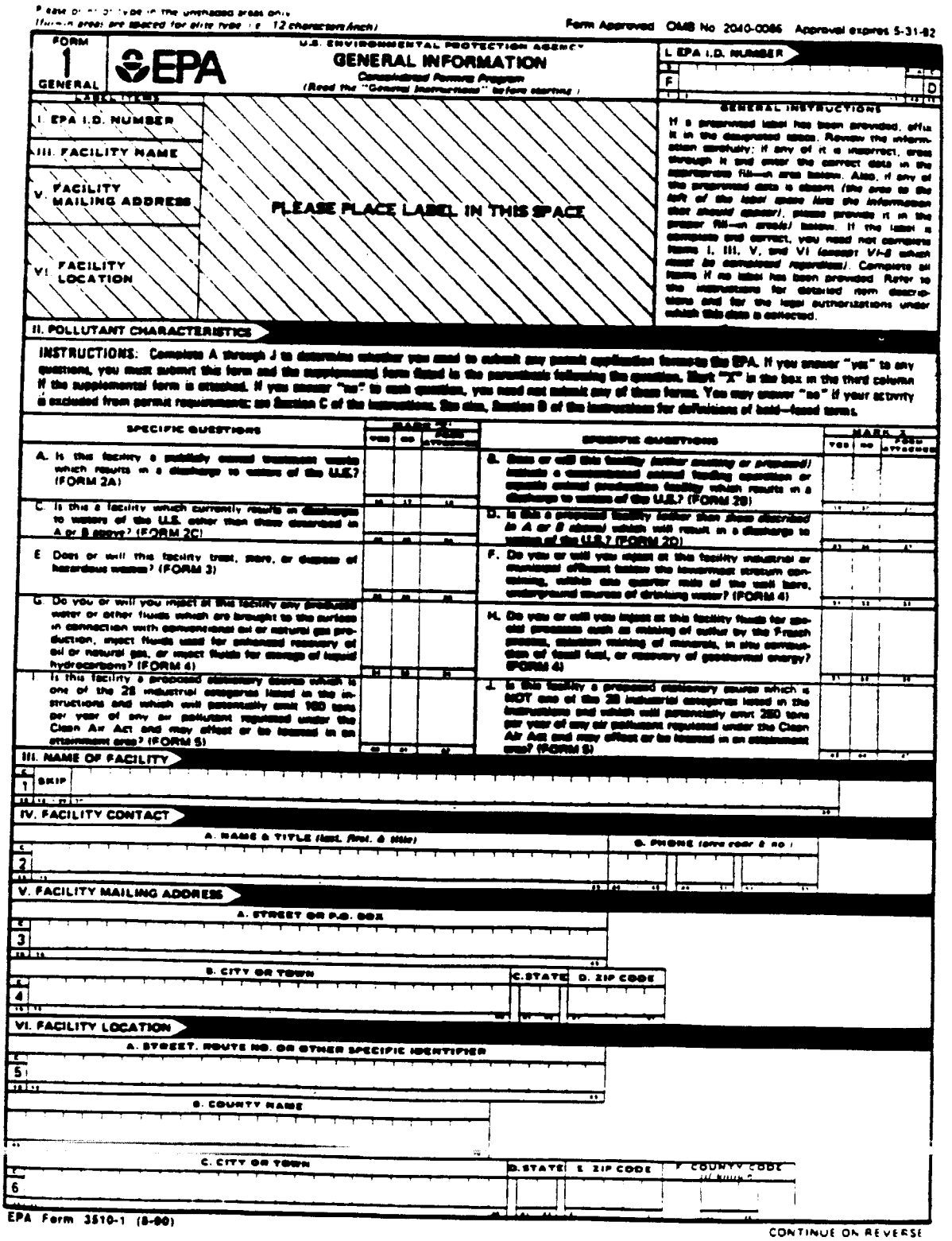
R0013508



Please print or type in the unshaded areas only
(Fill-in areas are spaced for elite type, i.e., 12 characters/inch)

Form Approved. OMB No. 2040-0086. Approval expires 5-31-92

FORM 1 GENERAL

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER

F | | | | | | | | | | | | D

LABEL ITEMS

I. EPA I.D. NUMBER

III. FACILITY NAME

V. FACILITY MAILING ADDRESS

VI. FACILITY LOCATION

PLEASE PLACE LABEL IN THIS SPACE

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix it in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill-in area below. Also, if any of the preprinted data is absent (the area to the left of the label space lists the information that should appear), please provide it in the proper fill-in area(s) below. If the label is complete and correct, you need not complete items I, III, V, and VI (except VI-B which must be completed regardless). Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section B of the instructions for definitions of bold-faced terms.

SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED
A. Is this facility a publicly owned treatment works which results in a discharge to waters of the U.S.? (FORM 2A)				B. Does or will this facility (either existing or proposed) include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to waters of the U.S.? (FORM 2B)			
C. Is this a facility which currently results in discharges to waters of the U.S. other than those described in A or B above? (FORM 2C)				D. Is this a proposed facility (other than those described in A or B above) which will result in a discharge to waters of the U.S.? (FORM 2D)			
E. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)				F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)			
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)				H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)			
I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)				J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)			

III. NAME OF FACILITY

1 SKIP

IV. FACILITY CONTACT

A. NAME & TITLE (last, first, & title) | B. PHONE (area code & no.)

2

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX

3

B. CITY OR TOWN | C. STATE | D. ZIP CODE

4

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER

5

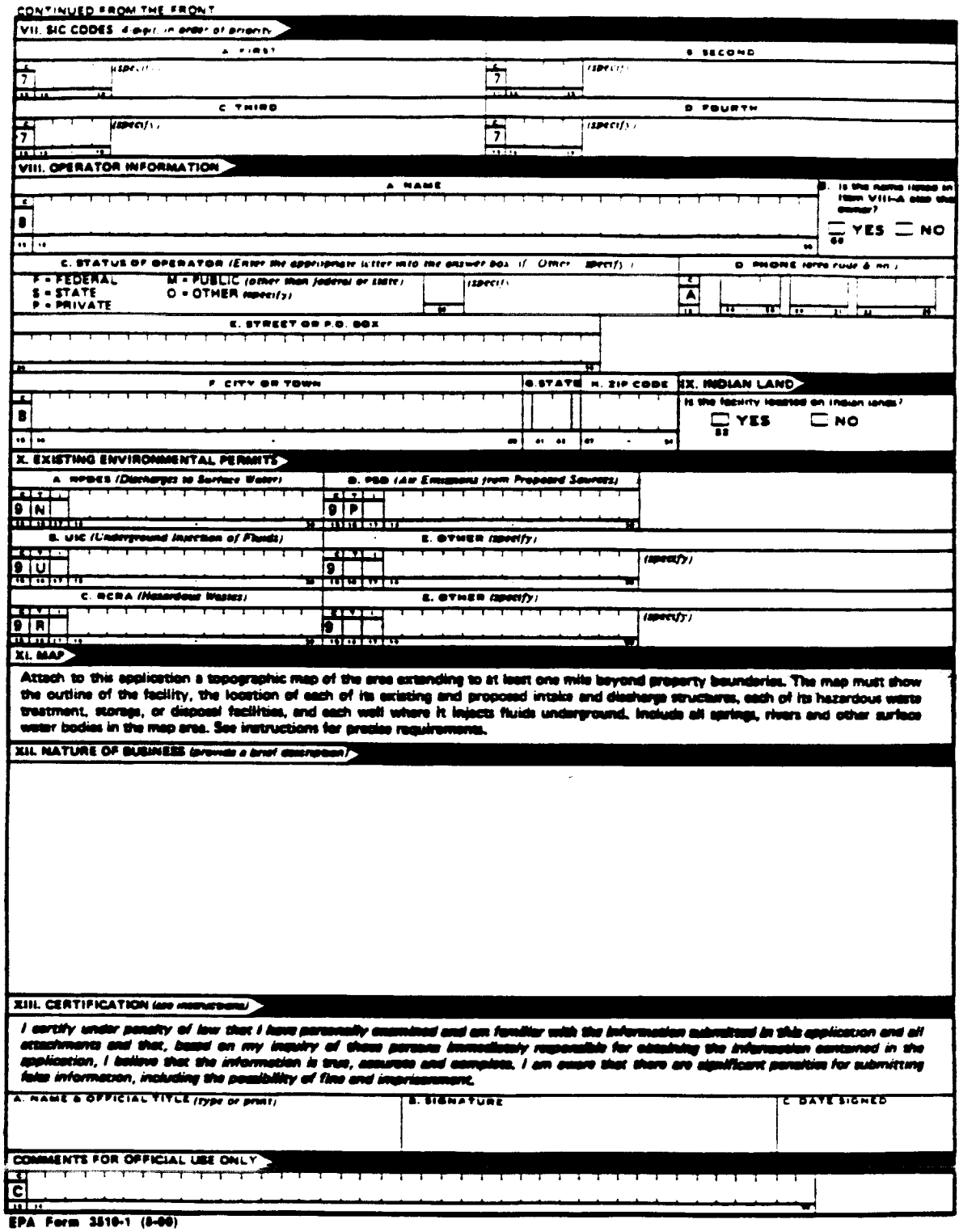
B. COUNTY NAME

C. CITY OR TOWN | D. STATE | E. ZIP CODE | F. COUNTY CODE (if known)

6

EPA Form 3510-1 (8-90)

CONTINUE ON REVERSE



CONTINUED FROM THE FRONT

VII. SIC CODES (4-digit, in order of priority)

A. FIRST | B. SECOND

C. THIRD | D. FOURTH

VIII. OPERATOR INFORMATION

A. NAME | B. Is the name listed in Item VIII-A also the owner? YES NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)
F = FEDERAL; S = STATE; P = PRIVATE; M = PUBLIC (other than federal or state); O = OTHER (specify)

D. PHONE (area code & no.)

E. STREET OR P.O. BOX

F. CITY OR TOWN | G. STATE | H. ZIP CODE

IX. INDIAN LAND

Is the facility located on Indian lands? YES NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water) — 9 N

B. PSD (Air Emissions from Proposed Sources) — 9 P

C. UIC (Underground Injection of Fluids) — 9 U

D. OTHER (specify)

C. RCRA (Hazardous Wastes) — 9 R

E. OTHER (specify)

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print) | B. SIGNATURE | C. DATE SIGNED

COMMENTS FOR OFFICIAL USE ONLY

C

EPA Form 3510-1 (8-80)

R0013510

APPENDIX B

NOAA WEATHER RADIO INFORMATION

NOAA WEATHER RADIO MANUFACTURERS LIST	
RADIO SHACK Weather Radio 2617 West Seventh St. Fort Worth, TX 76107 (817) 390-3011	✓ ●
GENERAL ELECTRIC Model 7-2934 (800) 626-2000	✓ ●
UNIDEN BEARCAT Bearcat Weather Alert 6345 Castleway Court Indianapolis, IN 46250 (800) 722-6637	■
ELECTROLERT Weatheralert Forecaster 4949 South 25A Tipp City, OH 45371 (513) 667-2461	✓ ● ■
SPRINGFIELD INSTRUMENTS Talking Weather Center/Station 76 Paccaic St. Wood-Ridge, NJ 07075 (201) 777-2900	■
WOODSON ELECTRONICS Plectron 505 Lincoln St. Overton, NE 68863 (308) 987-2404	X
GORMAN - REDLICH MANUFACTURING James T. Gorman 257 West Union St. Athens, OH 45701 (617) 593-3150	X

PRICE RANGE:

- ✓ Under $50
- ■ $50 to $100
- X Over $100
- ● Features AM/FM model radios with weather band

PLEASE NOTE, THIS LIST IS NOT ALL-INCLUSIVE, AND INCLUSION ON THIS LIST DOES NOT CONSTITUTE ENDORSEMENT OF ANY COMPANY BY EPA OR THE U.S. GOVERNMENT.

R0013512

NOAA WEATHER RADIO

The Voice of the National Weather Service

NOAA/PA 76015
Rev. July 1986

NOAA WEATHER RADIO IS A SERVICE...

...of the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce. As the "Voice of the National Weather Service," it provides continuous broadcasts of the latest weather information directly from National Weather Service offices. Taped weather messages are repeated every four to six minutes and are routinely revised every one to three hours, or more frequently if needed. Most of the stations operate 24 hours daily.

During severe weather, National Weather Service forecasters can interrupt the routine weather broadcasts and substitute special warning messages. The forecasters can also activate specially designed warning receivers. Such receivers either sound an alarm indicating that an emergency exists, alerting the listener to turn the receiver up to an audible volume; or, when operated in a muted mode, are automatically turned on so that the warning message is heard. "Warning alarm" receivers are especially valuable for schools, hospitals, public-safety agencies, and news media offices.

Under a January 1978 White House policy statement, NOAA Weather Radio was designated the sole Government-operated radio system to provide direct warnings into private homes for both natural disasters and nuclear attack. This capability is to supplement warnings by sirens and by commercial radio and TV.

The broadcasts are tailored to weather information needs of people within the receiving area. For example, stations along the sea coasts and Great Lakes provide weather information for boaters, fishers, and others engaged in marine activities as well as general weather information.

NOAA Weather Radio broadcasts are made on one of seven high-band FM frequencies ranging from 162.40 to 162.55 megahertz (MHz). These frequencies are not found on the average home radio now in use. However, a number of radio manufacturers offer special weather radios to operate on these frequencies, with or without the emergency warning alarm. Also, there are now many radios on the market which offer standard AM/FM frequencies plus the so-called "weather band" as an added feature.

NOAA Weather Radio broadcasts can usually be heard as far as 40 miles from the antenna site, sometimes more. The effective range depends on many factors, particularly the height of the broadcasting antenna, terrain, quality of the receiver, and type of receiving antenna. As a general rule, listeners close to or perhaps beyond the 40 mile range should have a good quality receiver system if they expect reliable reception. Also, an outside antenna may be required in these fringe areas. If practicable, a receiver should be tried at its place of intended use before making a final purchase.

The National Weather Service operates about 380 stations. Approximately 90 percent of the Nation's population is within listening range of a NOAA Weather Radio broadcast.

A similar network of about 15 stations using the same frequencies broadcasts continuous weather information across much of southern Canada.

If you have a question concerning NOAA Weather Radio or wish to receive a listing of NOAA Weather Radio receiver manufacturers, please contact your nearest National Weather Service Office, or write to National Weather Service (Attn: W/OM11), National Oceanic and Atmospheric Administration, Silver Spring, MD. 20910.

R0013513

NOAA WEATHER
RADIO NETWORK

R0013514

TECHNICAL APPENDIX C

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, HOLDING TIMES AND 40 CODE OF FEDERAL REGULATIONS (CFR) PART 136

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES			
Parameter	**Container(1)**	**Preservative (2), (3)**	**Maximum Holding Time (4)**
Bacterial Tests			
Coliform, fecal and total	P, G	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	6 hours
Fecal streptococci	P, G	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	6 hours
Inorganic Tests			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Chemical oxygen demand	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C NaOH to pH>12 0.6g ascorbic acid (5)	14 days (6)
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH<2 H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic Nitrogen	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Metals (7)			
Chromium VI	P. G	Cool, 4°C	28 hours
Mercury	P, G	HNO_3 to pH<2	28 hours
Metals, except above	P, G	HNO_3 to pH<2	6 months
Nitrate	P, G	Cool, 4°C	48 hours

R0013516

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES			
Parameter	Container(1)	Preservative (2), (3)	Maximum Holding Time (4)
Nitrate-nitrite	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Nitrite	P, G	Cool, 4°C	48 hours
O&G	G	Cool, 4°C H_2SO_4 or HCl to pH<2	28 days
Organic carbon	P, G	Cool, 4°C HCl or H_2SO_4 to pH<2	28 days
Orthophosphate	P, G	Filter immediately Cool, 4°C	48 hours
Oxygen, Dissolved Probe	G bottle and top	None required	Analyze immediately
Dissolved oxygen, Winkler method	G bottle and top	Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days
Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze
Turbidity	P, G	Cool, 4°C	48 hours

R0013517

REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES			
Parameter	**Container(1)**	**Preservative (2), (3)**	**Maximum Holding Time (4)**
Organic Tests (8)			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	14 days
Purgeable aromatics	G, Teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$ (5) HCl to pH<2 (9)	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$ (5) Adjust pH to 4-5 (10)	14 days
Phenols (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Benzidines (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction (13)
Phthalate esters (11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines (11), (14)	G, Teflon-lined cap	Cool, 4°C store in dark 0.008% $Na_2S_2O_3$	7 days until extraction, 40 days after extraction
PCBs (11) acrylonitrite	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitroaromatics and isophorone (11)	G, Teflon-lined cap	Cool, 4°C store in dark 0.008% $NA_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Polynuclear aromatic hydrocarbons (11)	G, Teflon-lined cap	Cool, 4°C store in dark 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Haloethers (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Chlorinated hydrocarbons (11)	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
TCDD (11)	G, Teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$ (5)	7 days until extraction, 40 days after extraction
Pesticides Tests			
Pesticides (11)	G, Teflon-lined cap	Cool, 4°C pH 5-9 (15)	7 days until extraction, 40 days after extraction
Radiological Tests			
Alpha, beta, and radium	P, G	HNO_3 to pH<2	6 months

R0013518

40 CFR 136.3 TABLE II NOTES

(1) Polyethylene (P) or Glass (G).

(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

(3) When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weights or less (pH about 12.30 or less).

(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.

(5) Should only be used in the presence of residual chlorine.

(6) Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

(7) Samples should be filtered immediately on-site before adding preservative for dissolved metals.

(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

(9) Sample receiving no pH adjustment must be analyzed within seven days of sampling.

(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

R0013519

40 CFR 136.3 TABLE II NOTES

(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark,and adjusting the pH to 6-9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine), and footnotes 12, 13 (re the analysis of benzidine).

(12) If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 $\pm$ 0.2 to prevent rearrangement to benzidine.

(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O^3$.

Source: 40 CFR 136.3 Table II

R0013520

TABLE IA—LIST OF APPROVED BIOLOGICAL TEST PROCEDURES

Parameter and units	Method [1]	EPA [2]	Reference (Method Number or Page)		
			Standard Methods 18th Ed.	ASTM	USGS
Bacteria:					
1. Coliform (fecal) number per 100 ml.	MPN, 5 tubes, 3 dilution; or, membrane filter (MF)[3]; single step.	Page 132.	908C		
2. Coliform (fecal) in presence of chlorine number per 100 ml.	MPN, 5 tubes, 3 dilution; or, MF [3]; single step.[4a]	p. 124	908		B-0050-77
3. Coliform (total), number per 100 ml.	MPN, 5 tubes, 3 dilution; or, MF [3] single step or two step.	p. 114	908A		
		p. 108	908A		B-0055-77.
4. Coliform (total) in presence of chlorine, number per 100 ml.	MPN, 5 tubes, dilution; or MF [3] with enrichment.	p. 114	908A		
		p. 111	909 (A+A.8c)		
5. Fecal streptococci, number per 100 ml.	MPN, 5 tubes, 3 dilution; MF [3]; or, plate count.	p. 139	910A		
		p. 135	910B		B0055-77.[5]
		p. 143	910C		

Table IA Notes

[1] The method used must be specified when results are reported.

[2] "Microbiological Methods for Monitoring the Environment, Water and Wastes, 1978", EPA-600/8-78-017, U.S. Environmental Protection Agency.

[3] Brenner, P.E., *et al.*, "Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples," U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 5, Chapter A4, Laboratory Analysis, 1977.

[4] 0.45 µm membrane filter or other pore size certified by the manufacturer to fully retain organisms to be cultivated, and free of extractables which could interfere with their growth and development.

[4a] Since the membrane filter technique usually yields low and variable recovery from chlorinated wastewaters, the MPN method will be required to resolve any controversies.

[5] Approved only if dissolution of the KF Streptococcus Agar (Section 5.1, USGS Method B-0055-77) is made in a boiling water bath to avoid scorching of the medium.

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES

Parameter, units and method	Reference (method No. or page)				
	EPA 1979 [24]	Std. methods 18th ED	ASTM	USGS [1]	Other
1. Acidity, as $CaCO_3$ mg/L: Electrometric end point or phenolphthalein end point.	305.1	402(4.a)	1067-69(E)		
2. Alkalinity, as $CaCO_3$ mg/L:					
Electrometric or colorimetric titration to pH 4.5, manual, or.	310.1	403	D1067-69(B)	I-1030-84	33.014[3]
Automated	310.2			I-2030-84	
3. Aluminum—Total,[6] mg/L: Digestion [6] followed by:					
AA direct aspiration	202.1	303C		I-3051-85	
AA furnace	202.2	304			
Inductively coupled plasma (ICP)					200.7.[4]
Direct current plasma (DCP) or					Note 33.
Colorimetric (Eriochrome cyanine R)		309B			
4. Ammonia (as N), mg/L: Manual distillation (at pH 6.8) [5] followed by:	350.2	417A			33.057.[3]
Nesslerization	350.2	417B	D1426-79(A)	I-3520-84	33.057.[3]
Titration	350.2	417D			
Electrode	350.3	417 E or F	D1426-79(D)		
Automated phenate or	350.1	417G	D1426-79(C)	I-4523-84	
Automated electrode					Note 6.
5. Antimony—Total [6], mg/L: Digestion [6] followed by:					
AA direct aspiration	204.1	303A			
AA furnace, or	204.2	304			
Inductively coupled plasma					200.7.[4]
6. Arsenic—Total [6], mg/L: Digestion [6] followed by	206.5				
AA gaseous hydride	206.3	303E	D2972-84(B)	I-3062-84	
AA furnace	206.2	304			
Inductively coupled plasma; or					200.7.[4]
Colorimetric (SDDC)	206.4	307B	D2972-84(A)	I-3060-84	
7. Barium—Total,[6] mg/L: Digestion [6] followed by:					
AA direct aspiration	208.1	303C		I-3084-85	
AA furnace	208.2	304			
ICP, or					200.7.[4]
DCP					Note 33.
8. Beryllium—Total,[6] mg/L: Digestion [6] followed by:					
AA direct aspiration	210.1	303C	D3645-84(A)	I-3095-85	
AA furnace	210.2	304			

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page)				
	EPA 1979 [34]	Std. methods 18th ED	ASTM	USGS [1]	Other
ICP					200.7.[4]
DCP, or					Note 33.
Colorimetric (aluminon)		3500			
9. Biochemical oxygen demand (BOD$_5$), mg/L:					
Dissolved Oxygen Depletion	405.1	507		I-1578-78 [7]	33.019 [5], p. 17.[6]
10. Boron—Total, mg/L:					
Colorimetric (curcumin)	212.3	404A		I-3112-85	
ICP, or					200.7.[4]
DCP					Note 33.
11. Bromide, mg/L: Titrimetric	320.1		D1246-82(C)	I-1125-84	p. 844.[6]
12. Cadmium—Total,[8] mg/L: Digestion [9] followed by:					
AA direct aspiration	213.1	303 A or B	D3557-84 (A or B).	I-3135-85 or I-3136-85.	33.089,[5] p. 37.[6]
AA furnace	213.2	304			
ICP					200.7.[4]
DCP					Note 33.
Voltammetry,[10] or			D3557-84(C)		
Colorimetric (Dithizone)		3109			
13. Calcium—Total,[8] mg/L: Digestion [9] followed by:					
AA direct aspiration	215.1	308A	D511-84(B)	I-3152-85	
ICP					200.7.[4]
DCP, or					Note 33.
Titrimetric (EDTA)	215.2	311C	D511-84(A)		
14. Carbonaceous biochemical oxygen demand (CBOD$_5$), mg/L [11]: Dissolved Oxygen Depletion with nitrification inhibitor.		507(5,a,d)			
15. Chemical oxygen demand (COD), mg/L:					
Titrimetric, or	410.1	508A	D1252-83	I-3560-84 or I-3562-84.	33.094 [5], p. 17.[6]
	410.2, or				
	410.3				
Spectrophotometric, manual or automated.	410.4			I-3561-84	Notes 12 or 13.
16. Chloride, mg/L:					
Titrimetric (silver nitrate)		407A	D512-81(B)	I-1183-84	
or (Mercuric nitrate), or	325.3	407B	D512-81(A)	I-1184-84	33.087.[5]
Colorimetric, manual or			D512-81(C)	I-1187-84	
Automated (Ferricyanide)	325.1, or	407D		I-2187-84	
	325.2				
17. Chlorine—Total residual, mg/L:					
Titrimetric:					
Amperometric direct	330.1	408C	D1253-79(A)		
Starch end point direct	330.3	408A	D1253-79(B)		
			Part 18.3		
Back titration other end point [14], or	330.2	408B			
DPD-FAS	330.4	408D			
Spectrophotometric, DPD	330.5	408E			
Or Electrode					Note 18.
18. Chromium VI dissolved, mg/L: 0.45 micron filtration followed by:					
AA chelation-extraction, or	218.4	3500		I-1232-84	
Colorimetric (Diphenylcarbazide)				I-1230-84	307B.[14]
19. Chromium—Total,[8] mg/L: Digestion [9] followed by:					
AA direct aspiration	218.1	308A	D1687-84(D)	I-3236-85	33.088.[5]
AA chelation-extraction	218.3	3500			
AA furnace	218.2	304			
ICP					200.7.[4]
DCP, or					Note 33.
Colorimetric (Diphenylcarbazide)		312B	D1687-84(A)		
20. Cobalt—Total,[8] mg/L: Digestion [9] followed by:					
AA direct aspiration	219.1	303 A or B	D3558-84 (A or B).	I-3239-85 or I-3240-85.	p. 37.[6]
AA furnace	219.2	304			
ICP, or					200.7.[4]
DCP					Note 33.
21. Color platinum cobalt units or dominant wavelength, hue, luminance purity:					
Colorimetric (ADMI), or	110.1	204D			Note 17.
(Platinum cobalt), or	110.2	204A		I-1250-84	
Spectrophotometric	110.3	204B			

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page)				
	EPA 1979 [24]	Std. methods 18th ED	ASTM	USGS [1]	Other
22. Copper—Total,[5] mg/L: Digestion [4] followed by:					
AA direct aspiration	220.1	3030 A or B	D1688–84 (C or E).	I–3270–85 or I–3271–85.	33.088,[6] p. 37.[6]
AA furnace	220.2	304			
ICP					200.7.[4]
DCP, or					Note 33.
Colorimetric (Neocuproine), or (Bi-cinchoninate).		312B	D1688–84(A)		Note 18.
23. Cyanide—Total, mg/L: Manual distillation with $MgCl_2$ followed by		412B			
Titrimetric, or		412C			p. 22.[6]
Spectrophotometric, manual or	335.2	412D	D2036–82(A)	I–3300–84	
Automated,[10]	335.3		D2036–82(A)		
24. Cyanide amenable to chlorination, mg/L: Manual distillation with $MgCl_2$ followed by titrimetric or spectrophotometric.	335.1	412F	D2036–82(B)		
25. Fluoride—Total, mg/L: Manual distillation[3] followed by:		413A			
Electrode, manual or	340.2	413B	D1179–80(B)		
Automated,				I–4327–84	
Colorimetric (SPADNS)	340.1	413C	D1179–80(A)		
Or Automated complexone	340.3	413E			
26. Gold—Total,[5] mg/L: Digestion [4] followed by:					
AA direct aspiration	231.2	303A			
AA furnace, or	231.2	304			
DCP					Note 33.
27. Hardness—Total, as $CaCO_3$, mg/L:					
Automated colorimetric	130.1				
Titrimetric (EDTA), or Ca plus Mg as their carbonates, by inductively coupled plasma or AA direct aspiration. (See Parameters 13 and 33.)	130.2	314B	D1126–80	I–1338–84	33.082.[6]
28. Hydrogen ion (pH), pH units:					
Electrometric, measurement, or	150.1	423	D1293–84 (A or B).	I–1586–84	33.008.[6]
Automated electrode					Note 20.
29. Iridium—Total[5], mg/L: Digestion[4] followed by:					
AA direct aspiration, or	235.1	303A			
AA furnace	235.2	304			
30. Iron—Total,[5] mg/L: Digestion [4] followed by:					
AA direct aspiration	236.1	303 A or B	D1068–84 (C or D).	I–3381–85	33.088.[6]
AA furnace	236.2	304			
ICP					200.7.[4]
DCP, or					Note 33.
Colorimetric (Phenanthroline)		312B	D1068–84(A)		Note 21.
31. Kjeldahl nitrogen—Total, (as N), mg/L: Digestion and distillation followed by:	351.3	420 A or B	D3590–84(A)		
Titration	351.3	417D	D3590–84(A)		33.051.[6]
Nesslerization	351.3	417B	D3590–84(A)		
Electrode	351.3	417 E or F			
Automated phenate	351.1			I–4551–78 [7]	
Semi-automated block digestor, or	351.2		D3590–84(A)		
Potentiometric	351.4		D3590–84(A)		
32. Lead—Total,[5] mg/L: Digestion [4] followed by:					
AA direct aspiration	239.1	303 A or B	D3559–84 (A or B)	I–3399–85	33.088.[6]
AA furnace	239.2	304			
ICP					200.7.[4]
DCP					Note 33.
Voltammetry,[10] or			D3559–85(C)		
Colorimetric (Dithizone)		316B			
33. Magnesium—Total,[5] mg/L: Digestion [4] followed by:					
AA direct aspiration	242.1	303A	D511–84(B)	I–3447–85	33.089.[6]
ICP					200.7.[4]
DCP, or					Note 33.
Gravimetric		316B	D511–77(A)		
34. Manganese—Total,[5] mg/L: Digestion [4] followed by:					
AA direct aspiration	243.1	304 A or B	D858–84 (B or C).	I–3454–85	33.089.[6]
AA furnace	243.2	304			
ICP					200.7.[4]
DCP, or					Note 33.
Colorimetric (Persulfate) or (Periodate)		319B	D858–84(A)		33.126.[6] Note 22.

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page)				
	EPA 1979 [24]	Std. methods 18th ED	ASTM	USGS [1]	Other
35. Mercury—Total [5], mg/L:					
Cold vapor, manual or	245.1	303F	D3223-86	I-3462-84	33.086 [6]
Automated	245.2				
36. Molybdenum—Total [4] mg/L: Digestion [3] followed by:					
AA direct aspiration	246.1	303C		I-3490-85	
AA furnace	246.2	304			
ICP, or					200.7 [4]
DCP					Note 33.
37. Nickel—Total [5] mg/L: Digestion [3] followed by:					
AA direct aspiration	249.1	303 A or B	D1886-84 (C or D).	I-3499-85	
AA furnace	249.2	304			
ICP					200.7 [4]
DCP, or					Note 33.
Colorimetric (Heptoxime)		321B			
38. Nitrate (as N), mg/L: Colorimetric (Brucine sulfate), or Nitrate-nitrite N minus Nitrite N (See parameters 39 and 40).	352.1		D992-71		33.063 [6], 4190 [14], p. 28. [6]
39. Nitrate-nitrite (as N), mg/L: Cadmium reduction, Manual or	353.3	418C	D3867-86(B)		
Automated, or	353.2	418F	D3867-86(A)	I-4545-84	
Automated hydrazine	353.1				
40. Nitrite (as N), mg/L: Spectrophotometric:					
Manual or	354.1	419	D1254-67		Note 24.
Automated (Diazotization)				I-4540-84	
41. Oil and grease—Total recoverable, mg/L: Gravimetric (extraction).	413.1	503A			
42. Organic carbon—Total (TOC), mg/L: Combustion or oxidation.	415.1	505	D2579-85 (A or B).		33.044 [6], p. 4. [24]
43. Organic nitrogen (as N) mg/L: Total [Kjeldahl N (Parameter 31) minus ammonia N (Parameter 4.)].					
44. Orthophosphate (as P), mg/L: Ascorbic acid method:					
Automated or	365.1	424G		I-4601-84	33.116 [6]
Manual single reagent	365.2	424F	D515-88(A)		33.111. [6]
or Manual two reagent	365.3				
45. Osmium—Total [5], mg/L: Digestion [3] followed by:					
AA direct aspiration, or	252.1	303C			
AA furnace	252.2	304			
46. Oxygen dissolved, mg/L: Winkler (Azide modification), or	360.2	421B	D888-81(C)	I-1575-78 [7]	33.088. [6]
Electrode	360.1	421F		I-1576-78 [7]	
47. Palladium—Total [5] mg/L: Digestion [3] followed by:					
AA direct aspiration	253.1				p. 527. [6]
AA furnace	253.2				p. 529. [6]
DCP					Note 33.
48. Phenols, mg/L:					
Manual distillation [24]	420.1		D1783-80 (A or B).		Note 28.
Followed by:					
Colorimetric (4AAP) manual, or	420.1				Note 28.
Automated [19]	420.2				
49. Phosphorus (elemental) mg/L: Gas-liquid chromatography.					Note 27.
50. Phosphorus—Total, mg/L: Persulfate digestion followed by	365.2	424C(III)			33.111. [6]
Manual or	365.2 or 365.3.	424F	D515-88(A)		
Automated ascorbic acid reduction, or.	365.1	424G		I-4600-84	33.116 [6]
Semi-automated block digestor	365.4				
51. Platinum—Total [5] mg/L: Digestion [3] followed by:					
AA direct aspiration	255.1	303A			
AA furnace	255.2	304			
DCP					Note 33
52. Potassium—Total [4] mg/L: Digestion followed by:					
AA direct aspiration	258.1	303A		I-3630-84	33.103 [6]
Inductively coupled plasma					200.7 [4]
Flame photometric, or		322B	D1428-82(A)		
Colorimetric (Cobaltinitrate)					317B [14]
53. Residue—Total, mg/L: Gravimetric, 103–105°C.	160.3	209A		I-3750-84	
54. Residue—filterable, mg/L: Gravimetric, 180°C.	160.1	209B		I-1750-84	
55. Residue—nonfilterable, (TSS), mg/L: Gravimetric, 103–105°C post washing of residue.	160.2	209C		I-3765-84	

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method No. or page)				
	EPA 1979 [1a]	Std. methods 16th ED	ASTM	USGS	Other
56. Residue—settleable, mg/L: Volumetric, (Imhoff cone) or gravimetric.	160.5	209E		1	
57. Residue—Volatile, mg/L: Gravimetric, 550°C.	160.4	209D		I-3753-84	
58. Rhodium—Total [9], mg/L: Digestion [4] followed by:.					
AA direct aspiration, or	265.1	303A			
AA furnace	265.2	304			
59. Ruthenium—Total [9], mg/L: Digestion [4] followed by:					
AA direct aspiration, or	267.1	303A			
AA furnace	267.2	304			
60. Selenium—Total [9], mg/L: Digestion [4] followed by:					
AA furnace	270.2	304			
Inductively coupled plasma, or					200.7 [4]
AA gaseous hydride	270.3	303E	D3859-84(A)	I-3667-84	
61. Silica—Dissolved, mg/L: 0.45 micron filtration followed by:					
Colorimetric, Manual or	370.1	425C	D859-80(B)	I-1700-84	
Automated (Molybdosilicate), or				I-2700-84	
Inductively coupled plasma					200.7 [4]
62. Silver—Total [5a] mg/L: Digestion [4] followed by:					
AA direct aspiration	272.1	303 A or B		I-3720-85	33.088 [5] p. 37. [6]
AA furnace	272.2	304			
Colorimetric (Dithizone)					3198 [10]
ICP, or					200.7 [4]
DCP					Note 33.
63. Sodium—Total [9] mg/L: Digestion [4] followed by:					
AA direct aspiration	273.1	303A		I-3735-85	33.107 [5]
ICP					200.7 [4]
DCP, or					Note 33.
Flame photometric		325B	D1428-82(A)		
64. Specific conductance, micromhos/cm at 25°C: Wheatstone bridge	120.1	205	D1125-82(A)	I-1780-84	33.002 [5]
65. Sulfate (as SO_4), mg/L:					
Automated colorimetric (barium chloranilate)	375.1				
Gravimetric, or	375.3	426 A or B	D516-82(A)		33.124 [5]
Turbidimetric	375.4		D516-82(B)		426C [11]
66. Sulfide (as S), mg/L:					
Titrimetric (iodine) or	376.1	427D		I-3840-84	228A [12]
Colorimetric (methylene blue)	376.2	427C			
67. Sulfite (as SO_3), mg/L: Titrimetric (iodine-iodate)	377.1	428A	D1339-84(C)		
68. Surfactants, mg/L: Colorimetric (methylene blue)	425.1	512B	D2330-82(A)		
69. Temperature, °C.: Thermometric	170.1	212			Note 31.
70. Thallium—Total [9], mg/L: Digestion [4] followed by:					
AA direct aspiration	279.1	303A			
AA furnace, or	279.2	304			
Inductively coupled plasma					200.7 [4]
71. Tin—Total [9], mg/L: Digestion [4] followed by:					
AA direct aspiration, or	282.1	303A		I-3850-78 [7]	
AA furnace	282.2	304			
72. Titanium—Total [9] mg/L: Digestion [4] followed by:					
AA direct aspiration	283.1	303C			
AA furnace	283.2	304			
DCP					Note 33.
73. Turbidity, NTU: Nephelometric	180.1	214A	D1889-81	I-3860-84	
74. Vanadium—Total [9] mg/L: Digestion [4] followed by:					
AA direct aspiration	286.1	303C			
AA furnace	286.2	304			
ICP					200.7 [4]
DCP, or					Note 33.
Colorimetric (Gallic acid)		327B	D3373-84(A)		
76. Zinc—Total [9] mg/L: Digestion [4] followed by:					
AA direct aspiration	289.1	303 A or B	D1691-84 (C or D)	I-3900-85	33.088 [5] p. 37. [6]
AA furnace	289.2	304			
ICP					200.7 [4]
DCP, or					Note 33.
Colorimetric (Dithizone) or		388C			
(Zincon)					Note 32.

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TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

[1] "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments," U.S. Department of the Interior, U.S. Geological Survey, Open-File Report 85-495, 1985, unless otherwise stated.
[2] "Official Methods of Analysis of the Association of Official Analytical Chemists," methods manual, 14th ed. (1984).
[3] For the determination of total metals the sample is not filtered before processing. A digestion procedure is required to solubilize suspended material and to destroy possible organic-metal complexes. Two digestion procedures are given in "Methods for Chemical Analysis of Water and Wastes, 1979." One (section 4.1.3), is a vigorous digestion using nitric acid. A less vigorous digestion using nitric and hydrochloric acids (section 4.1.4) is preferred; however, the analyst should be cautioned that this mild digestion may not suffice for all sample types. Particularly, if a colorimetric procedure is to be employed, it is necessary to ensure that all organo-metallic bonds be broken so that the metal is in a reactive state. In those situations, the vigorous digestion is to be preferred making certain that at no time does the sample go to dryness. Samples containing large amounts of organic materials would also benefit by this vigorous digestion. Use of the graphite furnace technique, inductively coupled plasma, as well as determinations for certain elements such as arsenic, the noble metals, mercury, selenium, and titanium require a modified digestion and in all cases the method write-up should be consulted for specific instruction and/or cautions.

NOTE: If the digestion included in one of the other approved references is different than the above, the EPA procedure must be used.

Dissolved metals are defined as those constituents which will pass through a 0.45 micron membrane filter. Following filtration of the sample, the referenced procedure for total metals must be followed. Sample digestion for dissolved metals may be omitted for AA (direct aspiration or graphite furnace) and ICP analyses provided the sample solution to be analyzed meets the following criteria:
a. has a low COD (<20)
b. is visibly transparent with a turbidity measurement of 1 NTU or less.
c. is colorless with no perceptable color, and
d. is of one liquid phase and free of particulate or suspended matter following acidification.

[4] The full text of Method 200.7, "Inductively Coupled Plasma Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes," is given at Appendix C of this Part 136.
[5] Manual distillation is not required if comparability data on representative effluent samples are on company file to show that this preliminary distillation step is not necessary; however, manual distillation will be required to resolve any controversies.
[6] Ammonia, Automated Electrode Method, Industrial Method Number 379-75 WE, dated February 19, 1976, Technicon AutoAnalyzer II, Technicon Industrial Systems, Tarrytown, NY 10591.
[7] The approved method is that cited in "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments", USGS TWRI, Book 5, Chapter A1 (1979).
[8] American National Standard on Photographic Processing Effluents, Apr. 2, 1975. Available from ANSI, 1430 Broadway, New York, NY 10018.
[9] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).
[10] The use of manual and differential pulse voltage ramps to increase sensitivity and resolution is acceptable.
[11] Carbonaceous biochemical oxygen demand (CBOD$_5$) must not be confused with the traditional BOD$_5$ test which measures "total BOD." The addition of the nitrification inhibitor is not a procedural option, but must be included to report the CBOD$_5$ parameter. A discharger whose permit requires reporting the traditional BOD$_5$ may not use a nitrification inhibitor in the procedure for reporting the results. Only when a discharger's permit specifically states CBOD$_5$ is required, can the permittee report data using the nitrification inhibitor.
[12] OIC Chemical Oxygen Demand Method, Oceanography International Corporation, 512 West Loop, P.O. Box 2980, College Station, TX 77840.
[13] Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, 1979, Hach chemical Company, P.O. Box 389, Loveland, CO 80537.
[14] The back titration method will be used to resolve controversy.
[15] Orion Research Instruction Manual, Residual Chlorine Electrode Model 97-70, 1977, Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA 02139.
[16] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition, 1976.
[17] National Council of the Paper Industry for Air and Stream Improvement, (Inc.) Technical Bulletin 253, December 1971.
[18] Copper, Bicinchoninate Method, Method 8506, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
[19] After the manual distillation is completed, the autoanalyzer manifolds in EPA Methods 335.3 (cyanide) or 420.2 (phenols) are simplified by connecting the re-sample line directly to the sampler. When using the manifold setup shown in Method 335.3, the buffer 6.2 should be replaced with the buffer 7.6 found in Method 335.2.
[20] Hydrogen Ion (pH) Automated Electrode Method, Industrial Method Number 378-75WA, October 1976, Technicon AutoAnalyzer II, Technicon Industrial Systems, Tarrytown, NY 10591.
[21] Iron, 1,10-Phenanathroline Method, Method 8008, 1980, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
[22] Manganese, Periodate Oxidation Method, Method 8034, Hach Handbook of Wastewater Analysis, 1979, pages 3-113 and 3-117, Hach Chemical Company, Loveland, CO 80537.
[23] Gaertitz, D., Brown, E., "Methods for Analysis of Organic Substances in Water," U.S. Geological Survey Techniques of Water-Resources Inv., book 5, ch. A3, page 4 (1972).
[24] Nitrogen, Nitrite, Method 8507, Hach Chemical Company, P.O. Box 389, Loveland, CO 80537.
[25] Just prior to distillation, adjust the sulfuric-acid-preserved sample to pH 4 with 1 + 9 NaOH.
[26] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 14th Edition. The colorimetric reaction is conducted at a pH of 10.0±0.2. The approved methods are given on pp. 579-81 of the 14th Edition: Method 510A for distillation, Method 510B for the manual colorimetric procedure, or Method 510C for the manual spectrophotometric procedure.
[27] R. F. Addison and R. G. Ackman, "Direct Determination of Elemental Phosphorus by Gas-Liquid Chromatography," *Journal of Chromatography*, vol. 47, No. 3, pp. 421-426, 1970.
[28] Approved methods for the analysis of silver in industrial wastewaters at concentrations of 1 mg/L and above are inadequate where silver exists as an inorganic halide. Silver halides such as the bromide and chloride are relatively insoluble in reagents such as nitric acid but are readily soluble in an aqueous buffer of sodium thiosulfate and sodium hydroxide to a pH of 12. Therefore, for levels of silver above 1 mg/L, 20 mL of sample should be diluted to 100 mL by adding 40 mL each of 2 M $Na_2S_2O_3$ and 2M NaOH. Standards should be prepared in the same manner. For levels of silver below 1 mg/L the approved method is satisfactory.
[29] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 16th Edition.
[30] The approved method is that cited in *Standard Methods for the Examination of Water and Wastewater*, 13th Edition.
[31] Stevens, H. H., Ficke, J. F., and Smoot, G. F., "Water Temperature—Influential Factors, Field Measurement and Data Presentation," U.S. Geological Survey, Techniques of Water Resources Investigations, Book 1, Chapter D1, 1975.
[32] Zinc, Zincon Method, Method 8009, Hach Handbook of Water Analysis, 1979, pages 2-231 and 2-233, Hach Chemical Company, Loveland, CO 80537.
[33] "Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes, Method AES0029," 1986, Applied Research Laboratories, Inc., 24911 Avenue Stanford, Valencia, CA 91355.
[34] Precision and recovery statements for the atomic absorption direct aspiration and graphite furnace methods, and for the spectrophotometric SDDC method for arsenic are provided in appendix D of this part titled, "Precision and Recovery Statements for Methods for Measuring Metals".

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS

Parameter [1]	EPA Method Number [2, 7]			Other
	GC	GC/MS	HPLC	
1. Acenaphthene	610	625, 1625	610	
2. Acenaphthylene	610	625, 1625	610	
3. Acrolein	603	[3]624, 1624		

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TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter [1]	EPA Method Number [2, 7]			Other
	GC	GC/MS	HPLC	
4. Acrylonitrile	603	[4]624, 1624		
5. Anthracene	610	625, 1625	610	
6. Benzene	602	624, 1624		
7. Benzidine		[5]625, 1625	605	Note 3, p. 1
8. Benzo(a)anthracene	610	625, 1625	610	
9. Benzo(a)pyrene	610	625, 1625	610	
10. Benzo(b)fluoranthene	610	625, 1625	610	
11. Benzo(g,h,i)perylene	610	625, 1625	610	
12. Benzo(k)fluoranthene	610	625, 1625	610	
13. Benzyl chloride				Note 3, p. 130; Note 6, p. S102.
14. Benzyl butyl phthalate	606	625, 1625		
15. Bis(2-chloroethoxy) methane	611	625, 1625		
16. Bis(2-chloroethyl) ether	611	625, 1625		
17. Bis(2-ethylhexyl) phthalate	606	625, 1625		
18. Bromodichloromethane	601	624, 1624		
19. Bromoform	601	624, 1624		
20. Bromomethane	601	624, 1624		
21. 4-Bromophenylphenyl ether	611	625, 1625		
22. Carbon tetrachloride	601	624, 1624		Note 3, p. 130;
23. 4-Chloro-3-methylphenol	604	625, 1625		
24. Chlorobenzene	601, 602	624, 1624		Note 3, p. 130;
25. Chloroethane	601	624, 1624		
26. 2-Chloroethylvinyl ether	601	624, 1624		
27. Chloroform	601	624, 1624		Note 3, p. 130;
28. Chloromethane	601	624, 1624		
29. 2-Chloronaphthalene	612	625, 1625		
30. 2-Chlorophenol	604	625, 1625		
31. 4-Chlorophenylphenyl ether	611	625, 1625		
32. Chrysene	610	625, 1625	610	
33. Dibenzo(a,h)anthracene	610	625, 1625	610	
34. Dibromochloromethane	601	624, 1624		
35. 1,2-Dichlorobenzene	601, 602, 612	624, 625, 1625		
36. 1,3-Dichlorobenzene	601, 602, 612	624, 625, 1625		
37. 1,4-Dichlorobenzene	601, 602, 612	625, 1624, 1625		
38. 3,3'-Dichlorobenzidine		625, 1625	605	
39. Dichlorodifluoromethane	601			
40. 1,1-Dichloroethane	601	624, 1624		
41. 1,2-Dichloroethane	601	624, 1624		
42. 1,1-Dichloroethene	601	624, 1624		
43. trans-1,2-Dichloroethene	601	624, 1624		
44. 2,4-Dichlorophenol	604	625, 1625		
45. 1,2-Dichloropropane	601	624, 1624		
46. cis-1,3-Dichloropropene	601	624, 1624		
47. trans-1,3-Dichloropropene	601	624, 1624		
48. Diethyl phthalate	606	625, 1625		
49. 2,4-Dimethylphenol	604	625, 1625		
50. Dimethyl phthalate	606	625, 1625		
51. Di-n-butyl phthalate	606	625, 1625		
52. Di-n-octyl phthalate	606	625, 1625		
53. 2,4-Dinitrophenol	604	625, 1625		
54. 2,4-Dinitrotoluene	609	625, 1625		
55. 2,6-Dinitrotoluene	609	625, 1625		
56. Epichlorohydrin				Note 3, p. 130; Note 6, p. S102.
57. Ethylbenzene	602	624, 1624		
58. Fluoranthene	610	625, 1625	610	
59. Fluorene	610	625, 1625	610	
60. Hexachlorobenzene	612	625, 1625		
61. Hexachlorobutadiene	612	625, 1625		
62. Hexachlorocyclopentadiene	612	[6]625, 1625		
63. Hexachloroethane	612	625, 1625		
64. Indeno(1,2,3-cd)pyrene	610	625, 1625	610	
65. Isophorone	609	625, 1625		
66. Methylene chloride	601	624; 1624		Note 3, p. 130;
67. 2-Methyl-4,6-dinitrophenol	604	625, 1625		
68. Naphthalene	610	625, 1625	610	
69. Nitrobenzene	609	625, 1625		
70. 2-Nitrophenol	604	625, 1625		
71. 4-Nitrophenol	604	625, 1625		
72. N-Nitrosodimethylamine	607	625, 1625		
73. N-Nitrosodi-n-propylamine	607	[6]625, 1625		
74. N-Nitrosodiphenylamine	607	[6]625, 1625		
75. 2,2'-Oxybis(1-chloropropane)	611	625, 1625		
76. PCB-1016	608	625		Note 3, p. 43;
77. PCB-1221	608	625		Note 3, p. 43;
78. PCB-1232	608	625		Note 3, p. 43;
79. PCB-1242	608	625		Note 3, p. 43;
80. PCB-1248	608	625		Note 3, p. 43;
81. PCB-1254	608	625		Note 3, p. 43;
82. PCB-1260	608	625		Note 3, p. 43;
83. Pentachlorophenol	604	625, 1625		Note 3, p. 140;
84. Phenanthrene	610	625, 1625	610	
85. Phenol	604	625, 1625		
86. Pyrene	610	625, 1625	610	

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TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS—Continued

Parameter [1]	EPA Method Number [2, 7]			Other
	GC	GC/MS	HPLC	
87. 2,3,7,8-Tetrachlorodibenzo-p-dioxin		[5] 613		
88. 1,1,2,2-Tetrachloroethane	601	624, 1624		Note 3, p. 130;
89. Tetrachloroethene	601	624, 1624		Note 3, p. 130;
90. Toluene	602	624, 1624		
91. 1,2,4-Trichlorobenzene	612	625, 1625		Note 3, p. 130;
92. 1,1,1-Trichloroethane	601	624, 1624		
93. 1,1,2-Trichloroethane	601	624, 1624		Note 3, p. 130;
94. Trichloroethene	601	624, 1624		
95. Trichlorofluoromethane	601	624		
96. 2,4,6-Trichlorophenol	604	625, 1625		
97. Vinyl chloride	601	624, 1624		

Table IC Notes

[1] All parameters are expressed in micrograms per liter (µg/L).

[2] The full text of Methods 601–613, 624, 625, 1624, and 1625, are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this Part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit," of this Part 136.

[3] "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September, 1978.

[4] Method 624 may be extended to screen samples for Acrolein and Acrylonitrile. However, when they are known to be present, the preferred method for these two compounds is Method 603 or Method 1624.

[5] Method 625 may be extended to include benzidine, hexachlorocyclopentadiene, N-nitrosodimethylamine, and N-nitrosodiphenylamine. However, when they are known to be present, Methods 605, 607, and 612, or Method 1625, are preferred methods for these compounds.

[6] 625, Screening only.

[7] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[8] Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 601–613, 624, 625, 1624, and 1625 (See Appendix A of this Part 136) in accordance with procedures each in section 8.2 of each of these Methods. Additionally, each laboratory, on an on-going bases must spike and analyze 10% (5% for Methods 624 and 625 and 100% for methods 1624, and 1625) of all samples to monitor and evaluate laboratory data quality in accordance with sections 8.3 and 8.4 of these Methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect and cannot be reported to demonstrate regulatory compliance.

NOTE: These warning limits are promulgated as an "interim final action with a request for comments."

TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES [1]

Parameter µg/L)	Method	EPA [2, 7]	Standard Methods 18th Ed	ASTM	Other
1. Aldrin	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
2. Ametryn	GC				Note 3, p. 83; Note 6, p. 868.
3. Ammoxsab	TLC				Note 3, p. 84; Note 6, p. 816.
4. Atraton	GC				Note 3, p. 83; Note 6, p. 868.
5. Atrazine	GC				Note 3, p. 83; Note 6, p. 868.
6. Azinphos methyl	GC				Note 3, p. 25; Note 6, p. 851.
7. Barban	TLC				Note 3, p. 104; Note 6, p. 864.
8. α-BHC	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[6] 625			
9. β-BHC	GC	608		D3086	
	GC/MS	625			
10. δ-BHC	GC	608		D3086	
	GC/MS	[6] 625			
11. γ-BHC (Lindane)	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
12. Captan	GC		509A		Note 3, p. 7.
13. Carbaryl	TLC				Note 3, p. 84; Note 6, p. 860.
14. Carbophenothion	GC				Note 4, p. 30; Note 6, p. 873.
15. Chlordane	GC	608	509A	D3086	Note 3, p. 7.
	GC-MS	625			
16. Chloropropham	TLC				Note 3, p. 104; Note 6, p. 864.
17. 2,4-D	GC		509B		Note 3, p. 115; Note 4, p. 30.
18. 4,4'-DDD	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC-MS	625			
19. 4,4'-DDE	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
20. 4,4'-DDT	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
21. Demeton-O	GC				Note 3, p. 25; Note 6, p. 851.
22. Demeton-S	GC				Note 3, p. 25; Note 6, p. 851.
23. Diazinon	GC				Note 3, p. 25; Note 4, p. 30; Note 6, p. 851.
24. Dicamba	GC				Note 3, p. 115.
25. Dichlofenthion	GC				Note 4, p. 30; Note 6, p. 873.
26. Dichloran	GC		509A		Note 3, p. 7.
27. Dicofol	GC			D3086	
28. Dieldrin	GC	608	509A		Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
29. Dimethoate	GC				Note 4, p. 30; Note 6, p. 873.
30. Dinoseb	GC				Note 3, p. [illegible]; Note 6, p. 851.
31. Diuron	TLC				Note 3, p. 104; Note 6, p. 864.
32. Endosulfan I	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	[6] 625			

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TABLE ID—LIST OF APPROVED TEST PROCEDURES FOR PESTICIDES [1]—Continued

Parameter, µg/L	Method	EPA [2,3]	Standard Methods 18th Ed	ASTM	Other
39. Endosulfan II	GC	608	509A	D3086	Note 3, p. 7.
	GC/MS	* 625			
34. Endosulfan sulfate	GC	608			
	GC/MS	625			
35. Endrin	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	* 625			
36. Endrin aldehyde	GC	608			
	GC/MS	625			
37. Ethion	GC				Note 4, p. 30; Note 6, p. 573.
38. Fenuron	TLC				Note 3, p. 104; Note 6, p. 884.
39. Fenuron-TCA	TLC				Note 3, p. 104; Note 6, p. 884.
40. Heptachlor	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30.
	GC/MS	625			
41. Heptachlor epoxide	GC	608	509A	D3086	Note 3, p. 7; Note 4, p. 30; Note 6, p. 573.
	GC/MS	625			
42. Isodrin	GC				Note 4, p. 30; Note 6, p. 573.
43. Linuron	TLC				Note 3, p. 104; Note 6, p. 884.
44. Malathion	GC		509A		Note 3, p. 55; Note 4, p. 30; Note 6, p. 551.
	TLC				Note 3, p. 94; Note 6, p. 880.
45. Methiocarb	GC		509A	D3086	Note 3, p. 7; Note 4, p. 30.
46. Methoxychlor	TLC				Note 3, p. 94; Note 6, p. 880.
47. Mexacarbate	GC		509A		Note 3, p. 7.
48. Mirex	TLC				Note 3, p. 104; Note 6, p. 884.
49. Monuron	TLC				Note 3, p. 104; Note 6, p. 884.
50. Monuron-TCA	TLC				Note 3, p. 104; Note 6, p. 884.
51. Neburon	GC		509A		Note 3, p. 55; Note 4, p. 30.
52. Parathion methyl	GC		509A		Note 3, p. 55.
53. Parathion ethyl	GC		509A		Note 3, p. 7.
54. PCNB	GC			D3086	
55. Perthane	GC				Note 3, p. 55; Note 6, p. 568.
56. Prometon	GC				Note 3, p. 55; Note 6, p. 568.
57. Prometryn	GC				Note 3, p. 55; Note 6, p. 568.
58. Propazine	GC				Note 3, p. 104; Note 6, p. 884.
59. Propham	TLC				Note 3, p. 94; Note 6, p. 880.
60. Propoxur	TLC				Note 3, p. 55; Note 6, p. 568.
61. Siduron	TLC				Note 3, p. 104; Note 6, p. 884.
62. Silvex	TLC				Note 3, p. 55; Note 6, p. 568.
63. Simazine	GC				Note 3, p. 7.
64. Strobane	GC		509A		Note 3, p. 104; Note 6, p. 884.
65. Swep	TLC				Note 3, p. 116; Note 4, p. 35.
66. 2,4,5-T	GC		6640B		Note 3, p. 116.
67. 2,4,5-TP (Silvex)	GC		6640B		Note 3, p. 55; Note 6, p. 568.
68. Tetrachlorvinfos	GC				Note 3, p. 7; Note 4, p. 30.
69. Tetrasul	GC	608	509A	D3086	
	GC/MS	625			
70. Trifluralin	GC		509A		Note 3, p. 7

Table ID Notes

[1] Pesticides are listed in this table by common name for the convenience of the reader. Additional pesticides may be found under Table IC, where entries are listed by chemical name.

[2] The full text of methods 608 and 625 are given at Appendix A, "Test Procedures for Analysis of Organic Pollutants," of this Part 136. The standardized test procedure to be used to determine the method detection limit (MDL) for these test procedures is given at Appendix B, "Definition and Procedure for the Determination of the Method Detection Limit", of this Part 136.

[3] "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September, 1978. This EPA publication includes thin-layer chromatography (TLC) methods.

[4] "Methods for Analysis of Organic Substances in Water," U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 5, Chapter A3 (1972).

[5] This method may be extended to include α-BHC, β-BHC, endosulfan I, endosulfan II, and endrin. However, when they are known to exist, Method 608 is the preferred method.

[6] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency," Supplement to the Fifteenth Edition of *Standard Methods for the Examination of Water and Wastewater* (1981).

[7] Each analyst must make an initial, one-time, demonstration of their ability to generate acceptable precision and accuracy with Methods 608 and 625 (See Appendix A of this Part 136) in accordance with procedures given in section 8.2 of each of these methods. Additionally, each laboratory, on an on-going basis, must spike and analyze 10% of all samples analyzed with Method 608 or 5% of all samples analyzed with Method 625 to monitor and evaluate laboratory data quality in accordance with Sections 8.3 and 8.4 of these methods. When the recovery of any parameter falls outside the warning limits, the analytical results for that parameter in the unspiked sample are suspect and should be reported to demonstrate regulatory compliance.

NOTE: These warning limits are promulgated as an "interim final action with a request for comments."

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TABLE IE—LIST OF APPROVED RADIOLOGICAL TEST PROCEDURES

Parameter and units	Methods	EPA	Reference (method No. or page)		
			Standard methods 16th ed.	ASTM	USGS [1]
1. Alpha-Total, pCi per liter	Proportional or scintillation counter.	900.0	703	D1943-81	pp. 75 and 78. [3]
2. Alpha-Counting error, pCi per liter.	Proportional or scintillation counter.	Appendix B	703	D1943-81	p. 78.
3. Beta-Total, pCi per liter	Proportional counter	900.0	703	D1890-81	pp. 75 and 78. [3]
4. Beta-Counting error, pCi	Proportional counter	Appendix B	703	D1890-81	p. 79.
5. (a) Radium-Total, pCi per liter.	Proportional counter	903.0	705	D3460-70	
(b) ^{226}Ra, pCi per liter	Scintillation counter	903.1	706	D3454-79	p. 81.

TABLE IE NOTES:

[1] "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," EPA-600/4-80-032 (1980 update), U.S. Environmental Protection Agency, August 1980.

[2] Fishman, M.J. and Brown, Eugene, "Selected Methods of the U.S. Geological Survey of Analyses of Wastewaters," U.S. Geological Survey, Open-File Report 76-177 (1976).

[3] The method found on p. 75 measures only the dissolved portion while the method on p. 78 measures only the suspended portion. Therefore, the two results must be added to obtain the "total."

R0013530

TECHNICAL APPENDIX D

REFERENCES

REFERENCES

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Federal Register, Vol. 55, No. 222, p. 48065, November 16, 1990.

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Ogden Environmental and Energy Services, "Storm Water Sampling Protocol Manual, Procedures and Protocols for Facility Data Collection and Storm Water Sampling," February 1992.

U.S. EPA, 40 CFR Parts 122, 123, and 124; National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges; Final Rule, November 16, 1990.

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U.S. EPA, "Methodology for the Study of Urban Storm Generated Pollution and Control," EPA-600/2-76-145, NTIS No. PB258743, August 1976.

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U.S. EPA, "Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Fresh Water and Marine Organisms," EPA/600/4-90-027, September 1991.

U.S. EPA, "NPDES Compliance Inspection Manual," May 1988.

U.S. EPA, "NPDES Compliance Monitoring Inspector Training: Sampling," August 1990.

U.S. EPA, Region V, "Urban Targeting and BMP Selection," November 1990.

Woodward-Clyde Consultants and Ted Friel Associates, "Guide for Industrial Storm Water Sampling," January 1992.

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TECHNICAL APPENDIX E

GLOSSARY

GLOSSARY

Aliquot: A discrete sample used for analysis.

Biochemical Oxygen Demand (BOD): The quantity of oxygen consumed during the biochemical oxidation of matter over a specified period of time, usually 5 days (BOD_5).

Chain-of-Custody: Procedures used to minimize the possibility of tampering with samples.

Chemical Oxygen Demand (COD): Measurement of all the oxidizable matter found in a runoff sample, a portion of which could deplete dissolved oxygen in receiving waters.

Composite Sample: Used to determine "average" loadings or concentrations of pollutants, such samples are collected at regular time intervals, and pooled into one large sample, can be developed on time or flow rate.

Confined Space: Enclosed space that an employee can bodily enter and perform assigned work, that has limited means of exit and entry, that is not designed for continuous employee occupancy, and has one of the following characteristics:

- Contains or has a known potential to contain a hazardous atmosphere
- Contains a material with the potential for engulfment of an entrant
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or a floor that slopes downward and tapers to a smaller cross section
- Contains any other recognized serious safety or health hazard.

Conveyance: A channel or passage which conducts or carries water including any pipe, ditch, channel, tunnel, conduit, well, or container.

Detention Ponds: A surface water impoundment constructed to hold and manage storm water runoff.

Discharge: Any addition of any pollutant to waters of the U.S. from any conveyance.

Effluent: Any discharge flowing from a conveyance.

Flumes: A specially shaped open channel flow section providing a change in the channel area and/or slope which results in an increased velocity and change in the level of the liquid flowing through the flume. A flume normally consists of three sections: (1) a converging section; (2) a throat section; and (3) a diverging section. The flow rate through the flume is a function of the liquid level at some point in the flume.

Flow-Weighted Composite Sample: Means a composite sample consisting of a mixture of aliquots collected at a constant time interval, where the volume of each aliquot is proportional to the flow rate of the discharge.

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Flow-Proportional Composite Sample: Combines discrete aliquots of a sample collected over time, based on the flow of the wastestream being sampled. There are two methods used to collect this type of sample. One collects a constant sample volume at time intervals which vary based on stream flow. The other collects aliquots at varying volumes based on stream flow, at constant time intervals.

First Flush: Individual sample taken during the first 30 minutes of a storm event. The pollutants in this sample can often be used as a screen for non-storm water discharges since such pollutants are flushed out of the system during the initial portion of the discharge.

Grab Sample: A discrete sample which is taken from a wastestream on a one-time basis with no regard to flow or time; instantaneous sample that is analyzed separately.

Head of Liquid: Depth of flow

Illicit Discharge: Any discharge to a municipal separate storm sewer that is not composed entirely of storm water except discharges pursuant to an NPDES permit and discharges from fire fighting activities.

Materials Management Practices: Practices used to limit the contact between significant materials and precipitation. These may include structural or nonstructural controls such as dikes, berms, sedimentation ponds, vegetation strips, spill response plans, etc.

Municipal Separate Storm Sewer Systems: A conveyance or system of conveyances including roads with drainage systems, storm drains, gutters, ditches under the jurisdiction of a city, town, borough, county, parish, or other public body.

Outfall: Point source where an effluent is discharged into receiving waters.

Point Source: Any discernible, confined, and discrete conveyance from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff (see 40 CFR 122.3).

Reverse Meniscus: The curved upper surface of a liquid in a container.

Runoff Coefficient: Means the fraction of total rainfall that will appear at the conveyance as runoff.

Significant Materials: Include, but are not limited to, raw materials, fuels, solvents, detergents, metallic products, CERCLA hazardous substances, fertilizers, pesticides, and wastes such as ashes, slag, and sludge that have potential for release with storm water discharges [see 40 CFR 122.26(b)(12)].

Storm Water: Storm water runoff, snow melt runoff, and surface runoff, and drainage.

Storm Water Discharge Associated with Industrial Activity: Discharge from any conveyance which is used for collecting and conveying storm water which is directly related to manufacturing processing or raw materials storage areas at an industrial plant [see 40 CFR 122.26(b)(14)].

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Time Composite Sample: Prepared by collecting fixed volume aliquots at specified time intervals and combining into a single sample for analysis.

Turbidity: Describes the capability of light to pass through water.

Weir: A device used to gauge the flow rate of liquid through a channel; is essentially a dam built across an open channel over which the liquid flows, usually through some type of notch.

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TECHNICAL APPENDIX F

ACRONYMS

ACRONYMS

BOD_5	Biochemical Oxygen Demand (5-day)
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
cfs	cubic feet per second
COD	Chemical Oxygen Demand
COV	Coefficient of Variation
CPR	Cardiopulmonary Resuscitation
CWA	Clean Water Act
DOT	Department of Transportation
ECD	Electron Capture Detector
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
ESE	Environmental Science & Engineering, Inc.
FWPCA	Federal Water Pollution Control Act
FID	Flame Ionization Detector
FR	Federal Register
GC/MS	Gas Chromatography/Mass Spectometry
gpm	gallons per minute
H	Head
HCl	Hydrochloric Acid
HNO_3	Nitric Acid
HPLC	High Pressure Liquid Chromatography
H_2SO_4	Sulfuric Acid
IATA	International Air Transport Association
LC_{50}	Lethal Concentration
NaOH	Sodium Hydroxide
$Na_2S_2O_3$	Sodium Thiosulfate
NCDC	National Climate Data Center
NIOSH	National Institute of Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Agency
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NWS	National Weather Service
O&G	Oil and Grease
OSHA	Occupational Safety and Health Administration
PCB	Polychlorinated Biphenyl
PE	Professional Engineer
ppb	parts per billion
Q	Flow Rate
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SIC	Standard Industrial Classification
s.u.	standard units
TKN	Total Kjeldahl Nitrogen
TSS	Total Suspended Solids
VOC	Volatile Organic Compound

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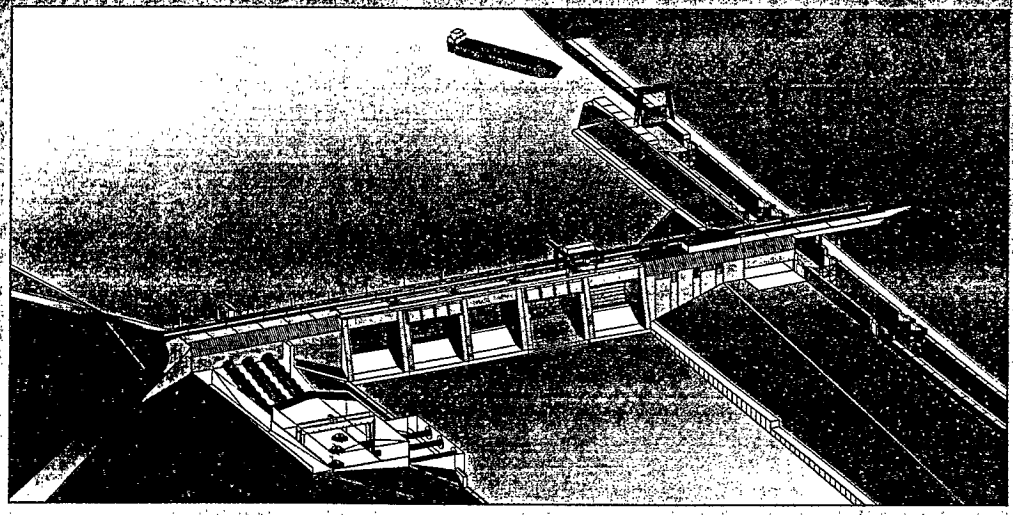

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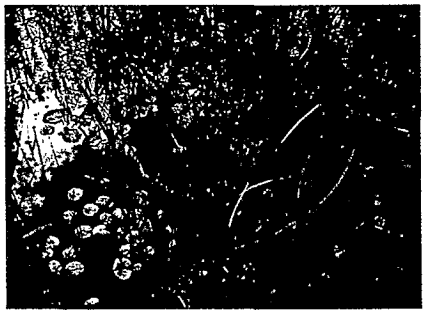

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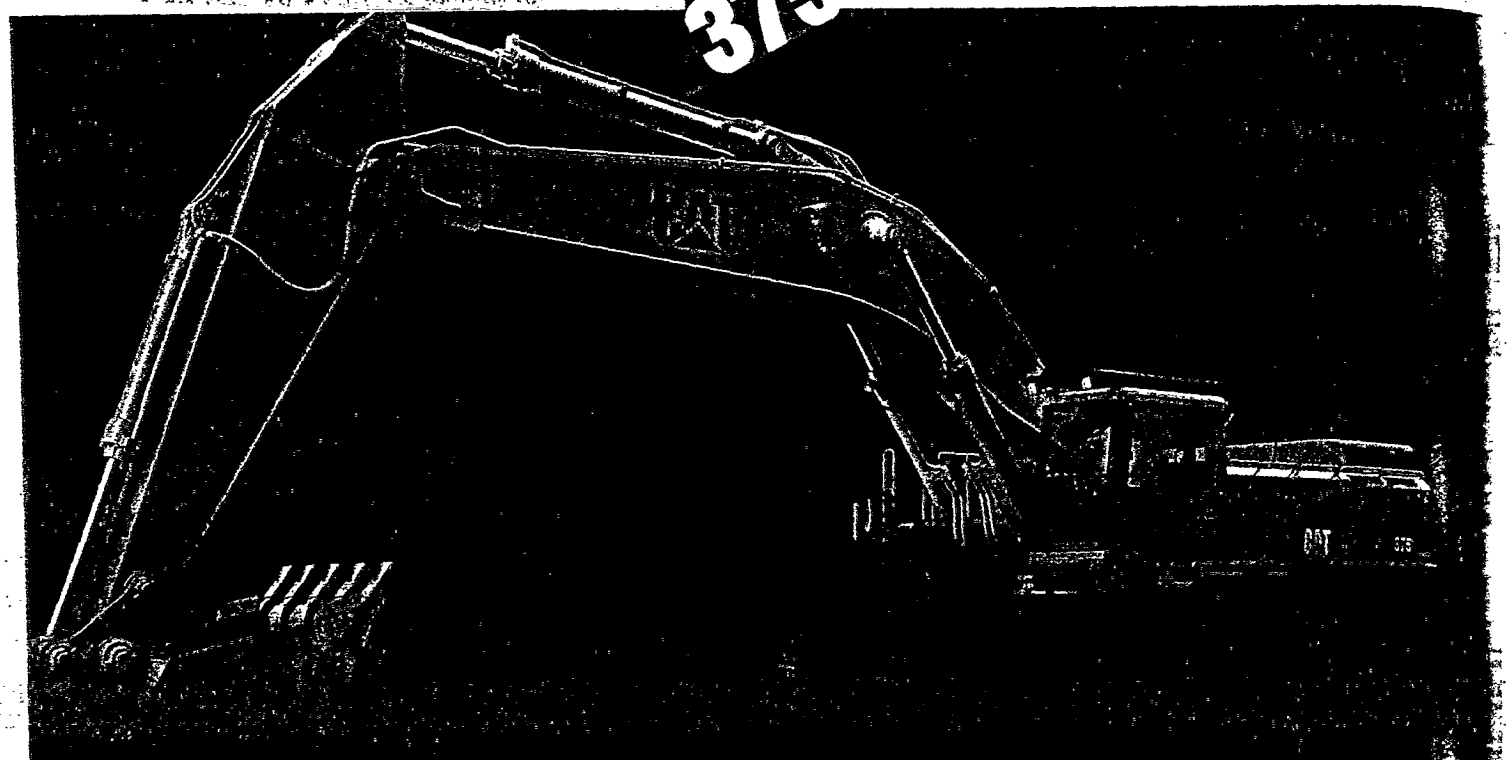

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Dutch firm courts Geraghty & Miller

Geraghty & Miller Inc., the Plainview, N.Y., environmental consultant, announced Sept. 10 that it is "negotiating a possible business combination" with Heidemij Holding NV, and could become the Dutch engineering firm's subsidiary. G&M Chief Financial Officer John McCusker declined to elaborate on the strategy behind the combination, nor confirm where the two firms are in their talks. Arnhem-based Heidemij and G&M already have a joint venture company now running an innovative soil-washing technology at a New Jersey Superfund site (ENR 7/19 p. 27). One analyst says this would be the first "cross-border transaction" involving environmental firms in several years, slowed by a dragging European economy. And another source says a stock swap could give G&M more access to global cleanup markets and financial capital.

U.S. opens only one new road to Vietnam

President Clinton disappointed businesses that want to work in Vietnam by lifting the trade embargo against that country only slightly. Clinton decided to permit U.S. firms to take part in "development projects" in Vietnam that are financed by international lending institutions. The White House acknowledged "recent steps taken by the Vietnamese government" on U.S. prisoners of war and those missing in action. But the U.S. didn't end the embargo "to make clear to the Vietnamese that more needs to be done."

ChemWaste kills incinerator plans

Chemical Waste Management Inc., has canceled plans to build a 50-million-Btu-per-hour hazardous waste incinerator at its Kettleman Hills, Calif., landfill. The the decision is a result of a 30% drop in the volume of incinerable hazardous wastes in California, which continues to decline about 10% a year. The plant had been on hold since 1991 because of legal challenges to its environmental impact review. The company declined to reveal the plant's dollar value and capacity.

Sweden to build seventh longest span

The Swedish National Road Administration is evaluating 20 bids for three contracts to build the country's biggest suspension bridge, with the seventh longest span in the world. Bids for the substructure and towers, steel superstructure and cables are below the project's $140-million budget, says a project source. The Høga Kusten Bridge will cross the Ångerman River near the Town of Härnösand. The bridge will be 5,905 ft long and include a 3,937-ft main span. The bridge is designed by Stockholm-based Kjessler Mannerstrale AB, with COWIconsult AS, Virum, Denmark.

Taiwan offers big power market

In a major liberalization of its power sector, Taiwan is inviting the private sector to build about half the powerplants it needs over the next 10 years. In addition, the government is encouraging industries to invest in cogeneration projects. The state-owned Taiwan Power Co. forecasts that installed capacity must increase by about 12,000 Mw to at least 31,000 Mw by 2002 to meet soaring demand. That total will include at least one new nuclear generating unit of no less than 2,000 Mw. Most of the new capacity will be in fossil-fuel plants, but some 2,000 Mw is to be hydropower. Total development cost is estimated at $22 billion.

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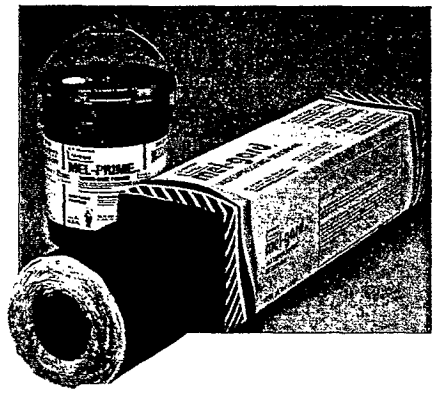



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Weigh options to levees

As Midwesterners plan to rebuild flood-damaged levees, the Clinton administration wants them to consider other options besides reconstruction. In an Aug. 23 memo to federal agencies, T.J. Glauthier, an associate director of the Office of Management and Budget, and Katie McGinty, director of the White House Office of Environmental Policy, state that as officials weigh applications for repairing levees, they "shall consider, to the extent practical, nonstructural alternatives and design modifications that could provide greater local benefits of flood control, reduction of future flood damages...lower long-term cost to the federal government and natural resource protection." But they don't want to "force alternatives...on unwilling participants."

Longer-range, Laurence W. Zensinger, Federal Emergency Management Agency public assistance division chief, told an American Consulting Engineers Council meeting Sept. 10 that the administration is looking at the possibility of setting up a commission or an interagency group to look at river system management.

GAO finds some Superfund gains, but there's still a long way to go

The Superfund program has cleaned up lots of waste at the sites where work has been completed, but there's plenty of work yet to do, according to a study from the General Accounting Office. Senate Superfund subcommittee Chairman Frank R. Lautenberg (D-N.J.) says the "good news" in the GAO report is that "the Superfund program has been successful in ending the health threats at many sites across the country" on the National Priorities List (NPL). But, he adds, "The bad news is that there are more than 1,000 other NPL sites that still need to be cleaned up. And many of these [are] the most expensive and difficult sites." GAO states that as of Sept. 30, 1992, the Environmental Protection Agency had deleted 40 of the 1,275 NPL sites and completed construction at another 109.

At a Sept. 9 hearing of his panel, Lautenberg said he plans to introduce a comprehensive new Superfund bill "later in this Congress." Lautenberg previewed some of the questions he wants to address, such as whether partial cleanups at sites should be acceptable. He suggests that permanent cleanups "may be too expensive." Another subcommittee member, Sen. David Durenberger (R-Minn.), says it may not be technically possible to achieve required cleanup levels, particularly when there is groundwater contamination.

Federal public works spending down as percentage from 1970s

In percentage terms, the federal government is spending less on infrastructure than it did 20 years ago, according to a new report from the Congressional Budget Office. The study, released Sept. 9, estimates 1993 federal infrastructure capital spending at $30.3 billion, up from $27.7 billion the year before. The 1993 capital spending total equals 0.5% of gross domestic product, compared with 0.48% in 1992. The recent high was 0.83% in 1980. The 1970s average was 0.7%.

"What is most disturbing is that within the last year, almost nothing has changed," says House Public Works and Transportation Committee Chairman Norman Y. Mineta (D-Calif.), who requested the study. "This nation has to do better than we did in 1992," he declares, "when as a percentage of gross domestic product there was virtually no increase in federal infrastructure spending. When you have Japan spending $3 trillion to improve its infrastructure over 10 years, and Germany spending nearly $2 trillion, we have to do more than merely run in place."

Senate panel cuts wastewater aid

The Senate Appropriations Committee voted to slash fiscal year 1994 wastewater treatment spending and reduce Superfund spending 5%. In approving appropriations for the Environmental Protection Agency, Dept. of Veterans Affairs and other agencies on Sept. 9, the panel recommended $2.5 billion for "water infrastructure." That includes $599 million for the new drinking water state revolving fund the Clinton administration has proposed (see p. 19), assuming Congress authorizes the program. Also included in the water infrastructure area was $1.7 billion for wastewater treatment aid, with $500 million of that available for grants to "cities with special needs," including those with high sewer rates and Mexican border projects. This year, EPA has $1.9 billion for wastewater revolving funds.

For Superfund, the committee approved slightly less than $1.5 billion for fiscal 1994, 5% below this year's level, but 6% higher than the House recommended.

The panel also trimmed VA major construction spending by 25%, to a total of $369 million, but that mark is 14% more than in the House-passed version. In addition, the Senate committee continued spending for the space station, providing $1.9 billion. That's $176.5 million less than 1993 and $154 million less than in the House version.

By Tom Ichniowski

R0013547

SAFETY

Fall protection rules up in the air

While the Occupational Safety and Health Administration drags out rulemaking on fall protection for steel erection, some regional OSHA officials are going their own way in enforcing standards and are doing so aggressively, say many contractors. Confusion and inconsistency are growing, they claim.

OSHA officials in Denver started the trend last year, prompted by fatalities during construction of the the Denver International Airport and a rash of fall-related fatalities in homebuilding. Some of the regional offices are refusing to exempt any jobsite duties and are using a 6 ft, 8 ft or 10 ft standard for requiring fall protection, depending on the region and type of work. The current OSHA standard calls for employers to provide protection above 25 ft for exterior work and 30 ft for interior work.

Region II Administrator James W. Stanley says the New York-New Jersey office enforces a tougher standard "when there is a recognizable hazard." The situation is acute in OSHA's Region V, which covers Illinois, Ohio, Wisconsin, Michigan, Indiana and Minnesota, although the first three, as federal plan states, are the most active. Ohio area OSHA officials changed their fall protection policy earlier this year. This summer, Illinois regional officials followed suit, setting as their ultimate goal "100% fall protection."

Some regional OSHA officials believe the current OSHA standard is too lenient and are getting around it by having their compliance officers use OSHA's "general duty" clause to enforce their new policies. OSHA officials justify this decision with a recent internal study of 3,496 deaths over five years, which found that 60% of the deaths by falls were from heights of less than 30 ft. "OSHA believes and recommends that 100% fall protection is feasible and preferable," says the Region V policy.



Steel erection is being hit hard by inconsistent OSHA enforcement.

OSHA considers the new policies to be a local emphasis program. As a result, inspections are not bound by normal scheduling criteria and can occur at any time.

Regional officials have held numerous meetings with local contractors and union representatives. They feel that they have gotten the message out and have started issuing citations. However, the first step usually is a notification letter with abatement information.

The contracting community feels that the situation still is "very confusing," says Thomas A. Broderick, executive director of the Chicagoland Construction Safety Council, a labor-management group. With only a one-page policy to go by, "it's just real squishy," he claims.

Broderick says contractors are particularly upset because it is difficult for them to go back to owners and ask for the additional cost of the extra fall protection. They also are having trouble finding fall-protection technology that can be adapted for the different stages of construction that now are covered.

Contractors working in multiple OSHA regions say the agency's inconsistent policies and applications are giving them headaches. Inconsistency "is one of the main issues confronting our industry," says Noel Borck, executive vice president of the National Erectors Association. The biggest impact has been in steel erection, particularly when ironworkers making connections need to move from point to point, he explains.

OSHA officials say they recognize the difficulty of adapting to multiple policies. They plan to address the inconsistencies once they receive recommendations from their construction advisory committee on September 30. The issue has united labor and management in many cases. They want a better national fall protection standard promulgated through negotiated rulemaking.

"We're beginning to see signs that

R0013548

OSHA is willing to reach workable solutions," says Jim Patterson, vice president of Talbert Corp., Denver, and a member of Associated General Contractors' safety and health committee. While he doesn't agree with the inconsistent policies, he notes that the agency is working with individual contractors to address their situations.

Still, many industry safety experts say they will fight until OSHA takes a more formal rulemaking approach with documentation and comes up with one clear standard to follow. ▣

By Hazel Bradford

HEALTH INSURANCE

One Clinton proposal would dent designers

Details of the Clinton administration's plans for overhauling the nation's health care system are leaking out and one analysis shows design firms taking a big hit in new costs.

According to a review by *Professional Services Management Journal,* the administration's proposal will cause average overhead for an architectural-engineering firm to rise "a little over 4%," says PSMJ Research Director William J. Fanning in Atlanta. The 500,000 persons employed nationwide by such firms would pay up to $450 million more annually in health insurance premiums, he claims. The estimates are based on a draft of the Clinton plan circulated in recent weeks, says Fanning. The review is being studied by the American Consulting Engineers Council.

The Clinton proposal would calculate employers' premiums as a percentage of payroll, rather than the current flat rate charge per employee under private insurance, says Fanning. It proposes a premium of 7.9% of annual pay. Employees would be enrolled in large insurance pools administered by states.

A-E firms currently pay an average of $2,200 annually per employee for health insurance, says Fanning. Based on the national average annual A-E salary of $39,000, the average premium would increase to about $3,100. Insurance for employees earning $75,000 per year would cost $5,925.

"The [Clinton] philosophy is those who make more will pay more for health coverage," says Fanning. "If A-E firms have to absorb that cost, 60% of their pre-tax profits will evaporate," he claims. Passing costs through in a soft market will be a tough proposition, he claims. ▣

INTERNATIONAL WORK

Mideast peace dividend?



Israel's Rabin (left), and PLO's Arafat shake on peace agreement that could boost construction.

The historic peace accord between Israel and the Palestine Liberation Organization signed in Washington, D.C., last week will likely stimulate unprecedented construction in the West Bank and Gaza Strip. The extent and timing of building will depend on funding levels for aid to the authority that implements Palestinian self-rule. Palestinian experts foresee abundant near-term foreign involvement in West Bank and Gaza Strip projects.

Officials say that the largest project under consideration is the deepening of an existing small Mediterranean port in Gaza to handle large vessels. The French government says it would help fund the job. "The cost of such a project would run up to $500 million and take several years," says Simcha Bahiri, a leading Israeli construction industry consultant who has studied building in the occupied territories.

Housing is another area with big investment potential. Hundreds of millions of dollars are expected to go into housing for refugees. Samir Houlele, a leading Palestinian economist, estimates that at least 20,000 units annually are needed in the Gaza Strip and the West Bank for the next five years.

In addition, large infrastructure investments are planned. A World Bank proposal seeks $1.35 billion in investments over the next five years for water and sewer works, transportation and powerplants. Israeli and Palestinian officials stress that the pace of construction will largely be dictated by the level of outside assistance.

The World Bank will play an important role, predicts Nicholas H. Ludlow, managing director of Washington, D.C.-based Development Bank Associates. The lending agency looks at the Middle East-North Africa area as a whole, ranking it as an aid candidate just behind eastern Europe and the former Soviet states, Southeast Asia and southern Africa. Projects stretching from Egypt to Syria worth some $5 billion are in the bank's planning pipeline, says Ludlow. Commitments are likely to increase in the next few years, he predicts, "provided peace can be sustained."

The European Community so far has committed some $600 million for the next five years, with Nordic countries chipping in about $120 million. The U.S., Japan, the wealthy Gulf states and organizations like the World Bank are also expected to provide capital. ▣

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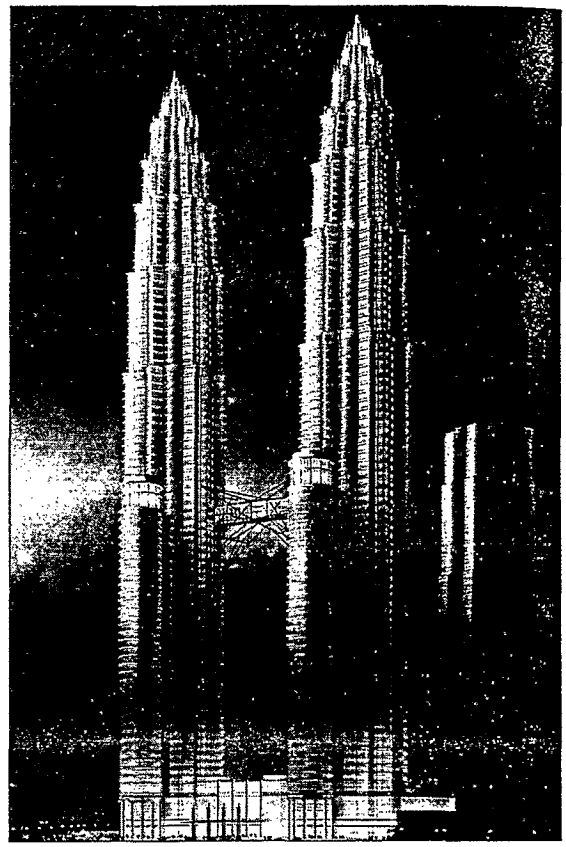
BUILDINGS

Aspiring to new heights

If completed in 1996 as now planned, the twin PETRONAS Towers in Kuala Lumpur would, at 1,476 ft, beat the Sears Tower height record by 22 ft. But the recent decision to increase their height seems almost an afterthought, considering that Kuala Lumpur City Centre already stands out as the most ambitious commercial development under way in the world.



Towers, at 1,476 ft, would exceed height of Sears Tower.

Foundations are 50% complete for the first phase of work, to encompass more than 10 million sq ft (ENR 1/25 p. 56). KLCC overall is proposed as a 17-million-sq-ft-plus project on a 97-acre site in the Malaysian city's commercial district.

Described by its local developer Kuala Lumpur City Centre Berhad (KLCCB) as a city-within-a-city, the first phase, called Northwest Development, will alone accommodate more than 50,000 people daily. To help strengthen or create the required city infrastructure, KLCC is working on a comprehensive area-road improvement program. KLCC traffic consultants, including the Singapore office of Wilbur Smith Associates and the local Dewan Bandaraya Kuala Lumpur, are recommending road widenings, underpasses and intersection upgrades. A KLCC people mover will help as will proximity to a city light-rail system, proposed but not yet built.

Relocation. Northwest Development, designed by Cesar Pelli & Associates, New Haven, Conn., with KLCCB's architectural division, Toronto-based Adamson Associates and a long list of other consultants, is challenging from bottom to top. For example, the current location of the metal and glass-clad towers is 150 ft from the original one planned. The move was made during design after subsurface investigation revealed that within the tower footprints, bedrock elevation varied from the level of the lowest basement to more than 600 ft below grade, raising the potential for major differential settlement, says the owner.

KLCCB is a wholly owned subsidiary of KLCC (Holdings) Sdn. Bhd., which is 51% owned by the national petroleum company, PETRONAS, and 49% owned by MAI Holdings, Pacific States Investment Ltd. and the Selangor Turf Club. PETRONAS will be the main tenant of the towers.

In addition to the twin towers, Northwest Development includes two office buildings, a 50-acre public park, a 630-room hotel and a 1.5-million-sq-ft shopping and entertainment center. There will be parking for 7,000 cars.

According to the owner, which is handling all press inquiries, DBF, a consortium led by Dragages Et Travaux Publics, a construction subsidiary of the Paris-based Bouygues Group, is excavating 14 acres for a five-level, below-grade foundation structure to support a six-level podium and the towers. The foundation contract alone is valued at about

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$55 million. Lehrer McGovern Malaysia leads KLCCB's project management team.

As designed by structural engineer Thornton Tomasetti/Engineers, New York City, with the local firm Ran Hill Bersekutu Sdn. Bhd., both nearly 2-million-sq-ft supertall towers will be framed by a roughly 152-ft-dia concrete perimeter tube connected by floor diaphragms consisting of composite metal deck on 18-in.-deep rolled steel beams to a 74.8 x 75.4-ft, high-strength, reinforced concrete core. Four reinforced concrete outrigger Vierendeel trusses in a 38th floor double-height mechanical room link the core corners to the perimeter tube. A two-level bridge connects the towers at the 40th floor.

Beyond the tube. Each tower, with 88 occupied floors and several setbacks, extends beyond the main structural tube. In plan, there is basically a series of eight circle segments that alternate with eight triangles encircling the perimeter tube. Each segment or triangular section is supported by steel trusses that cantilever from the perimeter tube. Each tower top is a pinnacle.

Tower foundations consist of a raft and 4 x 9-ft rectangular friction piles, called barrette piles, that range in length from 130 to 340 ft. The piles do not reach bedrock.

The goal is to wrap up foundation work by the beginning of January. Construction of the tower frames will follow. Cladding should be complete by the end of 1995 or early in January 1996. First occupancy is set for the following August or September.

Though total project costs are not available, core and shell construction in the region is about $100 per sq ft, according to knowledgeable sources.

By Nadine M. Post

CLEAN AIR

Emission credit trades hot

The Clinton administration is boosting its support of market-based approaches to meet Clean Air Act requirements, U.S. Environmental Protection Agency officials said earlier this month at an industry conference in Washington, D.C. But local authorities are already doing fine in pushing their own programs.

EPA is proposing a rule that would allow companies other than utilities to trade sulfur dioxide emission allowances, agency Administrator Carol M. Browner told attendees of the Clean Air Act Marketplace conference. That approach now allows 110 utilities to trade credits gained from reducing SO_2 emissions below the required 10 million tons per year, beginning in 1995. The so-called "opt-in" rule, set for publication soon in the *Federal Register*, will "create new market opportunities for companies in a variety of industries, not just utilities," said Browner.

Robert Brenner, acting deputy assistant administrator of EPA's office of air and radiation, conceded that such public/private ventures have been hindered by existing regulatory barriers and scrutiny by agency inspectors general and the Office of Management and Budget.

"I think we're going to do a lot better," said Brenner. He also admitted that EPA funding for trading efforts remains a problem, "but we're hoping there will be a snowballing effect as people see the benefit" of such programs.

Interest is already growing. On Sept. 9, southern California's South Coast Air Quality Management District (AQMD) heard testimony on its new Regional Clean Air Incentives Market proposal. It would set emission levels for SO_2 and oxides of nitrogen for about 400 large facilities, beginning in 1994. These would be lowered each succeeding year through 2003. Emitters that exceed their annual reduction targets could sell credits on the open market. However, facilities could not "bank" credits for future years, and would face penalties for not meeting emission reduction levels.

The program has already garnered support from some of southern California's largest industrial firms, according to AQMD. But others voiced opposition at the hearing, citing severe economic impacts. AQMD is set to vote on the proposal on Oct. 15, although an agency spokesman says that could be delayed if the final proposal needs extensive changes based on testimony.

Meanwhile, a similar regional trading effort is being considered by the Northeast States for Coordinated Air Use Management, said Michael Bradley, executive director. He added that Massachusetts is about to launch its own trading program, which he termed "the most innovative."

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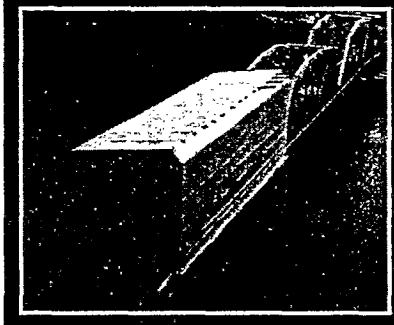

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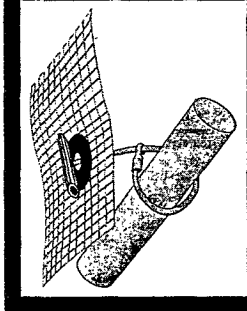

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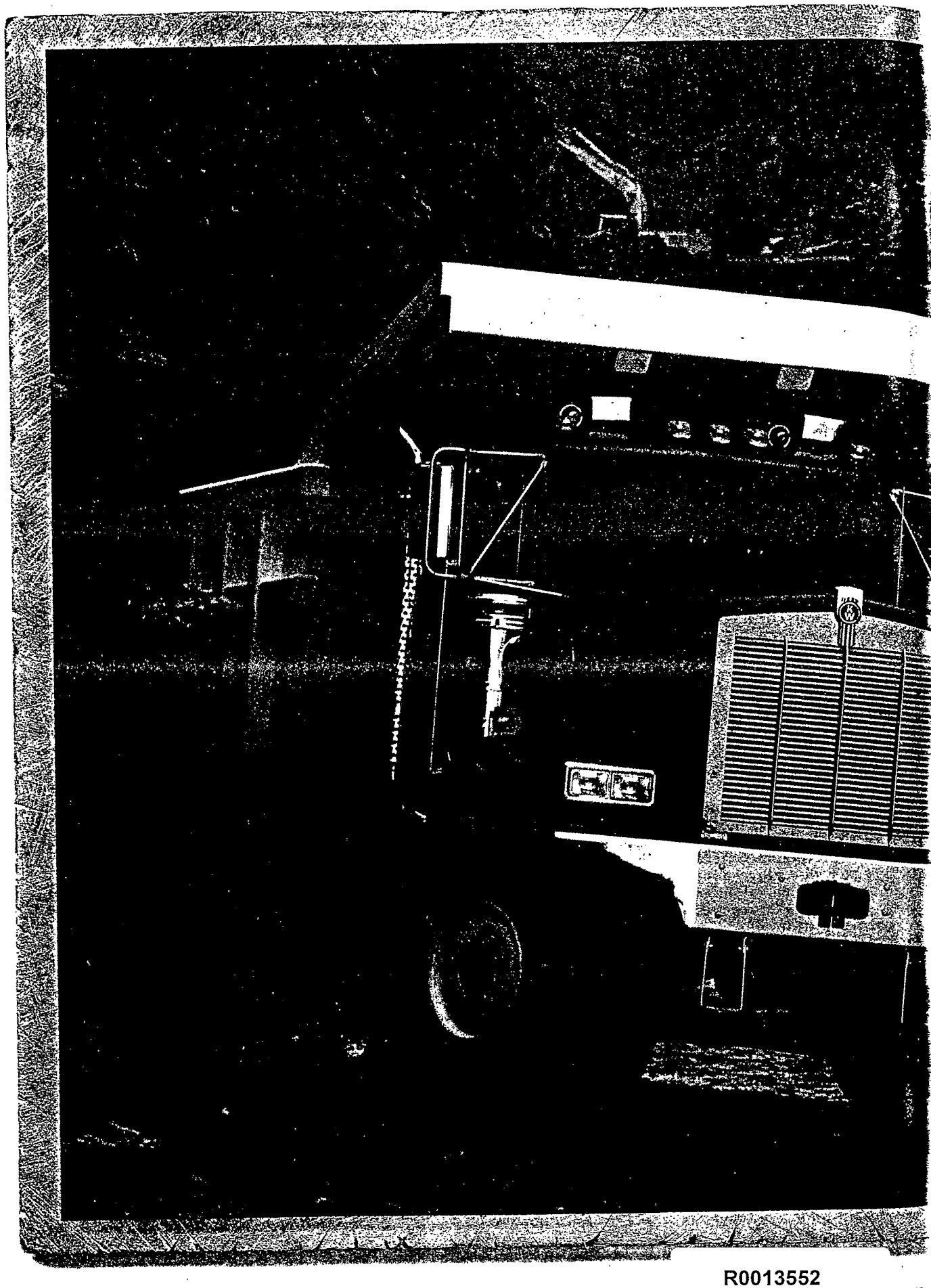

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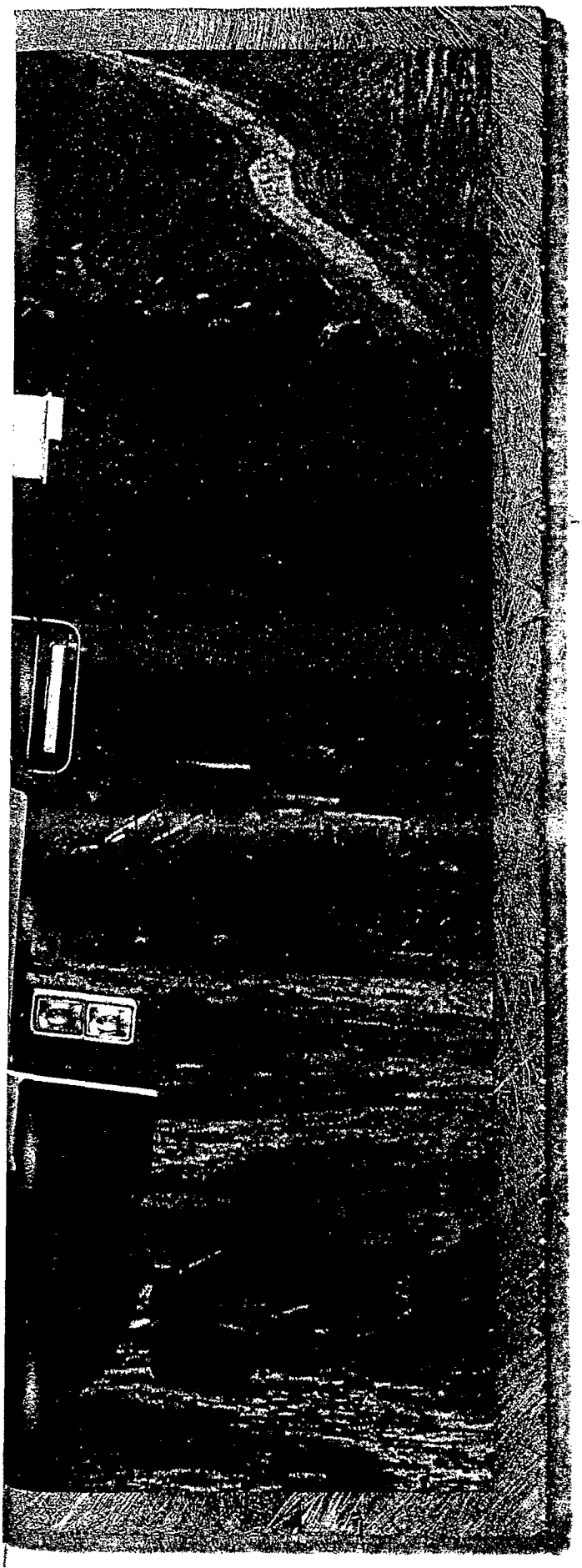

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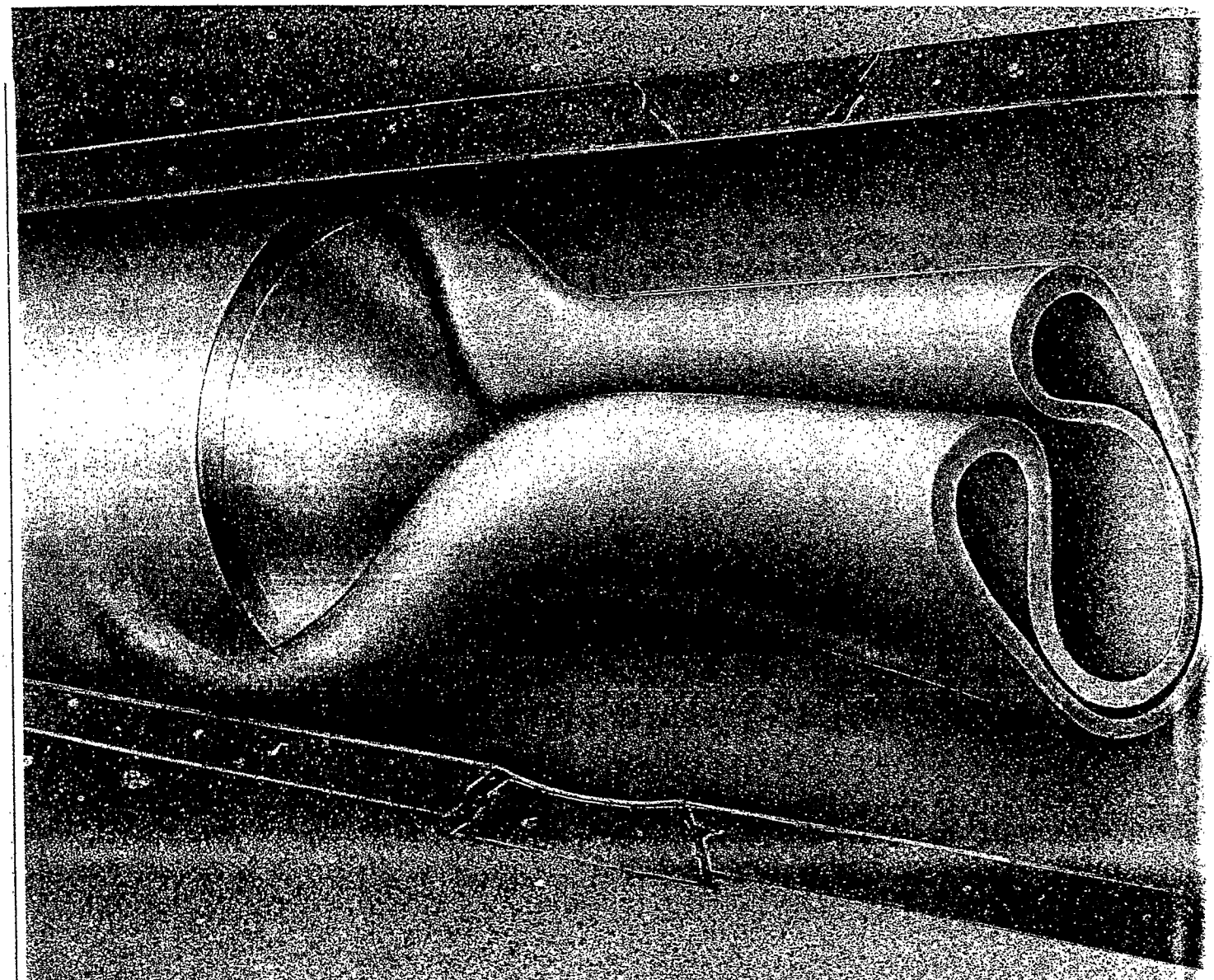

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WASTEWATER

Florida county agrees to replace sewer pipe

Florida's Dade County and the Miami-Dade Water and Sewer Authority have agreed to replace a 5.3-mile-long, 72-in.-dia sewer force main beneath Biscayne Bay, under a consent decree filed Sept. 9 in U.S. District Court in Miami.

The agreement settles one of five claims against the entities, all brought in June by the U.S. Environmental Protection Agency for violations of the federal Clean Water Act. EPA says the action is the first use of the act's Section 504 provisions as a response to "imminent and substantial endangerment."

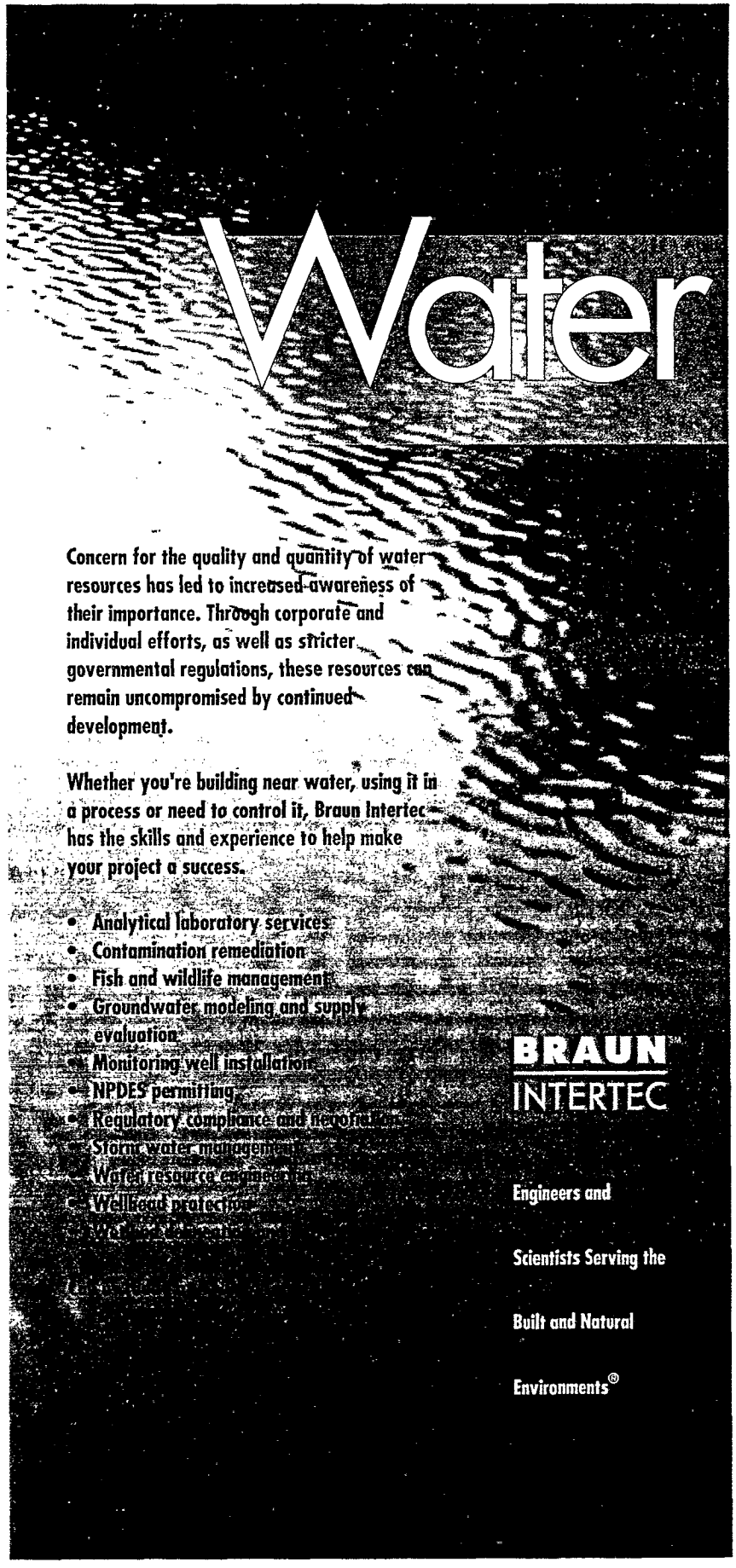
Officials in EPA's Atlanta-based region say they are concerned about the integrity of the existing concrete pipe, built in 1956. They say a Miami area land-based line of similar construction and age ruptured from corrosion in 1989. "We wanted to get this replacement under a construction schedule before we have raw sewage in the bay," says David Olson, chief of the regional office's data management unit.

The existing pipeline is in bay sediment and carries about 100 million gal per day of wastewater from Miami, Coral Gables, South Miami and Miami Springs to the county wastewater treatment plant on Virginia Key. The bay is a national sanctuary.

Construction of a new 102-in.-dia pipe is set to begin by the end of the month and has a scheduled November 1994 completion date. Six construction awards to five firms were made earlier this month for the project, estimated to cost about $60 million. The new pipe will be of reinforced concrete with an impervious plastic lining, says Robert A. Cuevas, the utility's chief engineer. Pipelaying will also involve special precautions because of delicate seagrasses.

The consent decree also requires the county to suspend new sewer hookups in areas where adequate treatment capacity cannot be provided. An authority spokeswoman says those restrictions are county wide. "We have not suspended permits, but they are being delayed until the capacity is available," she says. Officials say the new pipeline and improvements to two treatment plants will provide the needed capacity.

An emergency contingency plan is due by early October and a second consent decree resolving illegal discharges and overflows is under negotiation, say EPA officials. ▣



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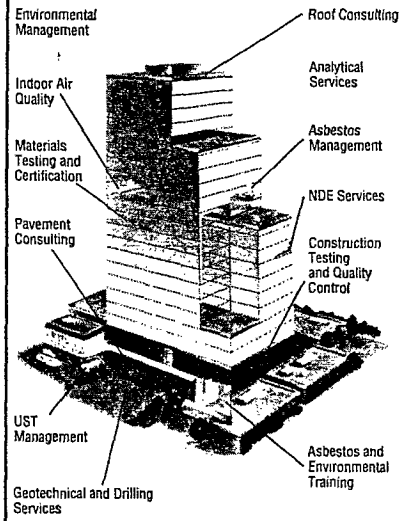

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BONDING

Jury awards hefty sum over surety dispute

A state court jury in Contra Costa County, Calif., has ordered a surety to pay $116.5 million to a general contractor because the jurors believed the surety breached its contract and "interfered" with the contractor's business by refusing to continue to provide bonds. The surety cut off the firm's bonding after disagreeing with it over who was at fault on a troubled project.

The jury ordered St. Paul Fire & Marine Insurance Co., St. Paul, Minn., to pay $100 million in punitive damages and $16.5 million in compensatory damages to Arntz Contracting Co., a general building contractor in Novato, Calif. The jury supported the claim that St. Paul prevented the company from bidding and winning projects during the 1980s. "We asked the jury to send a message to the boardrooms throughout the country that surety companies cannot act with impunity," says R.W. Miller, a Kansas City, Mo.-based attorney who represented Arntz.

Appeal. St. Paul Fire and Marine pledges to "vigorously appeal" the decision. "The verdict is not supported by the evidence" and "the award is grossly excessive," says a company spokesman.

Dennis Wine, vice president of the Surety Association of America, Iselin, N.J., says the surety industry is facing a growing problem of lawsuits based on claims of broken promises for future projects. "I can conceive of sureties trying to cope [by including] something stronger in applications for bonds or in indemnification agreements that would make it abundantly clear to contractors that we are not making a lifetime agreement to bond you."

The dispute began in 1982, when St. Paul provided bid, payment and performance bonds to Arntz for construction of a $4.7-million housing project in Richmond, Calif. In 1984, with most of the project completed, the Richmond Housing Authority terminated Arntz for refusing to redo the buildings' stucco walls. St. Paul informed Arntz that it was stepping in to complete the project, but Arntz claimed it was not at fault in the matter.

In December 1984, Arntz agreed to provide St. Paul with an additional $1.2 million in collateral that Arntz claimed would entitle it to future bonds. But about 8 months later, St. Paul refused to provide any more bonds, Arntz claimed. ▣

R0013556

ACCIDENTS

Scotland investigates recent fatal 'implosion'

Investigations are under way into the death of a spectator at the demolition of two large concrete buildings in Glasgow, Scotland, on Sept. 12. Flying debris from what was called Europe's largest building implosion escaped into the spectator exclusion zone, causing the fatality and some injuries.

The demolition contractor initially suspects that the buildings' great size and structural form helped eject debris more than 394 ft from the explosions. "The buildings are so heavy that the stresses could have caused concrete to burst," says Michael Higginbothan, a director of Ladkarn Demolition Ltd., Crook, Durham. "This has never happened before in Britain," he says.

"The exclusion zone was created in accordance with [the government's] Health and Safety Executive guidelines," says an HSE spokeswoman. HSE, which requires exclusion zones to be no less than twice a building's height, is leading investigations.

The 190-ft-tall apartment buildings were built in the mid-1960s to replace slums in the once-notorious Gorbals district. Because of decay and social problems, the buildings were condemned by the city council, which awarded a $1.3-million demolition contract to a joint venture of Ladkarn and Wreckers Ltd., an international explosives expert with operations in South Africa and the U.S., according to Higginbothan. The joint venture appointed structural engineer Bullen & Partners, Glasgow, to advise on weakening the buildings in advance of demolition by mechanically cutting redundant structural elements.

"We surveyed the buildings before and...during the pre-weakening...and we were quite happy with the work," says Ian Paterson, a principal engineer with Bullen. Paterson says that the width of both buildings was 41 ft. One building was 213 ft long and the other 476 ft.

The structures consist of cast-in-place concrete slabs and walls. The contractor used 2.5 tons of explosives aiming to reduce the buildings to rubble. However, even discounting the fatality, the demolition was not entirely successful. "There is one section which did not fully collapse, but this is not seen as a problem," says Paterson. "The object was to bring down these very large buildings to ground level where they could be broken up." ▣



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SHRINES

Japan's 61st reconstruction

Early next month, Shinto priests will carry the symbols of Japan's most important deity from a 20-year-old wooden building to a just-completed reproduction a stone's throw away. Then the old building will be razed. In a tradition that began in 690, the process will be repeated in another 20 years.

The tradition is unique to the Grand Shrine of Ise, founded in about 4 B.C. and believed to be Japan's oldest. "In Shinto, the ideal of eternity and longevity is made possible by periodic renewal," says Kunio Kobori, a shrine official.

The renewal "has a central role in perpetuating traditional craftsmanship," says Yutaka Ishikawa, an official with the United Association of Shinto Shrines. Though some power tools are used, all joints are notched, fitted and wedged, as they were 1,300 years ago.

Located in Mie Prefecture, about 200 miles west of Tokyo, the Grand Shrine is a complex of more than 125 buildings in various locales. Though all are rebuilt periodically, the most significant is the main "Naiku" shrine and 13 auxiliary ones. The Naiku is a single-story building just 17.9 x 7.2 ft and on pillars.

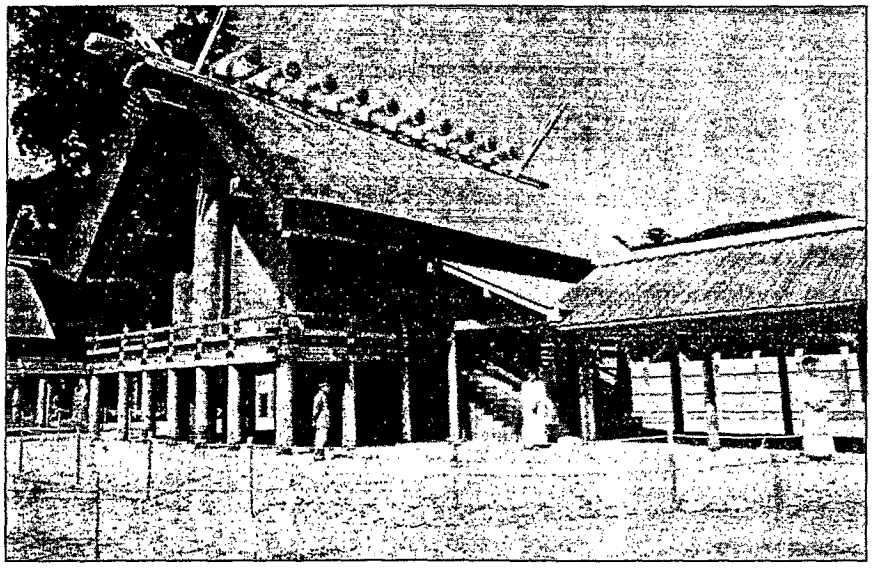
The $297 million for the 61st rebuilding, which also includes reproduction of 1,600 ceremonial items, comes from shrine reserves and public donations. Construction is executed by the shrine's master carpenter, who directs a permanent staff of 20 carpenters and other crafts specialists plus a seasonal work force that peaks at 170.

Kobori says the architecture was adapted from rice storehouses common at the time. The buildings' stark simplicity still characterizes Japanese architecture.

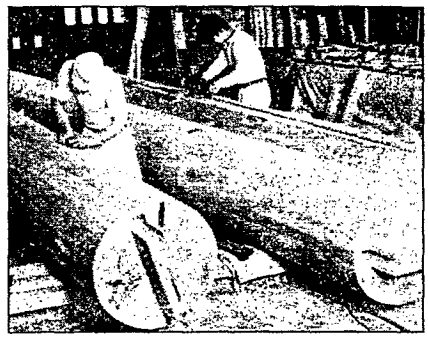
The buildings are unfinished hinoki cypress with steep roofs of miscanthus thatch. Main columns are set directly in the ground. Though a few bolts are used, nails or other fasteners are not.

Work began in May 1985 with the felling of trees from the shrine's own forests. The shrine also owns its own miscanthus fields and saw mill. The reason for the 20-year interval is unclear, though a generation's time makes sense and parallels material life, says Kobori.

Every stage is marked by ceremony. Carpenters must ritually bathe each morning and don white work outfits. As the main shrine is done, workers move to other buildings. "The construction process never ends," adds Kobori. ▣



Sacred wooden buildings that make up Japan's oldest shrine are reproduced every 20 years.



Workers pass along traditional techniques.

TUNNELS

Norway floats tube concept

Norwegian engineers are waiting for a government decision by year's end that would pave the way for the world's first floating tunnel. Parliamentary approval is needed for some $5 million in design research. Although the tunnel across an 820-ft-deep fjord near Stavanger is mentioned in Norway's 1994-97 road plan, no budget has been allocated for the work.

"We think the tunnel is possible," says Kaare Flaate, director of the Norwegian Road Research Laboratory (NRRL), in Oslo. "To convince ourselves that it is possible to cast such a structure, we have to make a full-scale section," he adds. The agency is looking at three concrete designs and one in steel, each conceived by a different design team.

The 33-ft-dia tunnel, with two traffic lanes, would be tethered to float beneath the surface of the 3,900-ft-wide Høgsfjord. Steel construction is relatively easy, but contractors familiar with the project say horizontally slip-formed concrete would be cheaper, says Flaate.

To exploit the latest technology for a watertight concrete tube, NRRL wants to stage full-scale trials no more than two years before construction, he adds.

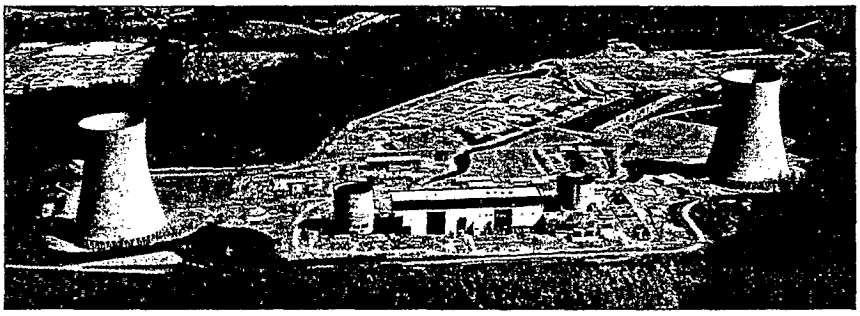
A floating tunnel would suit the road network in western Norway, which is punctuated by numerous fjords. Some are shallow and narrow enough for conventional tunnels and bridges, but others are too deep, says Flaate.

Høgsfjord is shallow for a fjord, Flaate says, but rock suitable for tunneling is too deep. A floating bridge is being built across the wide Salhusfjord north of Bergen, but a tethered tunnel would be cheaper, he says. ▣

R0013558

POWER

Plan offered to revive nukes



Inactive plant site includes mothballed Unit 3 (right) and Unit 5, which was abandoned 10 years ago.

A new plan would allow work to resume on two uncompleted nuclear power units in Washington state at a cost of $3.3 billion under an agreement with the federal government. If approved, the Dept. of Energy would fabricate plutonium from U.S. and former Soviet Union weapons into fuel.

Despite power shortages in the Pacific Northwest, the 1,240-Mw units were headed for termination, 10 years after being shut down during construction for economic reasons. (ENR 4/19 p. 14). Washington Public Power Supply System owns the projects—Unit 1 at Hanford and Unit 3 at Satsop.

The current proposal is part of a complex financing arrangement that involves raising more than $7 billion. A joint venture called Columbia Nuclear Corp., Kennewick, Wash., made the proposal to DOE. Gary Peterson, a consortium spokesman, says it will present details this week to WPPSS.

The consortium includes Science Applications International (SAI), San Diego, Calif., which specializes in defense and energy projects; a subsidiary of Newport News Shipbuilding of Virginia; and Battelle Memorial Institute, Columbus, Ohio, a research firm that has long been involved at Hanford.

Columbia Nuclear proposes to raise $3.3 billion by issuing revenue bonds to complete construction. Peterson says the company has talked to the units' original engineers, constructors and reactor suppliers about participating.

Columbia Nuclear would deed the nuclear steam supply portions of the units to DOE because a federal law prevents commercial plants from using weapon materials. WPPSS would retain ownership of the turbine-generator islands and buy steam from DOE to produce electricity. The federal Bonneville Power Administration would market the power, as originally planned.

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Columbia Nuclear plans to raise $4 billion more on the bond market. Half would be paid to BPA to pare its debt. The rest would go to former Soviet republics for plutonium, says Peterson.

Columbia Nuclear would be contractually guaranteed revenue from DOE's steam sales to WPPSS to service the developer's first bond issue, and revenue from WPPSS electricity sales to BPA to retire the second financing. ▣

MATERIALS

Virginia embankment: where the rubber really meets the road

Virginia disposed of nearly one-tenth of its stockpile of 25 million waste tires by shredding 2.2 million for use this summer as highway embankment fill near Williamsburg. State officials claim it is the most ambitious use of the approach to date in the U.S.

James C. Cleveland, construction engineer for the Virginia Dept. of Transportation's southeastern district, says the 100,000-cu-yd-plus embankment project evenly mixed shredded tires and sandy soil.

The Virginia Dept. of Environmental Quality, which runs the state's waste-tire program, says the project is the largest ever use of waste rubber and tire steel as structural fill, surpassing jobs in Minnesota, North Carolina, Oregon and Vermont.

The $750,000 job just finished by Barnhill Contracting Co., Tarboro, N.C., specified two 600-ft-long ramp embankments up to 20-ft high for part of a future interchange on Virginia Route 199. DOT supported the project because the state's largest tire-shredding operation is only 20 miles from the site, the embankments will settle for two years before roadway construction, and the lighter fill exerts less pressure on unstable, swampy soil beneath the site.

The waste tire program agreed to pay the extra $147,000 the DOT spent to use the shredded tires, says Allan Lassiter, program director. That works out to less than 15 cents per tire, or one-fifth to one-sixth the cost of landfill disposal.

E.J. Poindexter, Barnhill vice president, says his firm spread alternate 6-in. layers of shredded tires and soil, mixing them with a grader and rolling the mix. Thick layers of straight soil cover the top and sides of the embankments.

DOT plans to monitor the site to compare settlement there with settlement at conventional embankments. ▣

R0013560

DRINKING WATER

EPA would boost funds and reduce regulations

The Environmental Protection Agency released recommendations to revamp the nation's drinking water program, including a new state revolving fund to close an estimated $9-billion infrastructure gap. EPA also is stressing pollution prevention, wants to give local agencies more flexibility and proposes to let local authorities levy fees to pay program administration costs.

The federal agency hopes its recommendations, sent to Congress Sept. 8, will become part of a revised Safe Drinking Water Act. EPA Administrator Carol M. Browner contends that the current program is "broken in some



Browner wants to fix the broken water program.

instances and...needs to be fixed." She says many communities cannot keep up with the growing regulatory burden.

Under the drinking water fund proposed by President Clinton in February, the federal government would contribute $599 million in the first year, and $1 billion in each of the next four years. Aid would be funneled to states based on a formula including such factors as the number of water systems, population and geographic area, says James R. Elder, director of EPA's office of groundwater and drinking water. States would have to pay a 20% share.

Brian P. Deery, director of the Associated General Contractors' municipal utilities division, says the present act "sets stringent standards for local water companies to meet. Many are just not



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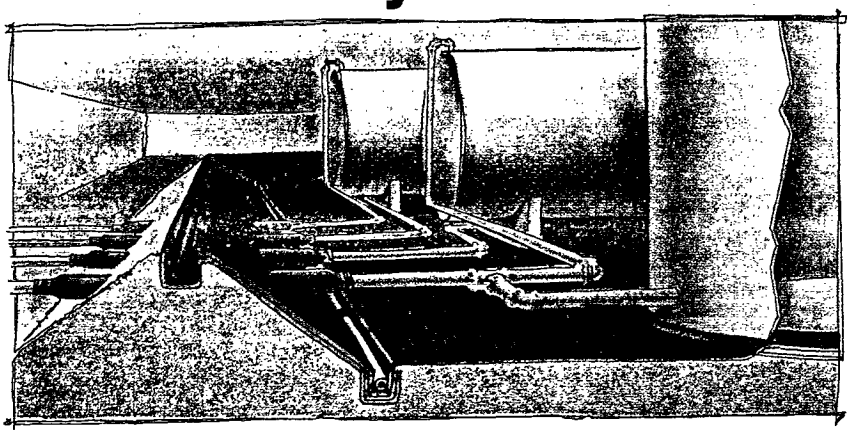

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going to be able to meet those standards without some kind of federal assistance." AGC thinks state revolving funds (SRFs) for wastewater treatment have a good record and will "work just as well in the drinking water area," says Deery.

Browner says EPA would let financially pressed small systems use "less expensive technologies" than big systems. And some systems could have up to 60 months to comply with new rules compared with 18 months now.

EPA wants to do away with the present legislative requirement to set new limits for 25 more contaminants every three years. Instead, it calls for splitting contaminants into two groups: those needing regulation and those requiring "further study," says Browner.

Two House committees passed drinking water SRF bills in April, but neither is a comprehensive measure. Senate Environment and Public Works Committee Chairman Max Baucus (D-Mont.) and the panel's ranking Republican, John H. Chafee of Rhode Island, are drafting drinking water legislation that may be introduced this month. ▣

CASINOS

Winner, loser join up, weigh grander plan

A month after selecting a developer to build and operate what would be the state's only land-based casino, the Louisiana Economic Development and Gaming Corp. is still not sure what it will get. Though the losing contender, who controls the site, joined the winner, both parties now say they need more time to hammer out a deal.

When Gov. Edwin Edwards threatened to call a special legislative session, Harrah's Jazz Co., a partnership of Promus Cos.' Harrah's Hotel Casinos and 10 New Orleans investors, agreed to give one third of the deal to loser Christopher Hemmeter in exchange for access to the New Orleans site, which he controls under a long-term lease with the city (ENR 9/6 p. 20).

Harrah's proposed to renovate the site's vacant New Orleans Rivergate Convention Center into a 120,000-sq-ft casino. But the city, which has to approve the project, wants a 300,000-sq-ft facility instead, as promised in Hemmeter's lease. Tom Morgan, Promus vice president of development, told the commission the partners have not decided whether to demolish or renovate. A decision is expected soon. ▣

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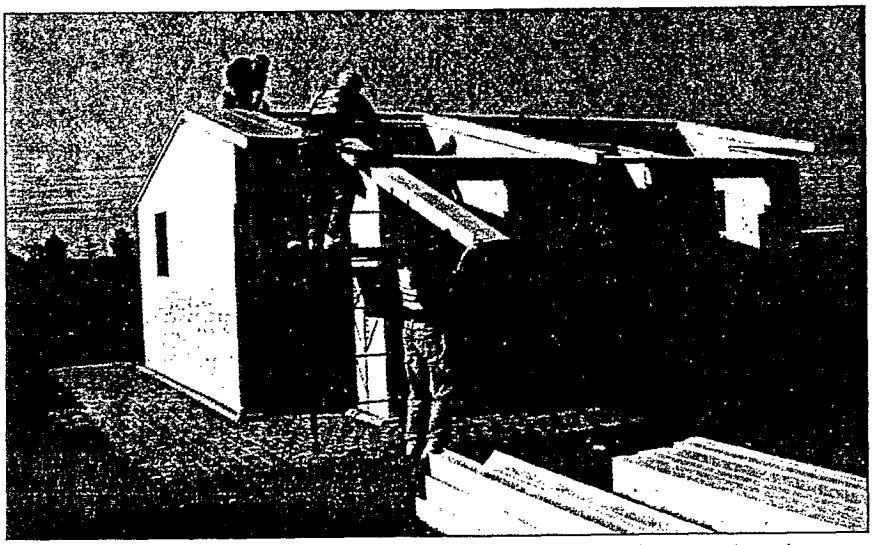
HOUSING

Modular low-cost homes give plastic new dimension



Composite panels, assembled on site, resist cracking, rust, rot and high winds, says the maker.

A Canadian modular homebuilder is starting production of affordable houses from a polymer composite that the maker says also has commercial, institutional and industrial applications. The resin belongs to a family of plastics used in a number of products from tennis rackets to the Stealth bomber.

The basic building block or panel is a hollow, extruded reinforced polymer composite based on polyvinyl chloride. Royal Plastics Group, the parent company of the modular homebuilder Royal Building Systems (Cdn) Ltd., Toronto, developed the material.

According to recent independent laboratory tests, the houses are able to resist 175 mph winds when hollow wall panels are filled on site with concrete. And the maker claims the material won't fade, crack, split, rust or rot, and is impervious to insect infestations.

It is the first PVC modular house to be tested for residential building code purposes by the Canadian Construction Materials Centre, a division of the National Research Council, says Brian Burton, technical specialist at Trow Consulting Engineers Ltd., Toronto, retained by Royal for testing. "That meant new criteria had to be written."

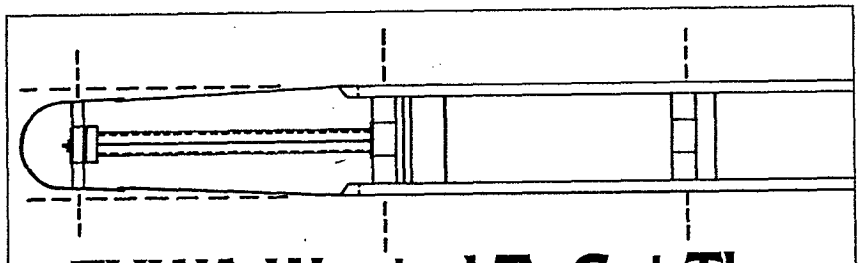
The houses range from 300 to more than 3,000 sq ft. They can be configured as single or multiple-story dwellings. Nearly everything is plastic.

Housing kits range from $17 to $38 per sq ft, including kitchen and bathroom fixtures, but not transportation to the site, the foundation pad, concrete fill, insulation and hookups. A stick-built house costs about $55 per sq ft, according to the National Association of Home Builders of the U.S.

After the concrete pad sets, three workers using hand tools can assemble a house in less than three days, according to John M. Garbin, Royal Building's general manager. The crew connects wall panels to reinforcing steel embedded in the concrete pad and attaches the roof using connector studs.

Royal Building recently sealed its first order—5,500 units for a public project in Buenos Aires. Royal is now turning its sights to Canada and the U.S. Garbin estimates that total demand for the units could hit 50,000 next year.

"I'm satisfied the house has technical substance, and it if costs a fraction of conventional technology, then it has enormous upside potential, particularly in developing countries," says Fred Hallahan, engineer-principal of a housing technology firm in Baltimore that bears his name. "The question is: Will it sell in the U.S.?" ▣



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"This French process quickly reduces 65 tons of organic waste to 33 tons of compost clean enough for farming."

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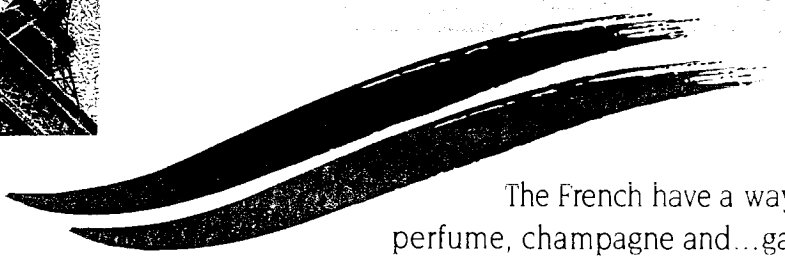
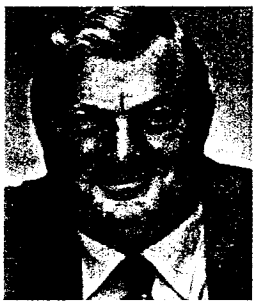




The French have a way with perfume, champagne and...garbage.

At least, that's what they're finding out at the Prarieland Solid Waste Board in Truman, Minnesota. Municipal authorities there turned to OTVD, owned by France's Compagnie Generale des Eaux, for an innovative solution to the county's garbage disposal problem.

Communities were already doing all they could to recycle, but 100 tons a day of solid waste were still loading up landfills. The bright spot was that some 65 tons were compostable, if only the technology could be found to do it on such a huge scale.

OTVD introduced Prarieland to French Siloda technology, never before used in the United States. A patented paddle wheel speeds up the composting. In just 28 days, the compost is ready for curing. After that, the clean compost can either be used for municipal projects or sold to farmers and nurseries.

Instead of going to landfills, 65% of the town's solid waste can be composted.



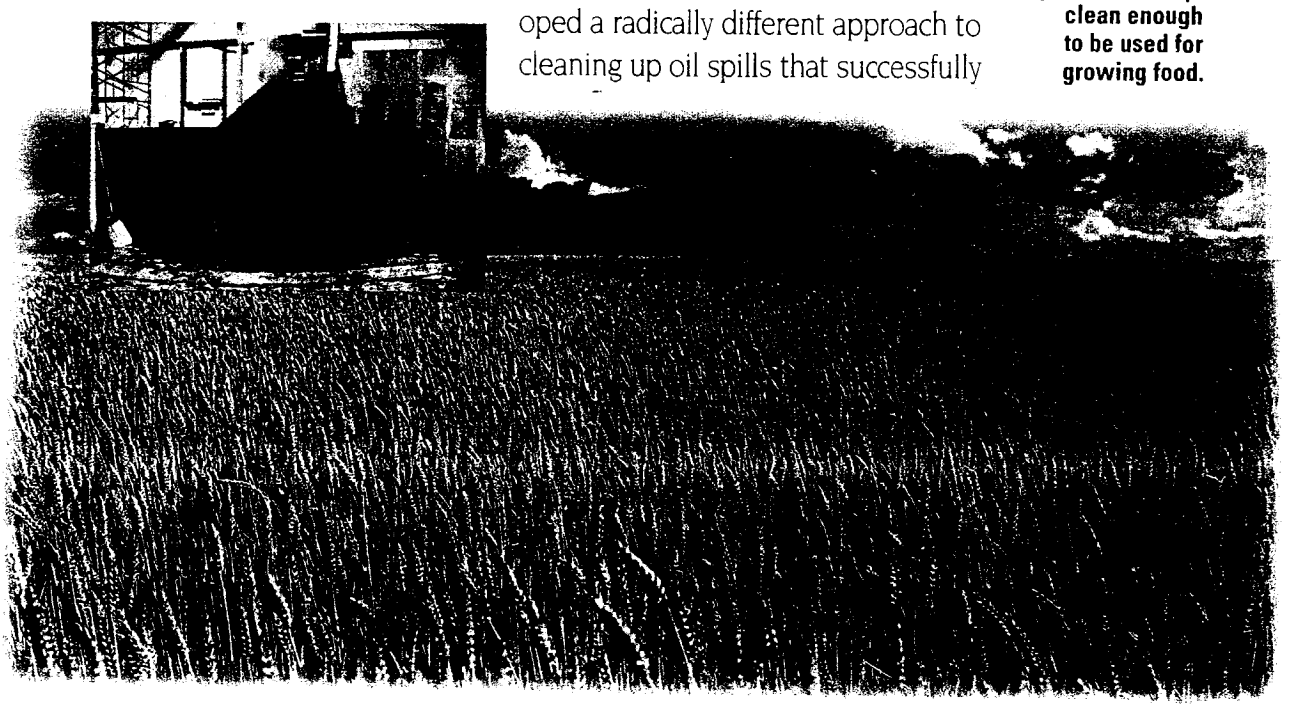
"We checked out just about every solid waste management system used in Europe or the U.S., and concluded that this one was best for large-scale composting," said Jerald Niebuhr, Chairman of the Prarieland Board. "This process will be a model for other communities that want to use composting in the future."

Perhaps it is the French eye for beauty that has led French companies to become so active in the environmental field.

Montenay, also owned by Compagnie Generale des Eaux, operates five ultra-modern incinerating plants in the U.S. and a medical waste incineration facility in the Bronx, New York.

Lyonnaise des Eaux-Dumez is helping water companies in 31 U.S. communities improve the quality of their drinking water to meet today's and tomorrow's higher standards. One example is a new ultra-filtration membrane process, marketed in the U.S. by Infilco-Degremont, Inc., that is being used by the New Rochelle, N.Y. Water Company.

And Société Nationale Elf Aquitaine has developed a radically different approach to cleaning up oil spills that successfully helped clean up the Alaskan coastline after the Prince William Sound oil spill.



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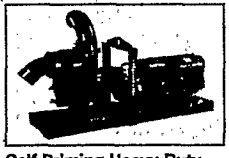

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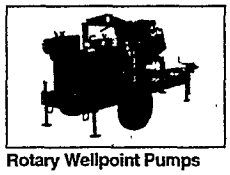

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Banks agree to bailout plan for Canary Wharf that creditors must ok

A consortium of banks has agreed to a $1.7-billion rescue package for Olympia & York's failed Canary Wharf office development in London. If the development's 1,400 unsecured creditors vote for the plan on September 30, the project will be taken out of Administration, the British equivalent of Chapter 11.

Unsecured creditors, claiming up to $224 million, will receive a maximum of 15 cents on the dollar. Of these, 130 construction companies owed $120 million will get an additional 25 cents on the dollar if they agree to warranty their work, says Administrator Nigel Hamilton, a director of accountant Ernst & Young, London.

The creditors' agreement to the package also would trigger construction of a $2.7-billion extension of London Underground's Jubilee Line to Canary Wharf. The banks have agreed to honor O&Y's pledge to partly fund the project, which is considered essential for the commercial development's success.

Canary Wharf failed with Toronto, Canada-based O&Y owing the banks $850 million. The project ultimately was to have contained about 10.5 million sq ft of leasable space in more than 20 major buildings (ENR 3/18/91 p. 22). When the court appointed Ernst & Young to take control of the project in May 1992, O&Y had built 4.4 million sq ft of office and retail space, representing about a third of the total plan. Construction halted, leaving one 472,500-sq-ft building, B3, without curtain walls. About 40% of the constructed space now is rented and that will rise to 49% if the rescue package succeeds, says Hamilton.

The package involves the banks deferring their $850 million worth of debt for 17 years, when interest will start accruing. Banks also will provide an additional $417 million, including $40.5 million for unsecured creditors and $230 million for long-term support of the project. Those additional funds will include a $147-million immediate payment toward the Jubilee Line extension. Another $450 million will be paid to the London Underground over a 25-year period after the subway line is completed.

Hamilton says that he knows of no immediate plans for further construc-

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tion at Canary Wharf, except for the completion of the B3 building's curtain walls.

O&Y's original owners in the Reichmann family will have no involvement in the revived project, says Hamilton. Skidmore, Owings & Merrill, Chicago, was the master planner for the Canary Wharf project and designed four of the major buildings. ▣

CONTRACTING

Design-build contracts spreading in industry

Design-build is continuing to gain momentum at the expense of other project delivery systems and the trend will continue, according to speakers at a recent conference on the future of project delivery systems sponsored by the Associated General Contractors. AGC also is nearing completion of model contract documents for design-build.

"I see it as the new project delivery system for the '90s and on into the next century," said speaker J. William Ernstorm, a Rochester, N.Y., attorney and member of the AGC task force working on the documents. However, other speakers at the Atlanta conference cautioned that design-build still has several unresolved hurdles, including design liability, bonding and selection process problems in the public sector.

Speakers called for shortlisting teams in advance of the costly process of producing detailed proposals for public owners. "The wanton use of [architects', engineers'] and contractors' time in developing proposals is our main objection," says John Busby, a partner with Atlanta-based architect Jova-Daniels-Busby. "It's absolutely downright damned disgusting. I'm disappointed that we're putting up with it."

The AGC documents should be available by November if the association's directors approve them at their mid-year meeting later this month, says task force chairman Paul J. Hoffman, who also is president of Hoffman Corp., Appleton Wisc., a design-build oriented general contractor.

AIA currently produces the industry's most widely used design-build contract documents. The Engineers' Joint Contract Documents Committee is working on another set. It may be ready by the end of the year, says Steven Polk, deputy executive director of business affairs of the American Consulting Engineers Council. ▣

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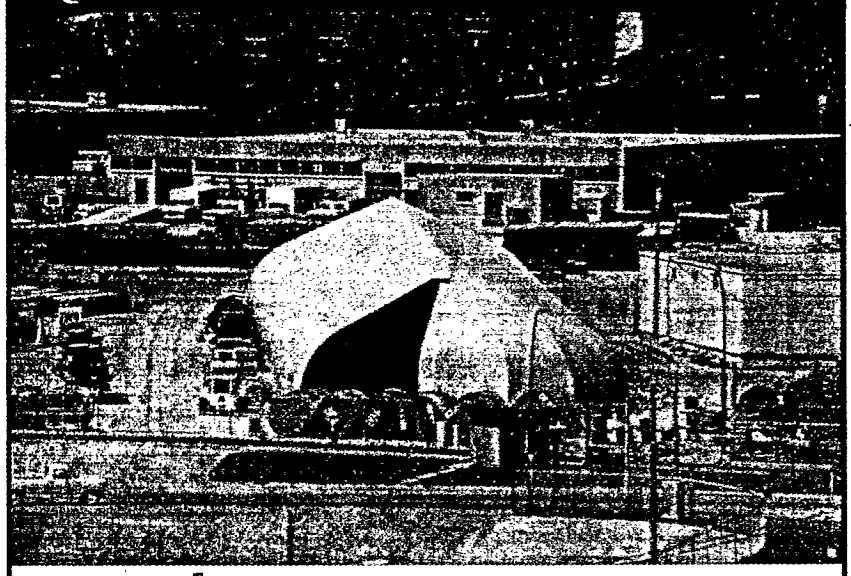

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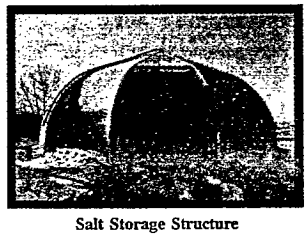

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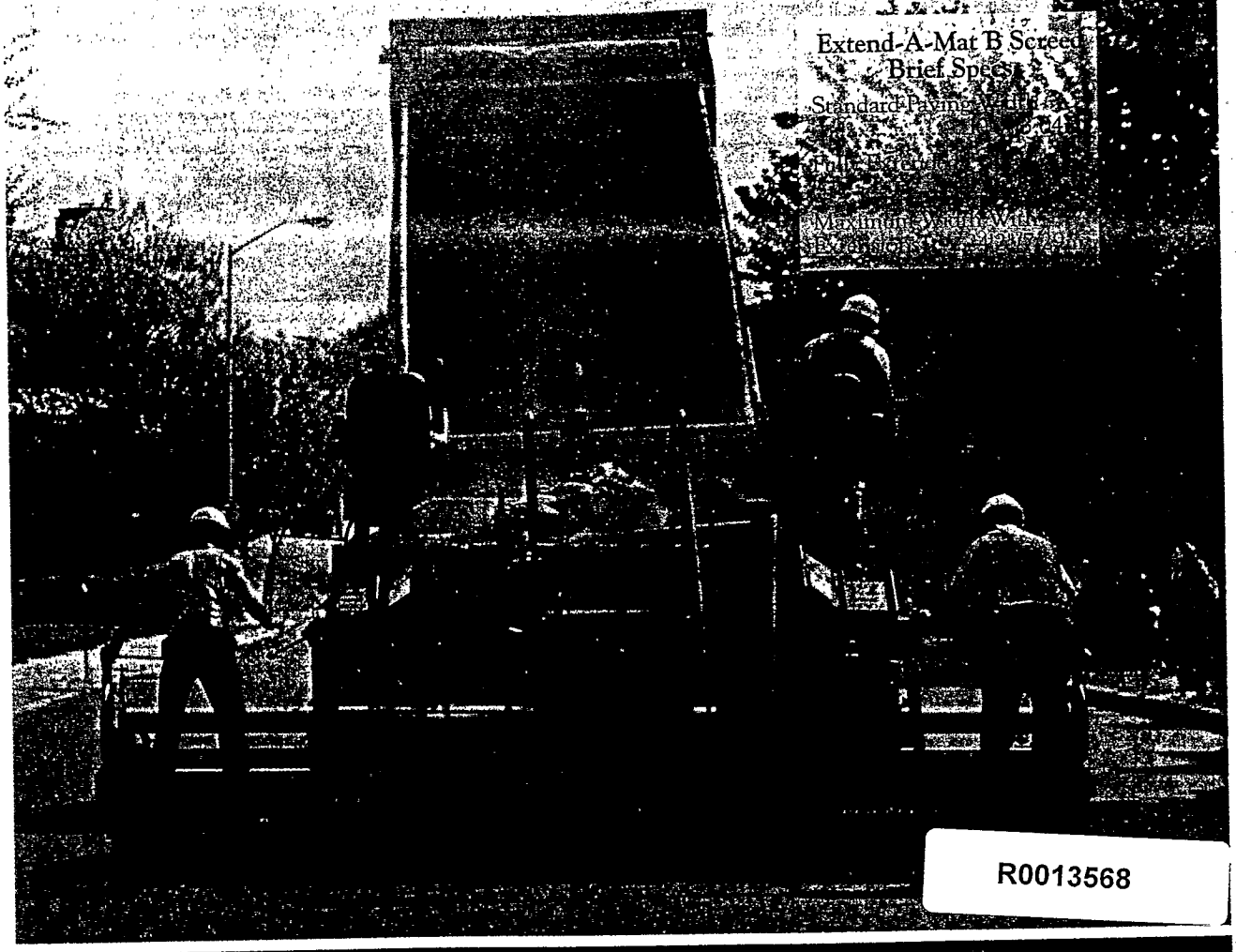

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INFRASTRUCTURE

Small town takes high road

Rush hour starts before noon in Branson, Mo.—population 3,700—and lasts until around midnight. Talk about a traffic jam! The 5 million visitors a year to the five-mile-long "strip" of more than 25 country music theaters can end up sitting in the parking lot for an hour after the show waiting to get onto the town's three-lane artery, Route 76, known as Country Music Blvd. The bumper-to-bumper crawl out of town can take another hour.

Branson, Taney County, the Missouri Highway and Transportation Dept. (MHTD) and the Federal Highway Administration (FHWA) all are coordinating efforts. A new 18-mile-long loop around the city, known as the Ozark Mountain High Road, is on the drawing board, as are several local roads. But there will be no instant relief. Ground was broken earlier this month on an $8.4-million connector road that may be open in about a year, but even on a very fast track, the Ozark highway won't be operational for at least four years.

Country Music Blvd carries about 30,000 cars per day and is "notorious" for "wall-to-wall cars," says Willis Graven, MHTD district engineer for the Springfield area. Widening the road to five lanes was not an option because buildings and hotel swimming pools tend to be on the right-of-way line. To take out another 8 to 10 ft along the strip would be "devastating to the existing properties," adds Graven.

The Ozark Mountain road will ease the load somewhat. It will have seven interchanges with connector roads that will lead into Rt. 76 in a wheel-and-spoke configuration. "It doesn't solve the problem by itself," says Scott M. Smith, transportation group director for HNTB Architects Engineers Planners, Kansas City, designer of the road.

The most remarkable part of the project is the environmental aspect. Branson is in a beautiful and environmentally sensitive area, and "we did not want to skip any of those issues," says Graven. The FHWA and MHTD developed a model of procedures that speeded things up. All the agencies involved assigned people to the effort. As many as 50 people attended meetings and consequently, it took just under eight months to get a notice to proceed, down from the usual two to three years. "It shows what they can do when they work together," says Smith.

The road will have "a lot of curvilinear alignment" to follow the area's natural curves, says Smith. Variable median widths and variable grades will make it "blend in with the area," adds Graven.

In the water and sewer areas, a 20-year plan has been squashed into four years, says David H. Miller, Branson city engineer. "We've kept up with [the growth], but it's been difficult," he says.

The city has built two new sewage treatment plants, done preliminary engineering on a third and is starting on a fourth. Because of the hilly landscape, the the city's eight lift stations in 1990 have soared now to 29.

Funding for these city-built projects should be no problem. If a tourism tax passes this November, $40 million of

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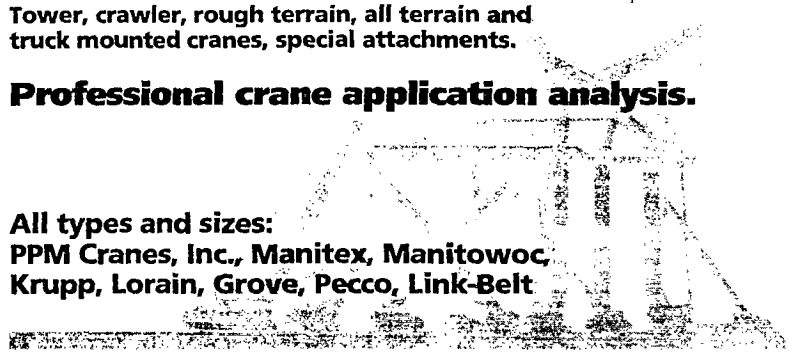

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bonds for water, sewer and roads will be issued and another $40 million in two years. "In 10 years that tax will generate $15 million in income if the growth keeps up," says Miller. It will. The city is issuing building permits for $40 million worth of commercial construction each month. Projects have included 38 motels and numerous new theaters. ▣

By Judy Schriener

TRANSIT

L.A. County takes first step to fund Blue Line

Months of uncertainty over the proposed Los Angeles to Pasadena leg of the Metro Blue Line ended recently when the Los Angeles County Metropolitan Transportation Authority voted to allocate $97 million to the project in its $3.3-billion, 1993 budget.

Though it represents only a fraction of the 13.6-mile line's estimated $841-million cost, the allocation includes $40 million of the $48.5 million necessary to complete final design, says Laurence Weldon, vice president and project manager for Rail Construction Corp. (RCC), MTA's construction subsidiary. In the next fiscal year, there are also funds for relocating utilities, hiring a construction manager and a contingency for removing hazardous waste.

The drawn-out funding—brought on by MTA's budget squeeze—will push back the line's opening date an undetermined period from its original target of November 1997, Weldon says. Agency staff will prepare a revised construction schedule and cost projection.

Next month, Blue Line officials will advertise the line's first construction contract: replacing a bridge across the Los Angeles River. With cast-in-place concrete abutments and segmental spans, the bridge will be similar to a bridge completed in 1992 for the Metro Green Line light-rail project.

To comply with Corps of Engineer requirements to stay out of the river channel during the rainy season, contractors will work between April 15 and Oct. 15, 1994.

Design consultant for all RCC projects is Engineering Management Consultant, a team led by Parsons Brinckerhoff Quade & Douglas Inc., and Daniel Mann Johnson & Mendenhall.

The team did the preliminary design, and RCC engaged local firms for final design, which is about 45% complete, says Robert Ball, facilities engineering manager for the light rail. ▣

R0013570

MEDICAL CONSTRUCTION

Market slumped long before Clinton's reform proposal

Details of the Clinton Administration's plan for health care reform finally landed on desks in Washington, D.C., last week, but the market for medical construction already had spent months in an unfamiliar funk. The President's initiative is actually just another sign of new market-dictated limits for a segment of the economy that was once thought to be recession-proof.

The pace of new medical construction this year is off 10% compared to 1992, when the market reached a peak of $10.9 billion in new contract awards, according to the F.W. Dodge Division of McGraw-Hill Inc. The decline, the first since 1984, is even greater for hospital construction, which is down 35% to $3.1 billion.

The seeds of the decline had been planted long before the President took office. Competition among health care providers had spawned cost-cutting moves and restructurings that already had put the brakes on some capital spending plans. Uncertainty over the planned reforms tipped the scales in favor of conservatism.

Pause. "We have seen a lot of our clients go on pause," says Jennifer Altenhoff, director of marketing for Stone, Marraccini, Patterson, a San Francisco-based architect. The market "is the weakest I've ever seen it," adds John Currie, senior vice president of Ellerbe Becket Co., Minneapolis. The downturn has hit Massachusetts particularly hard. Eight of Boston's major hospitals have $920 million worth of work either under way or on the drawing boards. But the intended uses of these buildings—either as clinics or laboratories—is in doubt.

For example, Massachusetts General Hospital recently decided to leave 10 floors of its new 14-story tower without completed interiors. The hospital has no specific plans for using the space.

"It was a wrenching decision," says a spokesman. "But we are facing a very rapid revolution in the way health care is provided in this country. And what was historically valid only a few short years ago, no longer holds true today."

Children's Hospital had planned to build an ambulatory care facility but dropped the project. And Beth Israel shelved all expansion plans for the near future.

Health maintenance organizations and managed care providers have cut deeply into the demand for hospital in-patient care. The presence of HMOs drove hospitals to compete for patients, says Alan Sager, a health policy analyst and professor at Boston University's School of Public Health.

Efforts to control medical costs have prompted physicians and hospitals to limit in-patient care and shorten hospital stays. Over a four-year period between 1987 and 1991, the number of hospital beds for in-patient care in Massachusetts shrank by 2,000, according to

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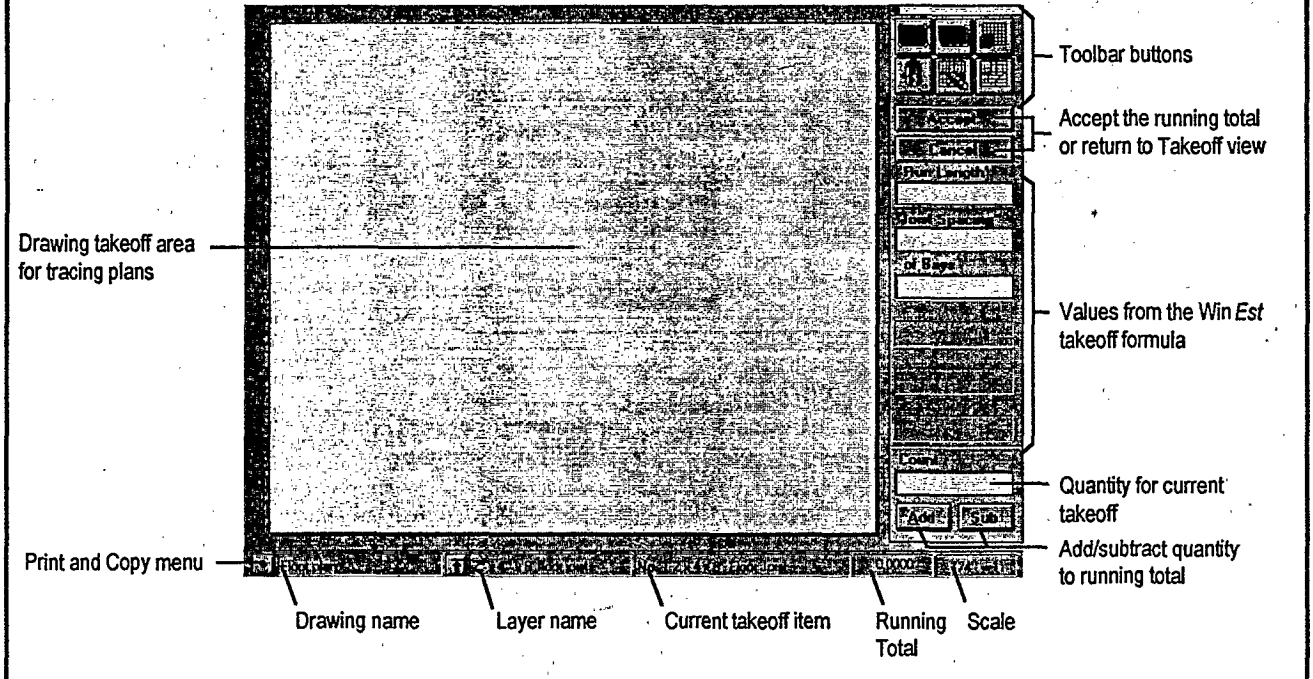

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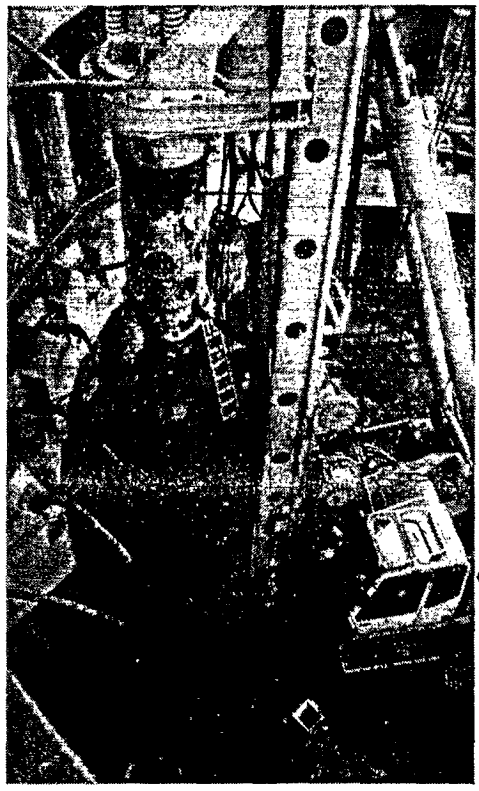

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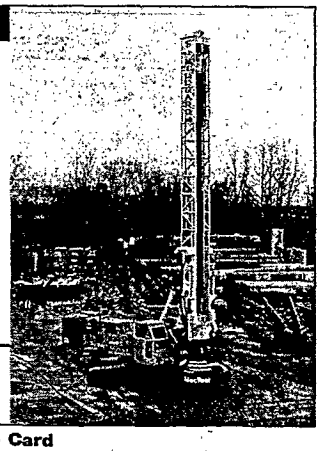

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the Massachusetts Hospital Association. The rest of the country is undergoing a similar downsizing, adds a spokesman for the American Hospital Association.

All of the rapid adjustments could have been avoided if hospitals hadn't made the error of believing health care was recession-proof, claims Sager. He says strong statistical evidence exists that cutbacks in health care spending start four years after a recession sets in.

Robert Murray, chief economist for F.W. Dodge, believes the downturn may be temporary as the industry pauses to catch its breath and assimilate the changes contained in the Clinton proposals. Others agree. "They're still trying to calculate how much impact it will have," says Altenhoff. "Then we see the potential for another boom."

Exceptions. Despite the drop-off in health care construction this year, industry experts note that the market remains segmented and some areas still are strong, if not booming. "Health care has always been strong relative to the overall construction market," says Ellerbe Becket's Currie. Despite the weakness in some health care sectors, "there are enormous exceptions" and large construction projects are under way in most major cities, he says.

Los Angeles County, for example, is two years into a five-year, $3-billion program to build county-run health facilities with state funds. But California has its own fiscal woes and a design contract held by Ellerbe Becket has "been put on hold, I think for a very long time," says Currie. In New York City, work is moving forward on the $600-million, multiphase expansion of Kings County Medical Center in Brooklyn.

And new projects still are being planned, although some of them are no longer driven by anticipated patient-generated revenue. One of them is a new $106-million research building recently announced by the Dana-Farber Cancer Institute. It is part of the Longwood medical complex, which includes Harvard Medical School and several affiliated teaching hospitals. The new research building will be financed by tax-exempt bonds issued by the Massachusetts Health and Educational Facilities Authority and will be paid off through rent from the research grants of the autonomous researchers for whose use the building has been planned.

Even a research building such as Dana-Farber's is not immune to change, suggests Sager. "Massachusetts receives a disproportionately large share of federal research dollars but that could change very easily," he concludes. ▣

By Stan Bicknell and Steven W. Setzer

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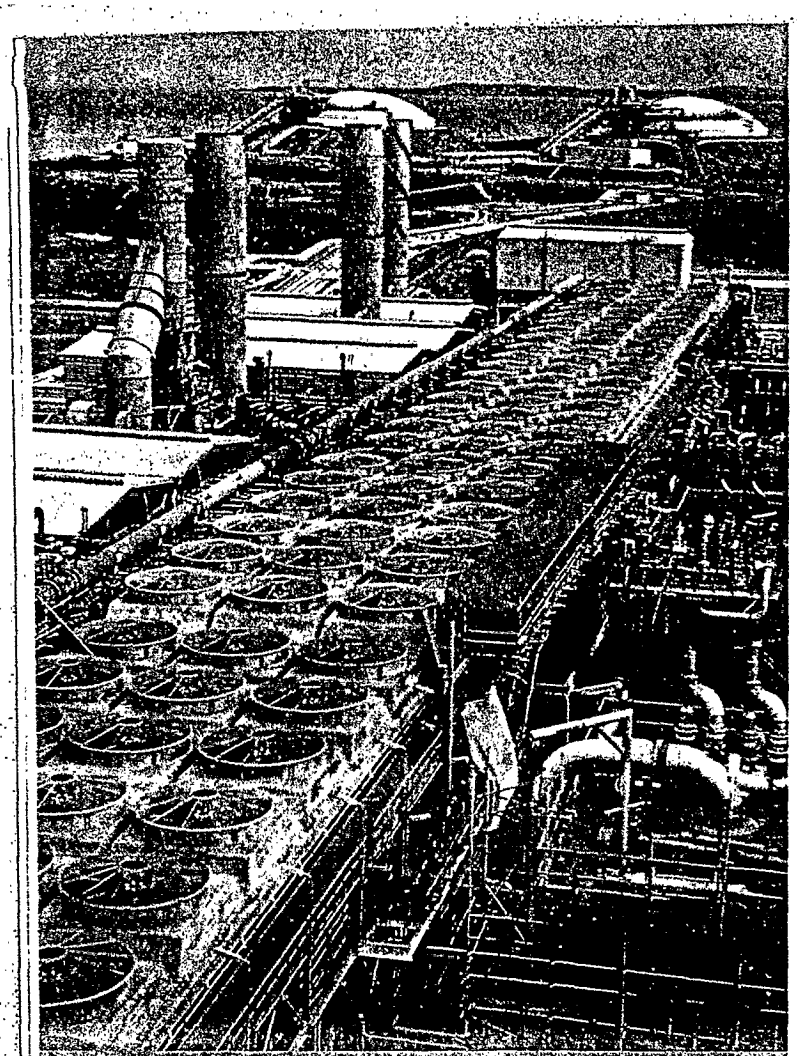

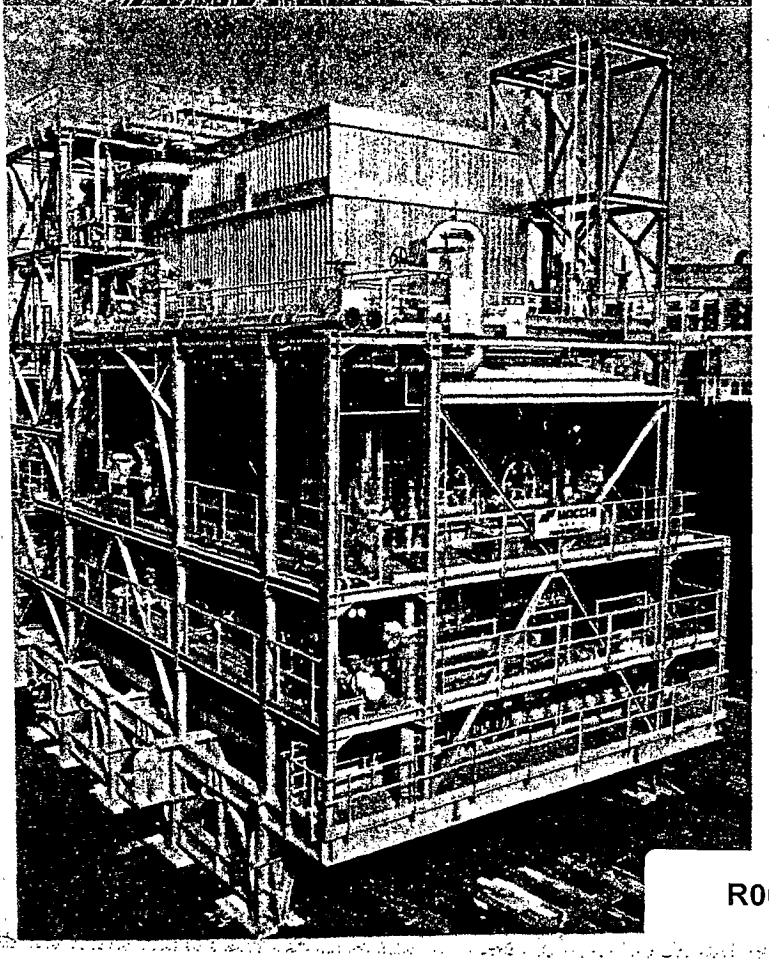

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Major refinery work planned

As oil refineries in California race to comply with federal and state clean air laws that require production of cleaner-burning vehicle fuels soon, Shell Oil Co. earlier this month overcame local opposition to its plans for a $1-billion expansion of its sole refinery in the state. Other refiners in California have ambitious plans as well.

Faced with threats of a lawsuit and delays by its neighbors east of San Francisco, Shell agreed to reduce emissions of volatile organic compounds by 326 tons annually at that Martinez facility, in exchange for permission to generate an equal amount of VOCs at the adjacent expansion. Although the company plans no increase of its current crude oil throughput of 150,000 barrels per day, in addition to producing cleaner-burning fuels, it plans to build new units for producing lighter fuels from heavier ones, and for making coke for steel production.

Environmentalists hailed Shell's concessions, including a pledge to meet quarterly with them if so requested during the design phase. Shell also agreed to install more sophisticated emissions sensors at the plant. "It was very important to us and people in the community that clean fuels didn't turn out to be a dirty deal for them," says Denny A. Larson, a spokesman for Citizens for a Better Environment, San Francisco.

Satisfied as well, the Contra Costa County Planning Commission plans to grant Shell a permit this week. And with approval from the regional air quality management district also expected shortly, Shell plans to select a general contractor soon. "We have a very tight time line to comply with the Clean Air Act," says Diane Kalas, a spokeswoman at Shell's Martinez refinery.

By federal law, refineries must produce reformulated gasoline by January 1995; California law gives them until March 1996 to produce even cleaner-burning fuels. According to a study released late last month by the National Petroleum Council, investments in this decade by U.S. refineries on reformulated gasoline facilities will reach $37 billion—or $6 billion more than the refineries' current book value.

Earlier this month, San Francisco-based Chevron Corp. announced plans to produce reformulated gas in California by upgrading its refinery near San Francisco for $370 million, and its refinery near Los Angeles for $580 million. Los Angeles-based Unocal Corp. plans to spend about $400 million on redoing its four California refineries: one in Santa Maria, one near San Francisco and two near Los Angeles. At its refinery in Martinez, Tosco Refining Co. plans to spend more than $300 million on producing chemical components for making cleaner gasoline.

Houston-based Exxon Co. declines to disclose plans for its refinery in Benicia east of San Francisco. And financially ailing Pacific Refining Co. plans to decide by Oct. 31 whether to spend more than $500 million to upgrade its refinery in Hercules east of San Francisco, or shut it down. ▣

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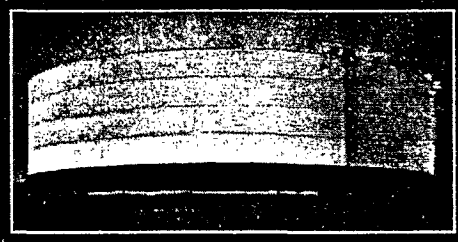

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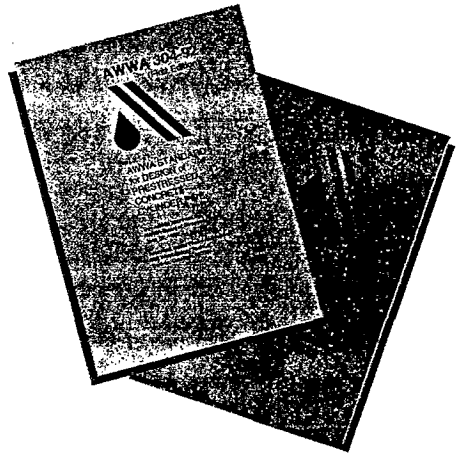

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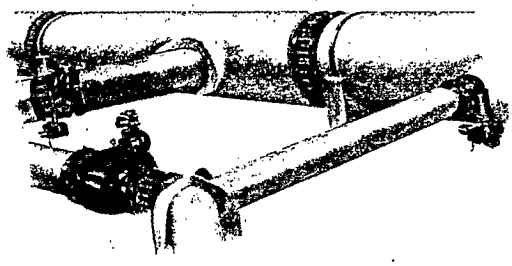

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Jerry Brockmeier has been named executive partner of R.W. Beck and Associates, a Seattle-based consulting engineering and environmental firm. A 20-year veteran of the firm, he had been a partner since 1985.

Blasland & Bouck Engineers P.C., a Syracuse, N.Y.-based consulting engineering firm, has appointed **Stephen B. Dublin** vice president in its Miami office. He had been project director for groundwater assessment and remediation services for various south Florida regulatory agencies. Most recently, he was Florida regional manager for International Technology Corp., Deerfield Beach, Fla.

McFarland-Johnson Inc., a Binghamton, N.Y., consulting engineering firm, has named **Russell A. Davis** managing engineer of its New England division. Davis had been chief of consultant design for the New Hampshire Dept. of Transportation.

Jeremy Isenberg has been named chief executive officer of Weidlinger Associates, a New York City-based civil and structural engineering firm. He had been the principal in charge of the firm's San Francisco office since 1974.

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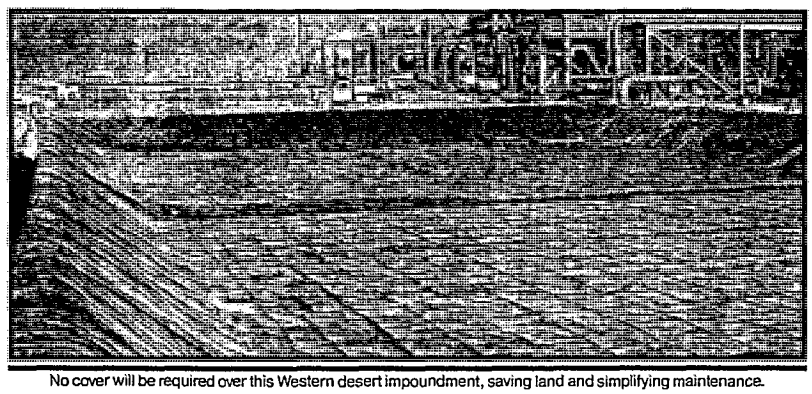

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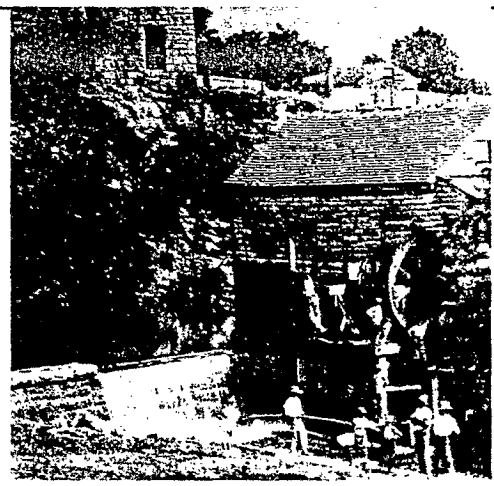

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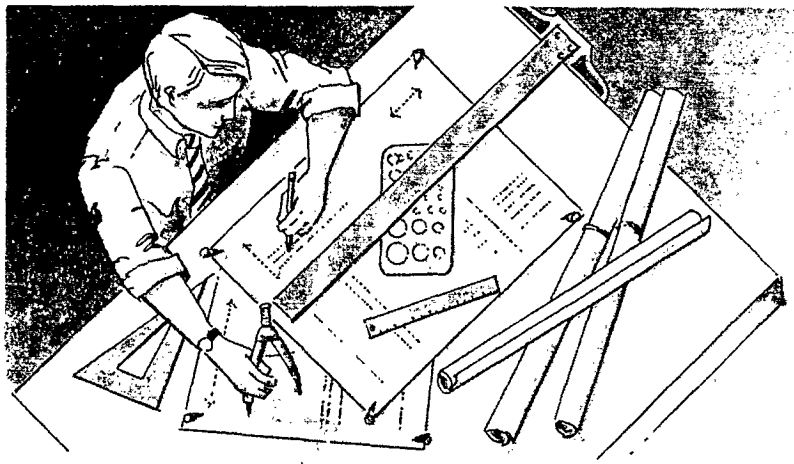

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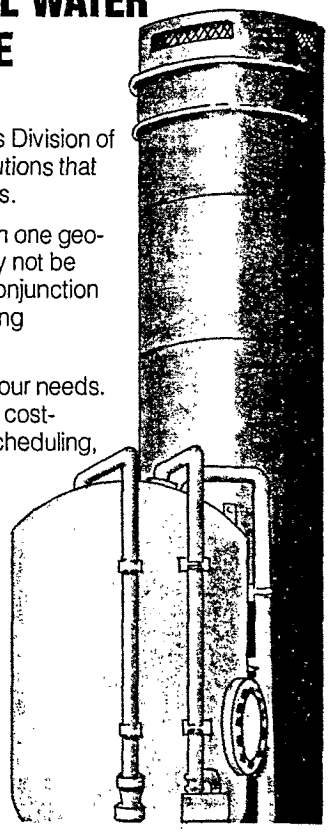

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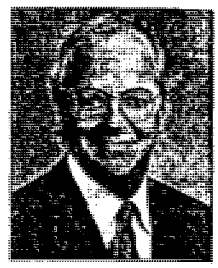

Aiken

projects. He had been director of government operations for Houston-based Halliburton NUS Environmental Corp.

The Fischbach Corp., a New York City-based mechanical and electrical contractor, has named **Wayne M. Sheridan** chief operating officer. He had been president and CEO of Fischbach's subsidiary, Fischbach and Moore, Inc., New York City. Fischbach also has named **Donald G. Burr** executive vice president of Fischbach and Moore. He had been senior vice president of the Marriott Corp.

Robert H. Luffy has been named president and CEO of American Bridge Co., Pittsburgh. He had held a similar position at Mellon Stuart Construction Inc., a subsidiary of Michael Baker Corp., Pittsburgh. Succeeding Luffy as president of Mellon Stuart is **Joseph N. (Nick) Alcorn III**, who had been executive vice president of operations.

John Brown, the Houston-based contractor, has named **Jim R. Collins** vice president and general manager of its midwest U.S. operations. He had been general manager of John Brown's Louisville, Ky., office.

Suitt Construction Co., Greenville, S.C., has named **Don Warren** president and chief operating officer of Suitt Construction and **John D. Aiken Jr.** as president and chief operating officer of Suitt International. Warren had been senior corporate vice president. Aiken had been vice president.

ASSOCIATIONS

The Society of Women Engineers has appointed **Elaine Pever Osterman** executive director. Osterman was previously executive director of the American Association of Physicists in Medicine.

The Concrete Reinforcing Steel Institute has elected **Lawrence Kubicki** as chairman. Kubicki is president and CEO of Houseman Steel Corp., Carmel, Ind.

By Gary J. Tulacz

R0013578

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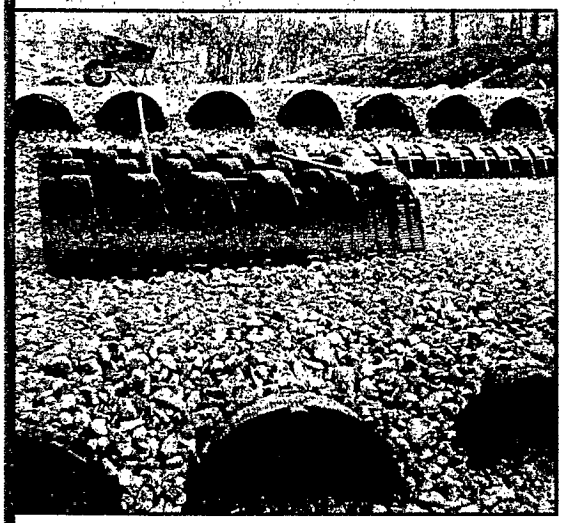

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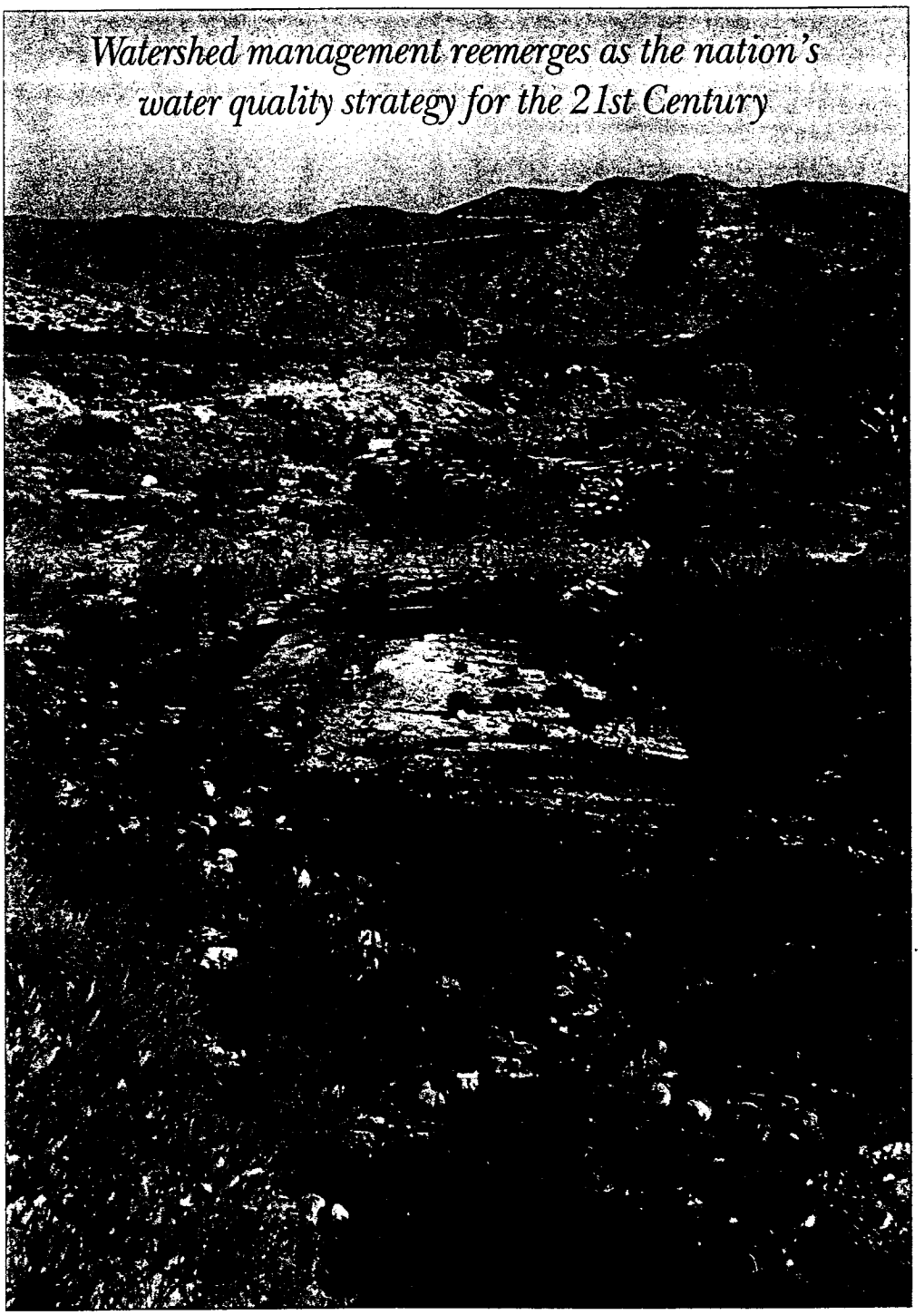
A 'whole' lot of planning going on



Watershed management reemerges as the nation's water quality strategy for the 21st Century

Two decades into America's water quality crusade, practitioners are realizing that the whole is greater than the sum of its parts. Cleanup strategies that targeted separate pollution dischargers and bowed to political boundaries are giving way to a more "holistic" approach—watershed management. The philosophy is nothing new to many water quality experts, but it's gaining renewed acceptance in states and in Washington.

"We're seeing new life in an old idea," says Ann Powers, general counsel of the Chesapeake Bay Foundation. "There is an interconnectedness at the watershed level." Even so, making that link is proving no easy task for the diverse array of watershed stakeholders.

Managing water quality by ecosystem is as old as the 1972 Clean Water Act itself, which authorized "area-wide" efforts. Multistate programs to protect high-profile, high-risk waters such as the Great Lakes, the Chesapeake Bay and the Gulf of Mexico are much touted.

But for the most part, water quality managers and regulators targeted pollution problems that were easiest to see, to fix and to fund. With federal monies then abundant and "end-of-pipe" problems persistent, the national strategy targeted individual municipal and industrial "point" sources of pollution.

The approach has fixed the worst pollution night-

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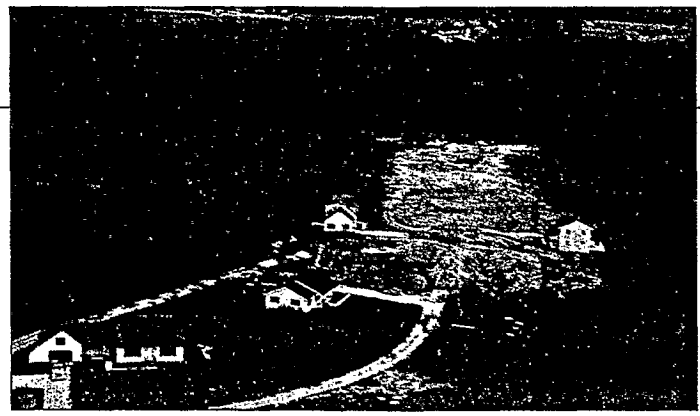


Development has created erosion in this Chesapeake Bay watershed community (right).



Farming and urbanization are key sources of nonpoint water pollution in the U.S. (below, left).

mares, but critics say it has neglected the less obvious but potentially more egregious impact of "nonpoint" pollution such as farm and stormwater runoffs and air emissions. "Unfortunately, efforts under these programs have been largely fragmented and piecemeal," said Tudor T. Davies, EPA's acting deputy assistant water administrator, in congressional testimony last month. "As a result, there are significant gaps in our efforts to protect ecosystems from the cumulative impacts of a multitude of activities that stress our waterbodies."

Value. With time, experience, and new sophistication, water quality managers have come to appreciate the value of a watershed-wide approach. It is the cornerstone of the much-praised *Water Quality 2000* report, a blueprint for 21st Century water quality management issued last year by a coalition of 75 industry groups. "We believe the nation is now ready, and indeed must, embrace this approach," says Paul Woodruff, coalition chairman and president of Environmental Resources Management Inc., an Exton, Pa., consultant.

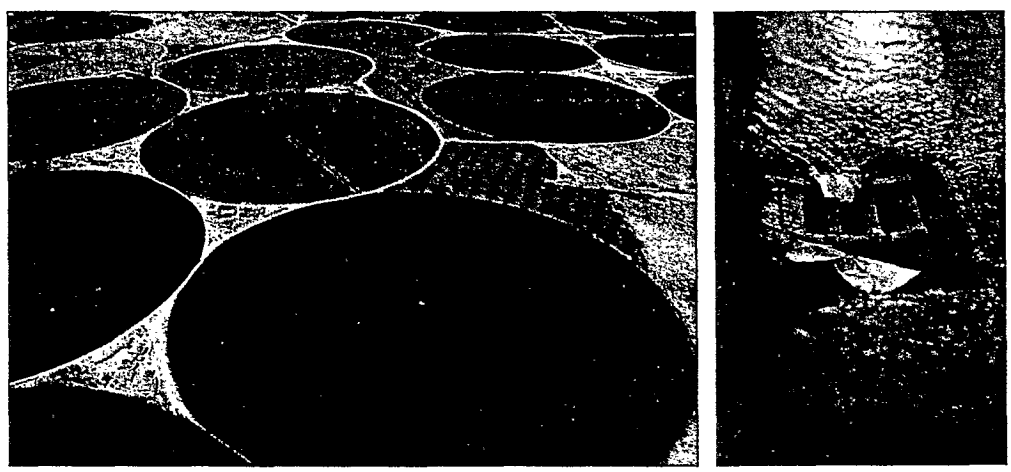
Already, local governments and their citizens are taking watershed matters into their own hands. "Our experience repeatedly shows that people are most likely to protect what they know," says EPA's Davies. "The watershed provides a logical area within which to build on this local commitment."

Cleanup of the nutrient-loaded Chesapeake Bay is a sterling example of a watershed approach that has successfully crossed state lines and linked point and nonpoint dischargers. With a goal of reducing bay nutrients by 40% by 2000 under a 1987 agreement, Maryland has already cut nitrogen levels by 13% and phosphorus 18%, says Cecily Majerus, Gov. William Donald Schaefer's Chesapeake Bay coordinator.

A key part of that effort now is implementing a "nesting" approach that targets smaller, localized watersheds that feed into the bay. Under a 1992 pact, bay-area states agreed to place nutrient caps on the Chesapeake's 10 main tributaries. "We've struggled a lot to bring the broader message to states like Pennsylvania that don't even have bay frontage," says Powers. The state, nevertheless, accounts for 70% of bay water. This past June, Pennsylvania enacted a law mandating new controls on farm-generated nutrient loadings and discharge planning.

Meanwhile, Majerus says Maryland is using a watershed approach even within its own boundaries in crafting plans to reduce nutrients in 10 state tributaries to the bay. Drafts will be sent by month's end to affected jurisdictions to thrash out whether steps are equitable and cost-effective. "We're doing this by watershed, not by county," she notes.

Other states are following suit. North Carolina has adopted what many consider the most far-reaching approach, dividing the entire state into 17 watersheds. The effort has allowed officials to synchronize discharge permits in each



Wastewater treatment plants (above) and other stationary dischargers have long been targets for water pollution regulators, but stormwater runoff impacts (right) can be better tracked in a watershed management approach.

R0013581

basin simultaneously, boosting management efficiency, says Steve Tedder, state water quality chief. "It's a way of doing business," he says.

Likewise, Oregon formally adopted a new watershed management strategy last year, which includes statewide assessment of conditions and voluntary "councils" to develop specific goals and action plans, says Lorna Stickel, chairwoman of the Oregon Water Resources Commission. She notes that state members of the Western Governors Association and the Western States Water Council will meet for the first time in November to share watershed management strategies.

And in another precedent-setting union, 23 representatives of state and federal agencies, environmental groups, developers and agribusiness met last week to begin charting a new environmental approach for the floodplain of the 100-mile-long Santa Clara River in southern California. "They're trying to make some multi-million-dollar decisions that are going to affect the river and all the stakeholders," says Michael T. Savage, senior water resources engineer for CH2M Hill Inc., the effort's engineering consultant. "Very seldom have we brought them together in a systems approach. But there's a growing understanding that you can't treat just one piece of it."

Woodstock. The watershed groundswell was apparent when EPA's first big watershed management conference in Washington last spring drew a standing room only crowd. "It's being called the Woodstock of water quality protection," says Robert H. Wayland III, director of the agency's new office of wetlands, oceans and watersheds, formed in 1991.

That was a watershed event for EPA itself. "There's an institutional change going on," says Wayland. Regional EPA water officials are meeting this week on watershed issues, "the largest block of time we will have spent on this," he notes. An EPA source says the agency will seek dedicated funds for watershed management efforts in its fiscal 1995 budget request. In past years, it has had to crib from other water program areas because budget overseers couldn't understand what watershed management was, says one agency source.

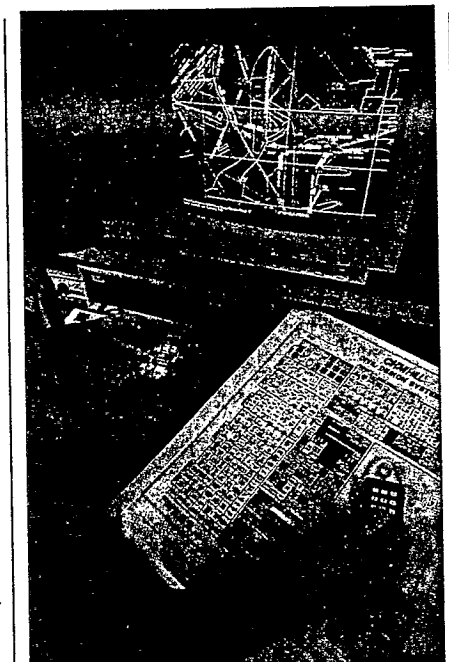
The agency's Seattle-based region, which includes the Pacific Northwest and Alaska, has already adjusted to management by watershed. In a restructuring begun last year, the region divided its domain into 22 key watersheds and assigned a staff member to each "to understand everything going on there," says Tom Wilson, senior policy advisor in its water division. "Before we were running programs. Now we're targeting those programs to solve problems, and we're getting the states to do likewise."

Wilson says this has worked in handling eutrophication problems in Idaho's Snake River basin. "We found the problem was caused by a multitude of small sources, so we changed our priorities and the state's to put needed resources there," he notes. "Before, we would not have recognized this."

Wilson says the regional refocus will come in handy as EPA and other federal agencies tackle the Clinton Administration's mandate for change in government management of Pacific Northwest forests. The effort, expected to set national precedent, will be based on a watershed approach, he notes.



Water quality monitoring has improved, key to an effective watershed strategy.



Computer mapping can analyze watersheds.

Transfixed. But nothing has created more of a stir in watershed management circles than pending legislation that references the approach for the first time. In particular, all eyes are on the Water Pollution Prevention and Control Act of 1993, introduced in the Senate last June by Max Baucus (D-Mont.) and John H. Chafee (R-R.I.), ranking members of the Committee on Environment and Public Works, as the vehicle for Clean Water Act reauthorization. What's important about the approach "is the integration," says Baucus. "Otherwise you address one part of the problem in a watershed, and neglect another."

The bill, S.1114, authorizes single or multiple states to voluntarily designate "watershed management units" and to identify impaired waters within them. It requires EPA to approve such designations and requires states to manage the units.The bill also asks states to submit watershed management plans for EPA approval; authorizes more attention to nonpoint source pollutant reductions in a watershed; and allows incentives such as state revolving fund (SRF) use and longer-term discharge permits in approved watersheds.

The bill's watershed approach is generally applauded in water quality management circles, but interest groups voice concern over certain provisions and are furiously lobbying to get their agendas addressed.

States in particular fear that their traditional primacy in water quality management could be undercut by federal watershed mandates. "The whole virtue of watershed management is that it bubbles up," says Robert J. Zimmerman, administrator of the surface water management section in Delaware's Dept. of Natural Resources and Environmental Control. "But this legislation is top down and will impair this."

State officials say the provisions would force states to adopt uniform solutions for very unique problems. "We don't want a one-size-fits-all process," says North Carolina's Tedder, a particularly outspoken critic for the Association of State and Interstate

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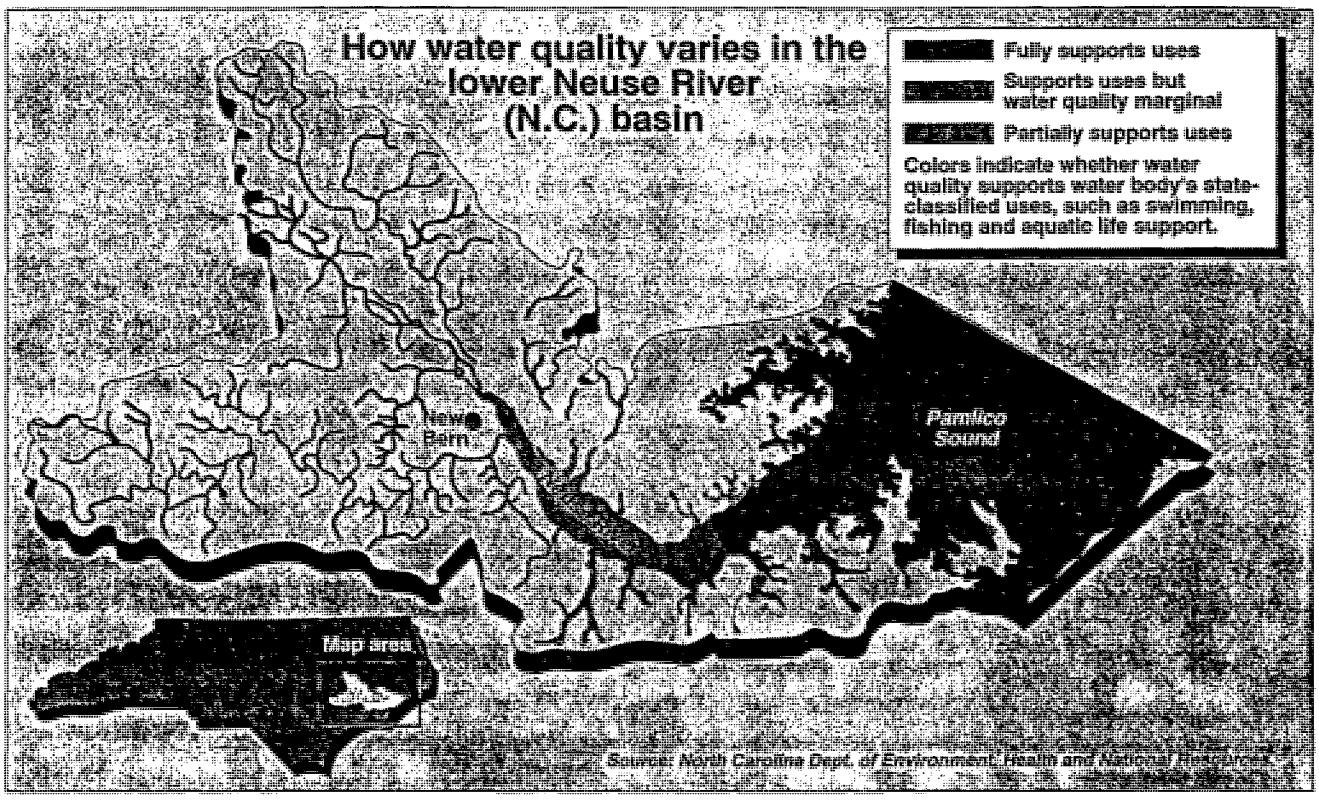

Water Pollution Control Administrators (ASIWPCA). "If they all start looking alike, we've defeated the concept." States hope for a sympathetic ear from EPA's newly named assistant water administrator, Robert Perciasepe, who formerly headed Maryland's Dept. of the Environment. "Having him is a reality check for the feds," says ASIWPCA Executive Director Roberta Savage.

States also worry about having to contend with too many outside interests in drafting and managing plans, particularly where watershed efforts are still very premature. Even Baucus admits that one pitfall of the approach is "you get too many cooks in the kitchen."

ASIWPCA is particularly unhappy with a proposal by the Association of Metropolitan Sewerage Districts (AMSA) to create formal "commissions" that would make watershed management decisions. AMSA contends such entities, staffed by relevant local stakeholders, would act as "bureaucracy busters," forcing agencies to coordinate efforts.

Meanwhile. AMSA and environmental groups make unlikely bedfellows in both calling for S.1114's provisions to be mandatory, not voluntary. "Making the program voluntary means that it is likely to fail," said Charles F. Gauvin, president of Trout Unlimited, a Virginia-based conservation group, in Senate testimony in July. Environmentalists also insist on strong EPA oversight of watershed programs, and are suspicious that the approach will allow states to ease up on point source dischargers. "The watershed planning provisions in S.1114 may represent an irresistible temptation to local governments to delay upgrading sewage treatment plants," testified Curt Spalding, executive director of Save the Bay, a Providence, R.I., group.



Santa Clara River will get a watershed focus.

And, advocates for farmers and other landowners worry about their liability for curbing nonpoint pollution in a watershed scenario. Farmers are adopting practices such as reduced tillage and contour planting to curb runoff, "but these changes are not without cost," says Gerald Talbert, director of policy for the National Association of Conservation Districts. While some industry spokesmen say farmers could benefit from a watershed approach, others want no part of it. "They see watershed planning as the first step toward a permit program for agriculture," says John H. Thorne, director of water quality programs for the National Agricultural Chemicals Association.

Senate Environment and Public Works Committee staff decline to elaborate on possible changes to S.1114, but a spokeswoman says these will be made when the bill heads for markup, possibly early next month.

Meanwhile, the House is targeting to introduce companion legislation within the next two months. Rep. James Oberstar (D-Minn.) introduced a bill several months ago that would tighten nonpoint source restrictions and pushes a watershed approach, but it has seen little activity lately, sources say. Most Washington observers don't expect a

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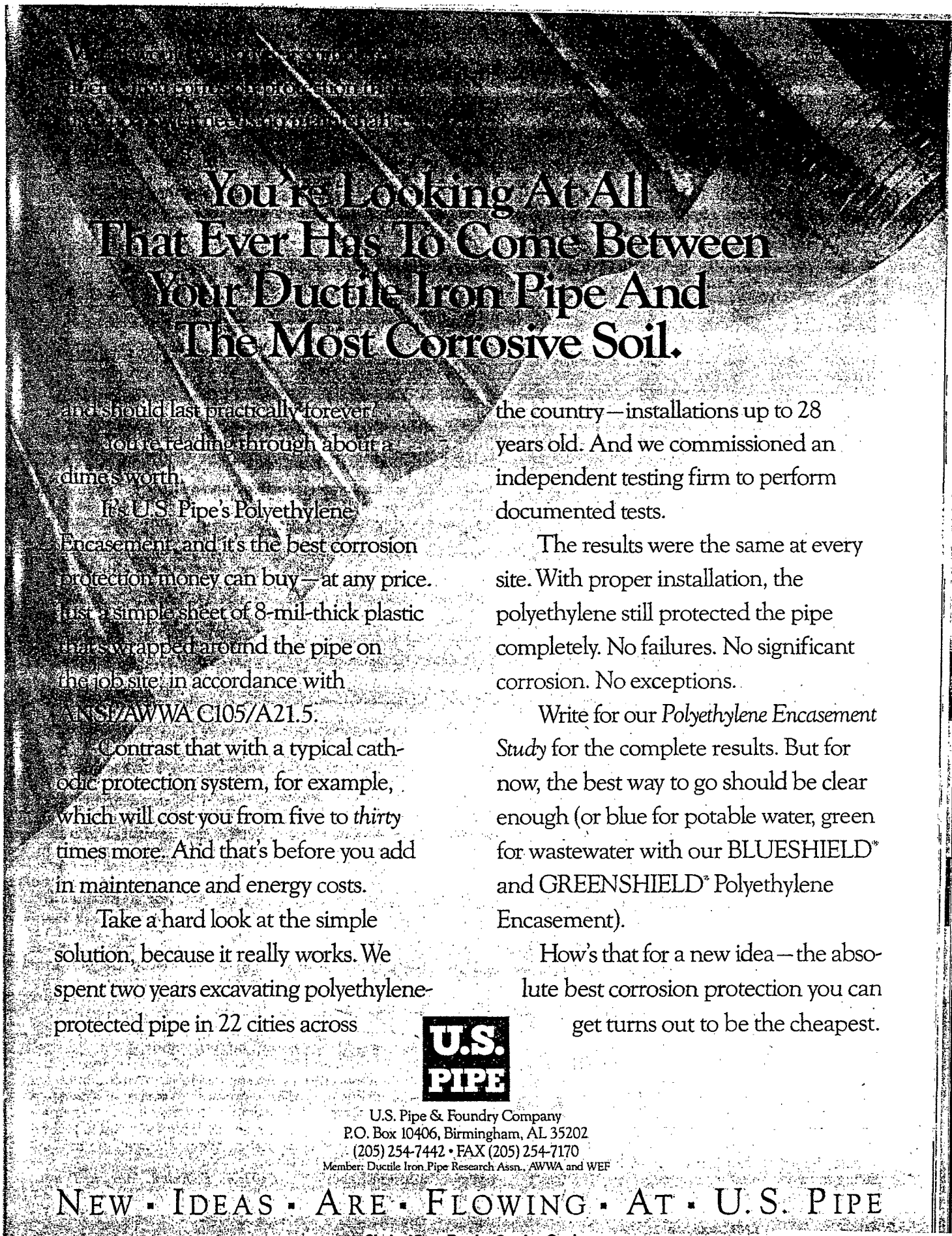

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Sens. Max Baucus and John Chafee, (above, left and center) are championing legislation that promotes watershed management. Rep. James Oberstar (right) has introduced a bill in the House also stressing the approach.

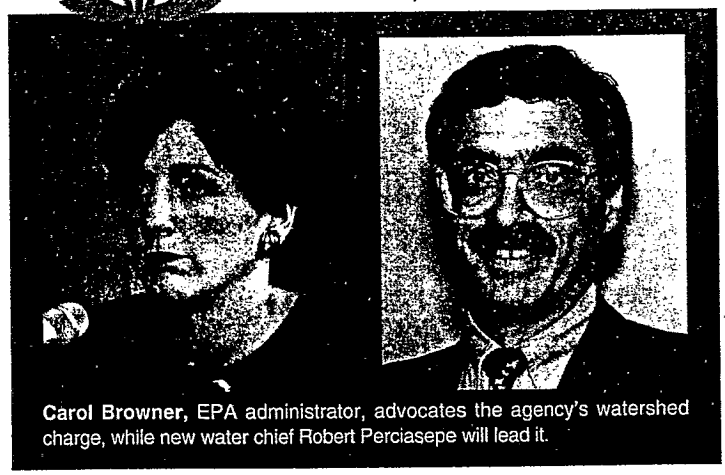
reauthorized Clean Water Act to come out this year.

In the meantime, practitioners wonder whether Congress will provide more financial and regulatory incentives to make watershed programs more politically palatable in economically hard-hit states. Confusion still reigns over how existing protocols for using SRF and federal grant monies will work in a watershed structure.

In particular, the bill is silent on the issue of trading water pollutant "credits," either between point sources in a particular area or between point sources and non-point sources. "As of now, [S.1114] doesn't include anything at all about trading or any other market-based approaches," says Mark Luttner, director of policy and resources management in EPA's water office. Environmental groups have been fighting such strategies "tooth and nail," he notes.

But government and private-sector experts say trading still has great potential. Trading consultant Kenneth I. Rubin, president of Apogee Research Inc., Bethesda, Md., says that several conditions appear necessary for trading to work. They include the presence of a definable watershed; a combination of point sources and controllable non-point sources that each contribute a significant portion of the total pollutant load; and a water-quality goal for the watershed that forces action.

Also, he says, point sources must be facing the need to either upgrade their facilities or trade for nonpoint reductions to meet water-quality goals; and significant non-point reductions must be possible at a lower marginal cost than reductions from point-source improvements. All told, there are more than 900 U.S. watersheds with water-quality problems that could potentially benefit from trading, says Rubin, and that number will grow. Among those eyeing trading are New York and Connecticut jurisdictions near Long Island Sound, the Tampa Bay region in Florida, the Chehalis River watershed in Washington State, and the Neuse River basin in North Carolina.



Carol Browner, EPA administrator, advocates the agency's watershed charge, while new water chief Robert Perciasepe will lead it.

Perhaps the first actual water-pollutant trade already is under way in North Carolina's Tar and Pamlico river basin. There, a state-administered fund has contributed $900,000 to help about 20 farmers and livestock managers on Chicod Creek institute best-management practices to reduce nutrient runoff.

This entitles them to credits of 15,000 kg per year of nutrients, about equal to the amount released by a 1 million-gal-per-day wastewater treatment plant.

Malcolm Green, general manager of the Greenville, N.C., Utilities Commission and chairman of the Tar-Pamlico Basin Association, a group of wastewater treatment plant owners, says it will use credits for those reductions to help members meet new, stricter limits on area-wide nutrient releases (ENR 12/21/92 p. 33).

Mark Tedesco, director of EPA's Long Island Sound office in Stamford, Conn., says 11 local management zones that have been established in New York and Connecticut to reduce nutrient release into the sound. "What we'd like to do is allow trading for nutrient reduction within the zones and possibly between the zones," he says.

Meanwhile, farther out on the horizon are calls for the watershed approach to reach beyond the Clean Water Act and to synchronize other environmental laws. *Water Quality 2000* has recommended a new national water policy that should be implemented through watershed planning and management.

Others want more attention to watershed management as a profession. "There are no watershed professionals, per se," says Harvey Olem, executive director of The Center for Watershed Protection, a nonprofit group based in Herndon, Va., which was formed last year to promote the approach. It soon plans to issue a quarterly newsletter and a variety of other technical guidance documents.

Even as water quality experts struggle to understand and implement watershed management, it is clear the philosophy is here to stay. EPA's Davies cites a 1911 quote by the famous naturalist John Muir that Davies says remains the essence of watershed management 82 years later: "When we try to pick anything out by itself, we find it hitched to everything else in the universe." ▣

By Debra K. Rubin, Mary B. Powers, Housley Carr and David B. Rosenbaum

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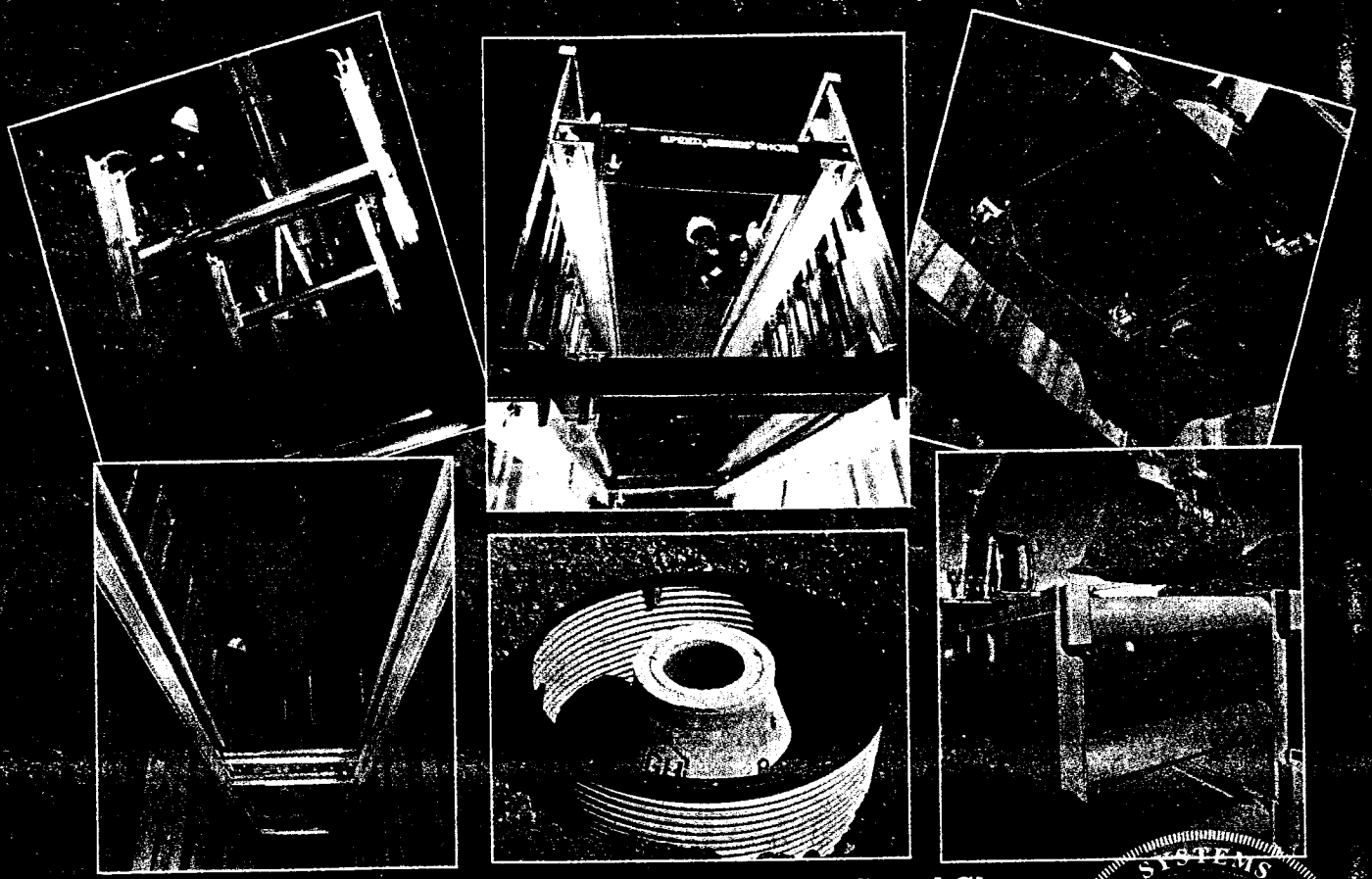

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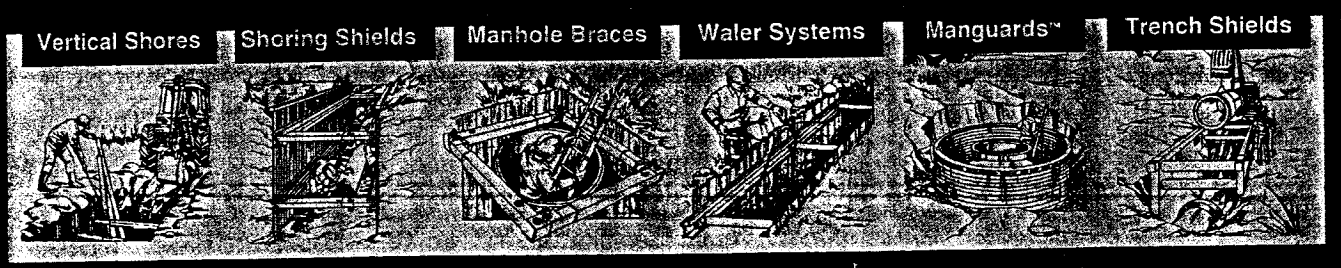

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CONFRONTING THE INFRASTRUCTURE CRISIS

Eyewitnessed examples show how funding falls far short of the money needed to repair and replace the nation's aging water and sewer works

By Gerry Dorfman, president, National Utility Contractors Association and a water/sewer contractor based in Woodland Hills, Calif.

Recently I visited a rural, northern California community and walked through families' backyards to determine the location of a new septic tank system. To my dismay, I found myself walking on saturated ground — saturated not with water, but with wastewater — raw sewage that had overflowed from failed leaching systems. The entire neighborhood was a public health hazard; children could not play in their backyards.

Happily, a grant from the Rural Development Administration's Water and Waste Disposal Program has since helped finance a new septic system, and families again have free use of their backyards.

Here's another: in Pawtucket, Rhode Island, a contaminated water system forced residents to boil their drinking water or buy bottled water for more than two months. My colleague Ted Bragger, of A.E. Bragger Construction, worked on the pipe replacement job.

"We replaced dangerously old and decaying water lines," he notes. "Some of the six-inch pipes had been in service for more than a century and were so encrusted that you could scarcely fit a ping-pong ball through the center.

"In May I took a section of the pipe to a congressional hearing, and the Senators were sufficiently disgusted. But restricted flow is more than disgusting," Bragger explains. "Water pressure in the pipes must be increased to transport the same volume of water to the user — which means that pumping stations effectively waste huge quantities of electricity.

"Plus, restricted flow throws a serious public safety hazard into the mix, because water volume and pressure available through fire hydrants is much lower."

The situation is menacing, as such examples prove. Every day, utility contractors expose decaying sewer lines and tuberculated drinking water systems. Sewer lines can rupture, and have done so, pouring sewage into a river or bay.

Fortunately, the United States possesses the resources — the contractors, suppliers, workers and engineers in the utility construction industry — and the essential programs to address the problems. Federal programs are in place, but they are seriously underfunded.

Based on recent needs surveys, the National Utility Contractors Association (NUCA) estimates a shortfall of more than $100 billion for wastewater and drinking water capital between the years 1993 and 2000. EPA estimates that the total 20-year design needs for publicly-owned wastewater treatment facilities will reach $111.5 billion.

Moreover, spending means jobs. The 1992 NUCA jobs study reveals that each $1 billion invested in water and sewer projects generates up to 57,400 jobs. What's more, the study found that water and sewer construction generates more jobs than other types of public works investment.

Funding Hurdles

Despite such documented needs and benefits, federal clean water investment has dwindled since the late 1970's, when EPA construction grants were funded at $5 billion-plus amounts annually. In June, the House approved just $1.25 billion for EPA's wastewater construction State Revolving Loan Fund (SRF) in fiscal 1994; that's $650 million less than fiscal 1993 spending.

NUCA recommends funding the SRF program at $5 billion per year, but in acknowledging current budget realities, requested a minimum appropriation of $2.4 billion for fiscal 1994. As the appropriations battle went to the Senate, we sought to replenish these vital funds, but instead are fighting to maintain depleted House figures.

There is some good news. President Clinton proposed a new Drinking Water State Revolving Loan Fund and asked for $599 million for fiscal 1994 and $1 billion per year thereafter to help communities comply with the Safe Drinking Water Act. The House approved the spending request, but significant hurdles remain.

Authorizing legislation must clear both Houses of Congress, and at this writing two House committees are squabbling over jurisdiction. Meanwhile the Senate is mulling it over. The idea may not develop this year, but NUCA will continue to push its persuasive case.

Also on the upside, Rural Development Administration (RDA) clean water construction programs apparently have managed to capture the only federal construction dollars in the fiscal 1993 supplemental spending package.

Before its August recess, Congress approved $1.4 billion for the RDA Water and Waste Disposal Grant and Loan Programs in fiscal 1994, a slight increase from current spending. These programs, which serve communities with fewer than 10,000 residents, netted $70 million in the final, watered-down "economic stimulus" package. Of that, $35 million will be grants, and $35 million will be used to service $250 million in loans.

Digging America Safely

Underground contractors, especially NUCA members, generally give safety an ever-higher priority these days. Underground construction groups have created safety agendas and promoted them to help contractors prevent injuries and comply with safety regulations. Our priority areas include training for "competent persons" (see following article), safety technologists and confined-space construction, and the development of widely accessible technical assistance and safety references.

By necessity, underground construction is linked to trenching and safety measures; trenching is one of OSHA's high-emphasis inspection programs. OSHA inspectors are required to inspect every open trench or excavation they en-

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counter, and OSHA rules call for qualified competent persons to oversee all trench and excavation sites.

With increased competent person training and an emphasis on safety, organizations such as NUCA have met this new demand. In fact NUCA has trained 31 competent person instructors, who in turn have trained more than 15,000 individuals nationwide.

In April, OSHA implemented a new confined-space standard for general industry, focusing on permit-required confined spaces that pose immediate safety threats. Though the new rule does not apply to the construction industry, which must adhere to a separate standard, OSHA inspectors will be more cognizant of confined-space safety. NUCA safety director George Kennedy expects the agency to use the new rule as a guide to enforcing confined-space entry in all industries.

To strengthen job site safety and compliance, construction and general industry employers have turned to various confined space training programs. NUCA has trained 23 instructors to teach the association's Confined-Space Entry Program, which incorporates the new standard.

The need for trained safety personnel in construction continues to grow. OSHA has reported that it cannot keep pace with the demand for training at the OSHA Institute, and other organizations have come forward to fill the gap. This fall NUCA will introduce a construction safety technologist program that will provide managers, safety directors and other personnel with a thorough understanding of OSHA regulations and safety. NUCA has also launched a safety subscription series that provides video and classroom safety training materials and maintains training records for employers.

NUCA also provides technical assistance and a full library of safety reference materials to the underground construction industry. The library includes ten safety training videos with topics ranging from confined space entry to heavy equipment operation to pipe handling; a 410-page safety manual, a pocket safety manual for employees, and up-to-date coverage of emerging safety issues in NUCA's many publications.

Even so, many on Capitol Hill disregard the industry's clear commitment to job site safety. They are calling for increased government intervention, greater workplace scrutiny and stronger penalties for violators. The Comprehensive Occupational Safety and Health Reform Act (COSHRA) has been introduced in both houses of Congress, and hearings are under way.

WHY TRENCHLESS TECHNOLOGY KEEPS GROWING

A variety of systems offer ways to pierce under congested areas

From New York City to Florida, and from Atlanta to California, in just nine years microtunneling has become an established method to place underground pipe. And it's growing rapidly in popularity, especially for sites where buildings, railroad tracks and the like make open-cut tunneling difficult if not impossible.

Nationally, more than 125,000 ft. of microtunnels have been bored. In Houston alone, more than 67,000 ft. of pipe with diameters from 18 to 30 in. have been placed with microtunneling systems at depths of 25 ft. or more.

Simply put, microtunneling is a sophisticated form of pipe jacking. Using remote controls and laser guidance, pipe sections are inserted into a jack, which pushes sections forward and retracts to receive the next section. Seeking a better way to dig ditches, the Japanese first developed it in the mid-1970s. Further advances came from German firms, namely Soltau Vortriebstechnik and Herrenknecht GmbH, which now offer machines in the U.S.

First used in the U.S. by subcontractor Salgado Eastern Corp. (SEC), of Columbia, Md. in 1984, microtunneling systems are offered in two varieties. One removes the spoil from the face of the tunnel using small augers in a dedicated casing; the other removes spoil from the tunnel as slurry. Pumps take the material to the surface, where excavated material can settle while the water is being reused.

Microtunneling is one type of "trenchless technology." Horizontal earth boring, including directional drilling, wet boring, and pipe jacking are others. Several methods of earth boring are available, including augers, wet boring machines, pipe ramming systems and directional ground-piercing tools. Ground-piercing tools can be powered with either hydraulics or compressed air; typically, pnematic piercing tools range from 2 to 10.5 in. in diameter.

Still, for most contractors, the hydraulic excavator remains the tool of choice for most pipelaying jobs. Excavators gain extra value in a contractor's fleet because they're so versatile. Not just for digging trenches, excavators can team with trucks or articulated haulers to make quick work of mass excavations, especially in wet, mucky sites that would prove tough going for scrapers.

Big player in future

"Right now, for most of our sewer, storm drain and water main projects, we are using open-cut equipment and using subcontractors for our microtunneling," says Gerry Dorfman, president of the National Utility Contractors Association and owner of Dorfman Construction Co., Woodland Hills, Calif. "We use trenchless technology for about 4 percent of our jobs and conventional methods for the other 96 percent. But I see trenchless technology as becoming a big player in the future of underground construction technology."

The cost of microtunneling? Currently it exceeds that of conventional cut-and-cover methods. But because trenchless excavation methods minimize surface damage, contracting agencies avoid the cost of traffic disruptions, rerouting, environmental disruptions — and can often bore under obstacles that would stop an excavator outright.

Because many of the nation's aging pipe systems serve highly congested areas — yet must be replaced in the next several years — trenchless technologies surely will play an ever-more important role in rebuilding the nation's underground water, sewer and electrical power systems.

Moreover, several leading construc-

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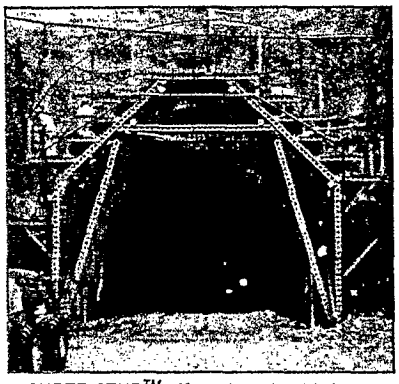

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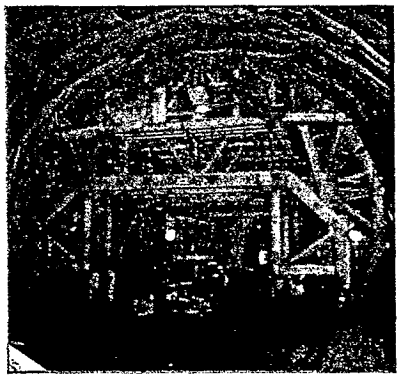
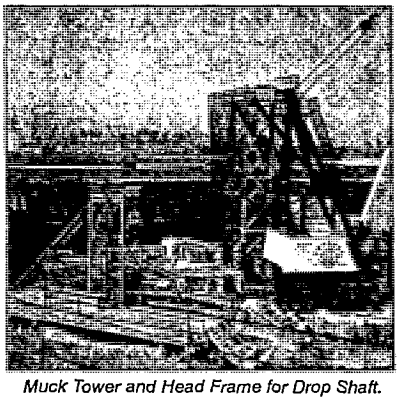
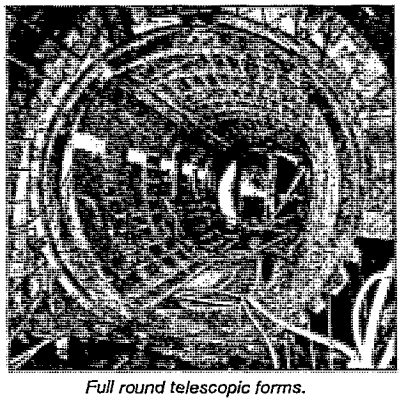


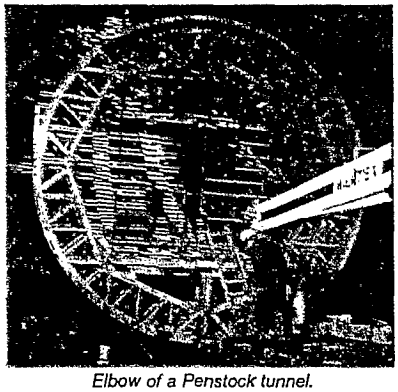
Mechanized carrier moves tunnel form.



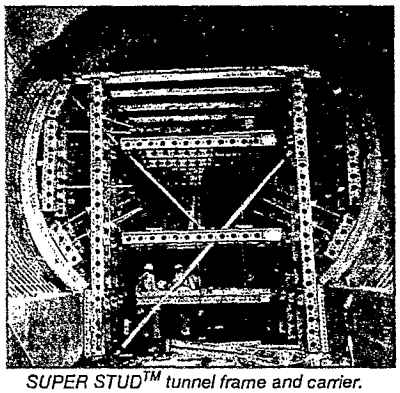
Muck Tower and Head Frame for Drop Shaft.



Full round telescopic forms.



Elbow of a Penstock tunnel.



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tion-related associations promise progress on the trenchless front. Earlier this year nine groups entered into a memorandum of understanding that provides a forum for the organizations to pool their resources to advance trenchless construction. The nine: The American Society of Civil Engineers, American Underground Space Association, American Waterworks Association, Associated General Contractors of America, National Association of Sewer Service Companies, National Utility Contractors Association, Trenchless Technology Center, Water Environment Federation, and North American Society for Trenchless Technology.

Safety: a prime concern

Unless proper safety precautions are taken, trench collapses can occur, and can injure or kill workers. Some 100 persons are killed each year in trenching and excavation accidents, according to the Occupational Safety and Health Administration. In recent years OSHA has worked diligently to enforce trench safety regulations and at the same time, to gain the cooperation of underground contractors in an effort to improve trench safety.

Stiff penalties await those who fail to comply with OSHA regulations: fines run up to $7,000 for serious violations and can hit $70,000 for willful violations. A serious violation, says NUCA safety director George Kennedy, is defined as one that could result in serious injury, loss of life or limbs. While OSHA rarely fines a contractor $70,000, such a fine would be imposed for intentional violations of OSHA rules.

Basic OSHA rules require that all trenches more than 5 ft. deep must be protected, either with shoring, shielding or sloping sides. OSHA standards include a system for classifying soils to determine which protection system best fits the application. And, the standard demands that a competent person do the soils analysis in that process.

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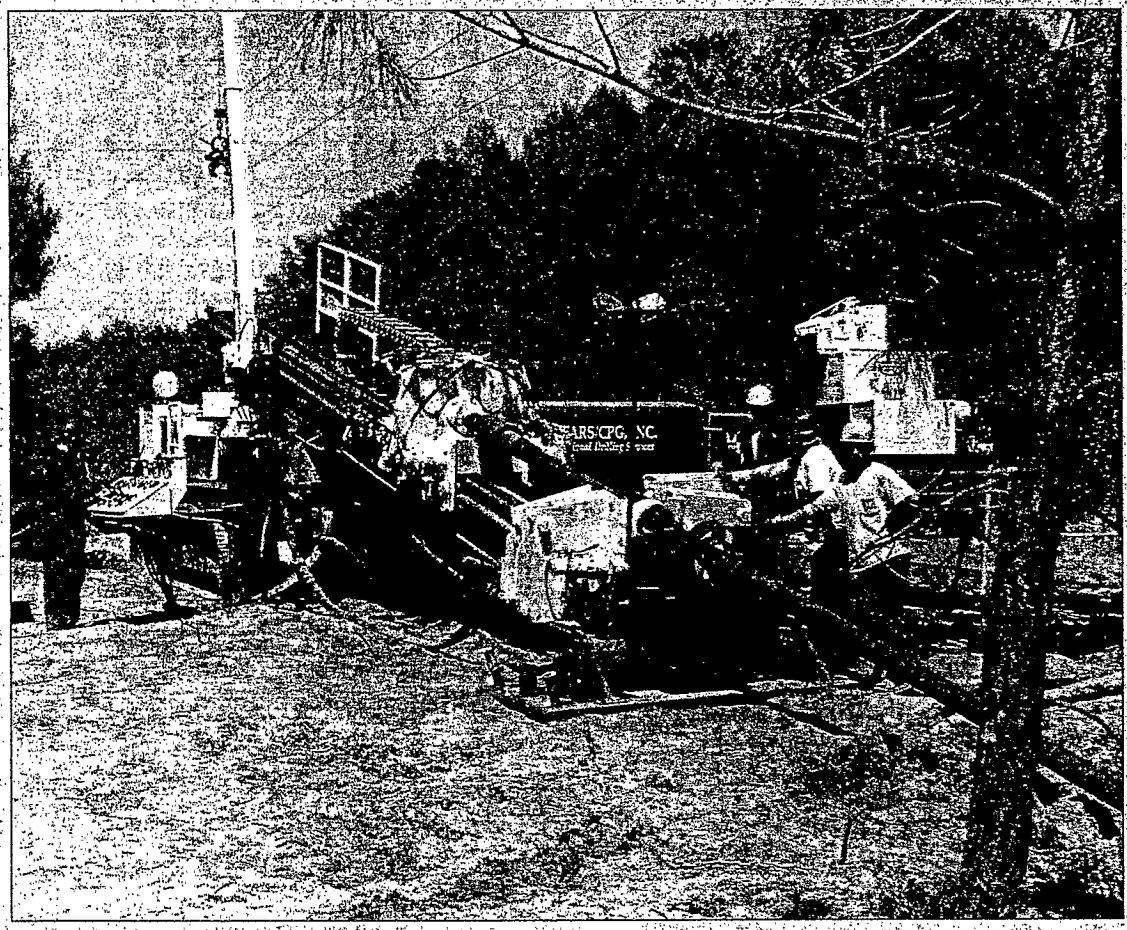

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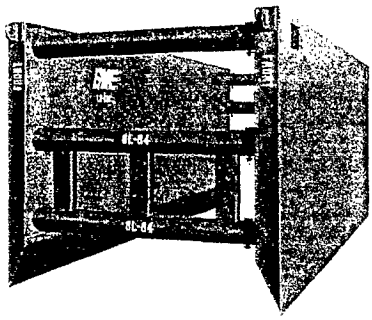
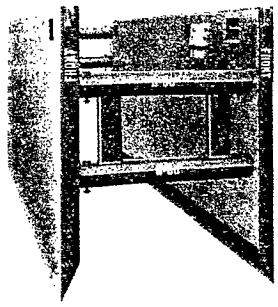
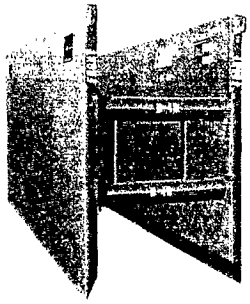


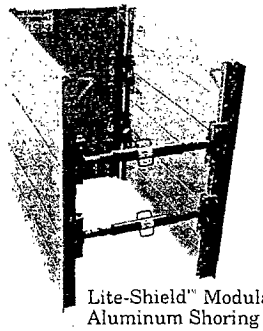
L Series: 10" and 8" wall thickness



K Series: 6" wall thickness



N Series: 4" wall thickness



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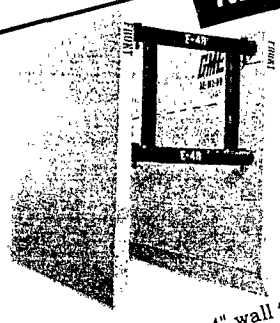

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If sloping sides are the chosen method, Kennedy says the typical OSHA specification is 1.5:1 — for every foot of depth, the trench edge must be set back 1.5 ft.

Shoring consists of bracing that usually is hydraulically forced against trench sides to support them and prevent the movement of soil in or around the trench. Such systems rely on soils' natural cohesion to prevent its movement. In very unstable soils hydraulic waler shores are used with solid sheeting that supports trench walls completely.

Shielding systems, in contrast, do not support trench walls; they simply protect workers in a box-like structure. Trench shields with upper-half cross braces provide clearance in the trench bottom for the pipe.

Trench boxes, a form of shielding, typically have walls relatively longer than their height, fit down inside the trench and protect workers who adjust and join the pipe sections. They range in size from 4 ft. high by 6 ft. long to 12 or 14 ft. high by about 30 ft. long. A new twist: trench boxes are now offered in aluminum, says Kennedy.

"Contractors should ask themselves if they can afford to be without safety equipment — not if they can afford it," says Rory R. McLean, marketing director for Kundel Industries, a NUCA member. "If I could only get contractors to do one thing, it would for them to plan every detail of their job before they start digging," he adds.

McLean offers the following safety tips:

- Make sure a competent person attends to the safety of the job at all times. OSHA defines a competent person as one capable of identifying existing and predictable hazards in and around trenching and excavation jobsites. Such a person can be a foreman or superintendent, and should be trained in soil evaluations, trench safety systems and OSHA and state regulations.
- Use adequate safety systems that meet applicable regulations.
- Assure that all laws and regulations are followed.

Naturally, site conditions should be considered when planning the project. Each project requires close attention to traffic patterns, nearness of structures and their condition, surface and groundwater and the weather.

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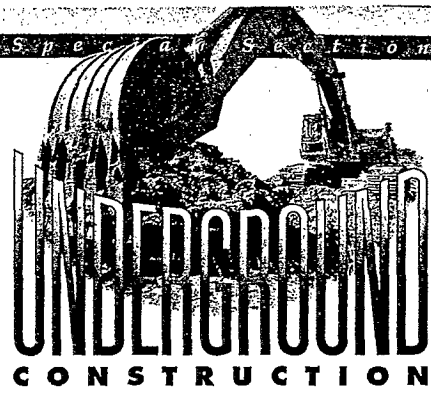


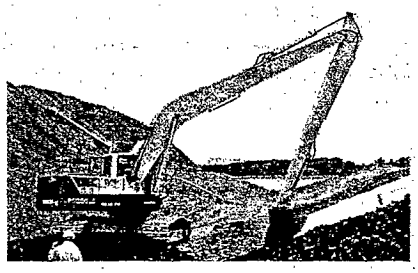
Case Histories

LONG BOOMS, BIG BUCKETS HELP EXCAVATE NEW CANAL

O & F Construction, Idaho Falls, Idaho, was recently faced with the challenge of building a canal to feed water to a newly constructed hydroelectric plant eight miles east of Ashton, Idaho. This new canal, named the Marysville Canal, would run parallel to the turbulent Falls River and would power the turbines of a 9.7 megawatt generating station, while also providing irrigation water for area seed potato farmers.

The Marysville Canal was a joint effort between five contracting companies. O & F excavated over one million yards of earth to dig the canal, which is approximately 85 ft wide at the top.

To excavate the canal, O & F used a fleet of Komatsu machines, which included six PC200LC-5 hydraulic excavators, two PC300LC-5 hydraulic excavators, one PC400LC-5 hydraulic excavator, one WA380-1 wheel loader and one WA450-2 wheel loader. Due to the width of the canal, three of the PC200 excavators were equipped with 50-foot Pierce Pacific long booms and 60-in. buckets.



"We needed the reach of the long booms to grade the banks of the canal, and they were indispensable," said La Vern Fowler, president of O & F.

After the cuts were made to build the canal, the soil was compacted, then a protective liner was placed by a California-based company specializing in that type of work. Fowler explained that the PVC liner has a protective coating underneath to help make the canal watertight. And, once it was in place, a 1 ft layer of 5-1/2-in. rock was spread over the liner—over 100,000 tons of crushed rock were used on the project.

Coordination and scheduling of the Marysville Canal made the project a challenge. According to Fowler, one of the biggest challenges involved orchestrating the work of all the company's equipment along a 12-14 ft wide road on the south side of the canal. "We had 38 major pieces of equipment moving in and out of that road's right of way while also having to move materials in and out from the road," Fowler said.

The project began in mid February, 1993 and was completed on July 15, 1993. Factors that contributed to O & F meeting a stringent completion date was the 97% uptime rate of Komatsu excavators.

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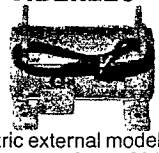

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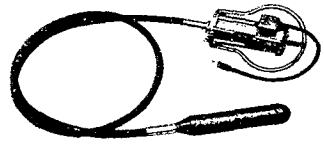



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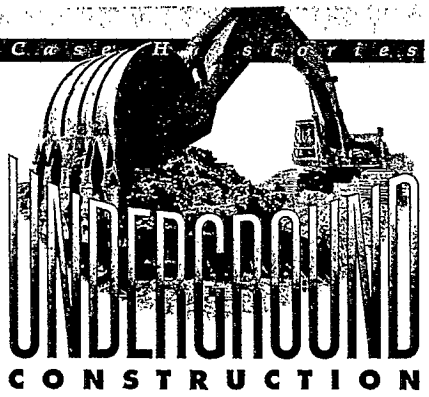


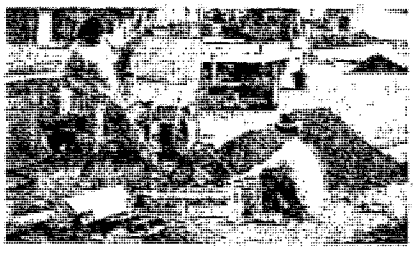
TRENCHLESS TECHNOLOGY USED FOR WATER LINE REPLACEMENT

Riverside-Highland Water Company, Colton, Calif., serves the municipal water supply needs for the community of Grand Terrace, California. Native soils are extremely corrosive to steel and galvanized water supply lines because of the hot chemical reaction. This reaction greatly reduces the lifetime of the supply lines and speeds their need for replacement. The ground conditions in the area can vary widely from sandy loam to gravel and very hard, dry, decomposed granite.

Kingdon and Sons, Inc., of Chino, California specializing in water, sewer, and storm drain construction, is under contract to Riverside-Highland Water Company to replace 4600 ft of steel main and 98 house service connections in Grand Terrace. Plans called for the old steel main to be replaced with new 6-in. and 8-in. certainteed A.C. pipe. New 1-in. poly tube, which seems to greatly outlast steel or copper in these soils, was used for the 98 new service connections.

In a search for a more cost effective way to replace the service crossings, Bill Kingdon, president of Kingdon and Sons, Inc., began looking for a better way.

Open cutting the trench was necessary for the installation of the new main line. However, a fast, efficient way of installing the service crossings without trenching would save not only pavement costs, but the problem of compacting ditches back to necessary standards. Kingdon discovered the POW-R Mole Model PD-4 hydraulic pusher/puller, and contacted Petersen Underground Equipment, Inc., of Murray, Utah.



12-volt hoist was used to lower and raise PD-4.

The PD-4 is a top loading machine which uses 1-5/8-in. solid steel rods in 2-1/2 ft lengths to push under the roadway. Solid steel rods are better suited to push through adverse soil conditions and yet maintain accuracy. The operating trench required is only 48-in. long, 20-in. wide and the PD-4 will operate from most hydraulic sources.

The main concern when Kingdon purchased the PD-4 and Power Stinger hydraulic power supply was the ability of the system to complete at least 10 service line crossings per day. After purchase of the POW-R Mole System, Kingdon set about designing a special trailer to transport the machine and streamline the operation.

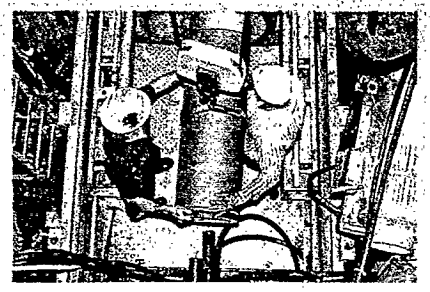
The trailer was 4 ft by 8 ft, equipped with mounts for the Power Stinger, tool box for accessories, POW-R MOLE PD-4, And a Venturo 12 volt crane. This crane allows the PD-4 to be lifted in and out of the operating trench without tying up an additional piece of equipment or unnecessary labor from the pipe crew.

A 410C John Deere backhoe prepares the operating trenches and target pits ahead of the pipe crew. Mike Colvin, foremen on the project, stated that from the beginning of the project, the PD-4 allowed the required 10 pushes to made under the average 30 ft of pavement between 7 a.m.. and 10:30 a.m. The only thing that prevented more pushes being made was the fact that the three man pipe crew is also responsible for the service hookups, backfill and cleanup. With more personnel, Kingdon believes the average number of crossings completed per day could have risen to 20 per work day on this project.

MICROTUNNELLING EQUIPMENT RESCUES SUSPENDED SEWER PROJECT

Microtunnelling was rapidly deployed to complete an open cut wastewater sewer installation which had been discontinued due to difficult geologic conditions within a populous California residential area.

Fremont is a typical California suburban community near downtown San Francisco. As part of an expansion of the wastewater collection system, Union



Sanitary District (USD), which serves the area, appropriated a project to relocate and upsize existing sewers to make way for planned improvements to adjacent Interstate 880, a major commuter route into the city.

Original attempts to construct the sewers by conventional open cut methods proved to be impossible due to the inability to dewater soils present in the area. The attempts at excavation were suspended after the contractor proved to the authorities that the dewatering methods specified for the project could not provide adequate soils stabilization.

To circumvent the risk of severe property damage and possible long term maintenance costs, USD discontinued the open-cut concept, and undertook a bold move to implement trenchless construction. The project was swiftly redesigned to accommodate microtunnelling, which would enable the installation of the utility without any dewatering requirements.

EMSCO Contracting of Oakland, Calif., was awarded the redesigned project in September, 1992. They subcontracted the microtunnelling work to Western Utility Contractors, Inc. (Westcon) of Pleasant Grove, Utah. A Herrenknecht AVN 300 microtunnelling machine and jacking frame were expedited by air, from Germany, to be used with Westcon's support package.

Residents in the neighborhood were consulted and advised by USD of the proposed method of construction in an effort to ease their concerns about possible damage to the area. Social awareness played a key role in the introduction of the new methodology. Noise abatement during extended working hours was a critical concern of this bedroom community.

The equipment was positioned into small 12 ft diameter steel caisson jacking shafts, which were constructed in welded sections, and lowered to an elevation below the existing groundwater. Reception shafts, 8 ft-in diameter, were constructed to make way for the first installation of jacked-in-place vitrified clay pipe in California.

R0013596

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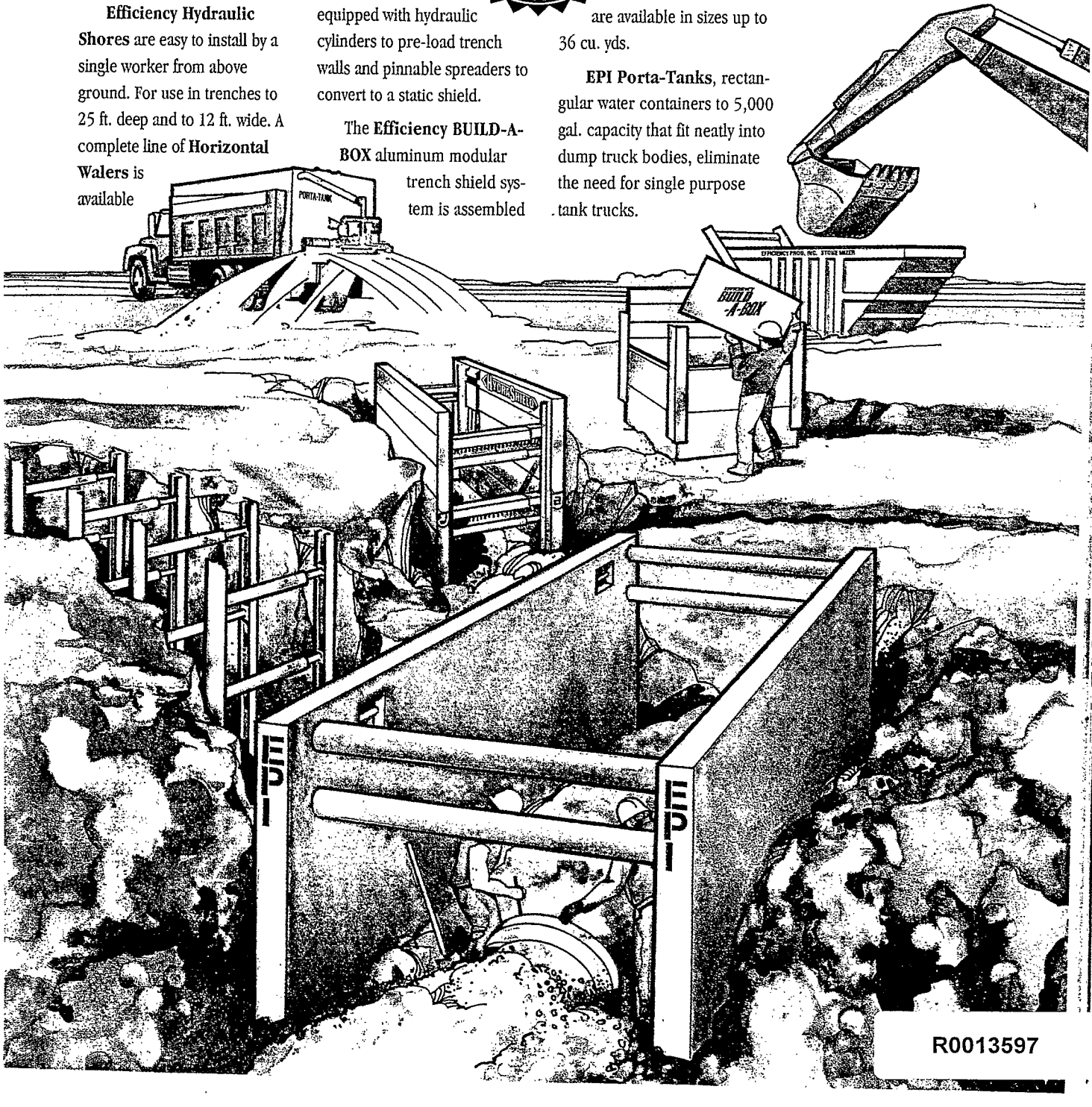


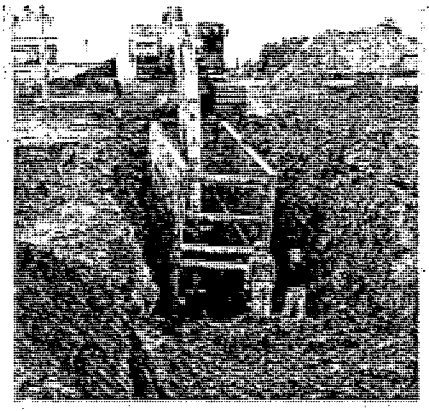
R0013597

Mission Clay Products of Pittsburg, Kan., supplied the newly designed 12 inch i.d. pipe sections in 4 ft lengths, which were inspected and tested prior to each individual installation. Because microtunnelling is quieter and less disruptive than open-trench construction methods, Westcon was able to work 18 hours per day without major disturbance to the neighborhood. Microtunnelling progressed from shaft to shaft through the neighborhood at a maximum production rate of 130 ft per day. All of the 1,000 ft comprising the four pipe drives were completed within a four week schedule.

Advantages and savings in the social sector continue to require individual assessment per project. In this case, the quick response and bold decisions proved that seemingly impossible conditions can be surmounted with technologically advanced methods.

ELABORATE TRENCH SHIELDING USED TO TUNNEL FOR SEWER PIPE

It took a whole lot of trench shield equipment to prepare entry and exit points for a tunnel constructed to insert 36" diameter cast iron sewer pipe under Washington Street in West Chicago, Illinois.



View from the east side of Washington Street shows 34-foot deep excavation opened to accommodate pipe emerging from tunnel.

The contractor, Harry Kuhn, Inc. of West Chicago, handled the $2 million contract to install 9,600 feet of the pipe in a time efficient, safety conscious fashion. The job is part of the overall expansion of the DuPage County Airport.

To tunnel under heavy traffic laden Washington Street from the West, the Kuhn firm constructed an elaborate tunnel machine entry point. Working with local Efficiency Production trench shield distributor, Lee Jensen Sales, Inc., Crystal Lake, Illinois, the contractor built a trench shield system to fit into a work site 39 feet long, 24 feet deep, and 10 feet wide. An additional 10 feet of trench was sloped back at the top in one-to-one ration, so that the total depth ended up being 34 feet.

The trench shielding equipment used was substantial. It consisted of three 8 ft. high trench shields stacked one on top of the other to form a 24 ft high wall of steel 27 feet long. Each section had 8-in. wide steel double walls.

A 12 ft. long section, also 8 ft high, in three sections was stacked behind the 27 ft. long sections to total 39 feet in length. Spreader bars for each section were 10 feet wide. So the entire enclosed entry work site ended up with a trench shield system that measured 14 feet high, 39 feet long and 10 feet wide. A boring machine capable of cutting a 48 in. tunnel was placed into the work site to cut under Washington Street.

At the exit point on the eastern side of Washington Street, a 33 ft. deep work site was excavated and three sections of 827HT Efficiency trench shields were placed in the pit stacked one on top of the other. This combination measured 24 feet high, 27 feet long and 10 feet wide.

The job was completed without major incident, without disturbing traffic, and with extra attention to worker safety.

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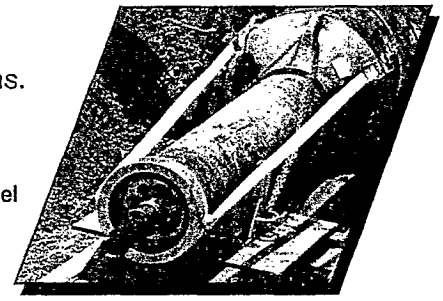

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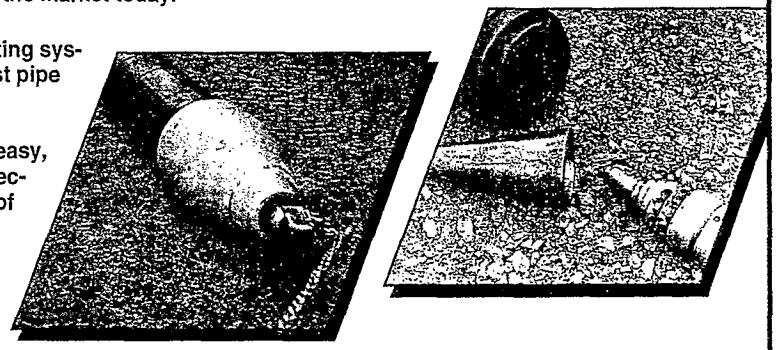

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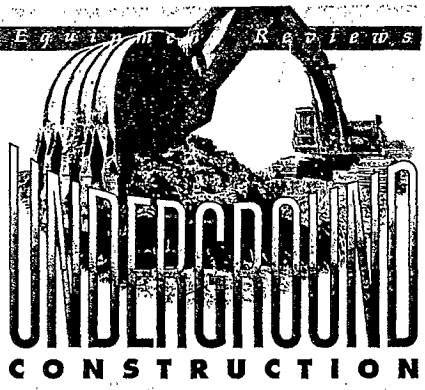
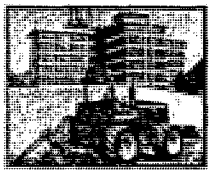


EQUIPMENT REVIEWS

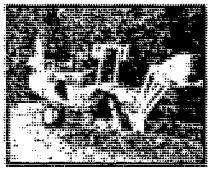
The Ditch Witch model 7610 is a mechanical drive trencher and vibratory plow which accepts a wide range of modules for a variety of underground construction jobs. The mechanical trenching and vibratory plow drive incorporates an enclosed gear box which protects components and eliminates daily maintenance. Available modules include trenchers; vibratory plow; combination trencher and plow, earth saw disc-type trencher, and front-mounted utility backhoe.



Circle # 101 on Reader Service Card

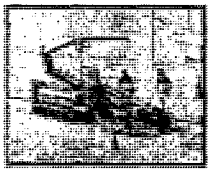
Parsons Trenchers has introduced a new 80 HP multi-purpose trencher. The Parsons T-750 can be equipped for trenching, cable plowing, back filling, backhoeing, boring and offset trenching.

The T-750's design incorporates an articulated frame and hydraulically powered automotive-type steering for maneuverability. Its special design provides optimum digging rates for soil and other materials. It includes a single master foot clutch to disengage both systems simultaneously in case of emergency. Other features: Hydraulic steering and transmission, centrally-located operator's station, offset or center mount trencher module, and rotary carbide teeth on a solid slide boom.



Circle # 102 on Reader Service Card

Ditch Witch has introduced the new 8/60 Jet Trac® long-range directional boring system. The 8/60, powered by an 85-HP diesel fluid system, can make horizontal bores to distances of 600 feet and pull back material as large as eight inches in diameter. The 8/60 drill unit drives its own anchoring stakes, has hydraulic drill pipe make up and breakout, has smooth operating capabilities due to its electric controls, and includes the Jet Trac electrical strike system.



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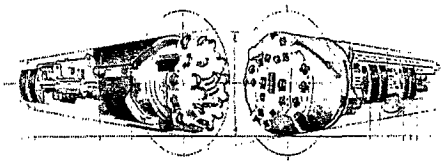

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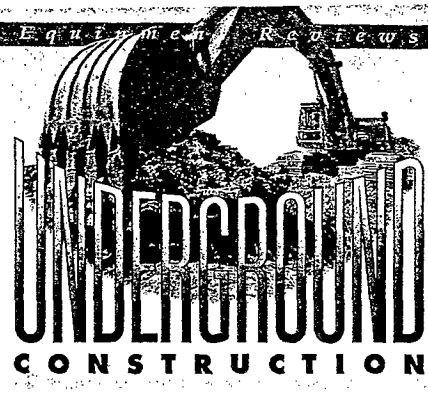
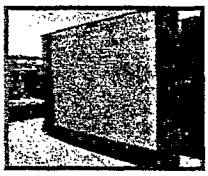
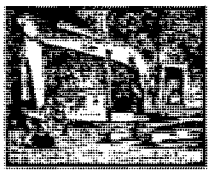


Kundel Industries has introduced their Shorlite Shield, designed with a ultra narrow 2 1/2-in. wall trench shield. Constructed from durable steel with the lightness and flexibility of aluminum, the Shorlite is designed to work as a system box that can be stacked, hooked-in-tandem and leap frogged. Its center is built with aluminum panels, and its outer wall is wrapped in a steel barrier. All steel end tubes are part of the trench shield barrier, and give extra strong support to the ends of the box where most of the driving force will be applied. These end tubes protect the aluminum panels while increasing the depth rating. And, its all steel cutting edge protects the aluminum panels from boulders and other objects that are encountered during excavation. An all steel cutting bar protects the bottom of the box for long wear.



Circle # 104 on Reader Service Card

Alitec's model CP30BH excavator cold planer is designed for use with excavators in the 50,000 to 150,000 lb. class and requires a minimum flow of 60 gpm at 3,000 psi. It features a planetary drum drive; a manual or hydraulic depth control from cab; and up to 120 hydraulic horsepower with 10,000 lbs. torque. The model CP30BH is compatible with most coupling systems; its planetary drum drive provides higher torque to cutting teeth and it has a lower initial cost vs. current methods, says Alitec.



Circle # 105 on Reader Service Card

The **Thor® 21B-E breaker** with vibration damped handles reduces jarring of operator's hands, elbows and shoulders making work more effective and safe. The 21PB-E features high power for excellent breaking; a swivel inlet; a high volume oil reservoir; a light weight and a silencer designed to reduce freezing problems. Its low air consumption offers economy and years of trouble free operation. Plus, the 21B-E breaker has been developed with an optional safety lock-off device to increase operator safety.

Circle # 106 on Reader Service Card

Speed Shore Corporation has introduced the new "Speed Strut" to their Shoring Shield line. "Speed Struts" incorporate the Shoring Shield's hydraulic cylinders and return springs within rugged telescoping steel sleeves to allow for 3 and 4 sided trench support, while providing increased protection to critical components. Quick- connect fittings facilitate hand assembly/disassembly and allow for transport in a light-duty truck. A patented hydraulic manifold enables independent strut control to accommodate irregular, non-uniform excavations.

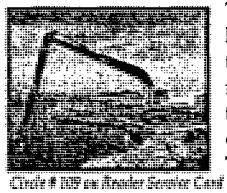


Circle # 107 on Reader Service Card

Vulcan Iron Works, Inc.'s air/steam powered pile hammers are built to install ocean and coastal structures. Vulcan Iron Work's single acting type hammers rely on gravity through a distance to achieve their striking energy. There are five standard hammer sizes, with striking energies ranging from 100,000 to 500,00 ft-lbs (13.8 to 69.2 tonnemeters), capable of driving piles up to 96-in. (2438mm) in diameter.

Circle # 108 on Reader Service Card

Link-Belt Construction Equipment Co.'s LS-4300WLF C Series II excavator is equipped with a 25 ft 6-in. (7.77m) long arm provides contractors with operator and machine production efficiency. The 80,300 lb. (36, 424 kg) LS-4300WLF features a 60 ft 9-in. (18.51 m) reach and can be fitted with a 60-in. (1.52m) ditch cleaning bucket. The boom and arm fold and lower to 12 ft (3.66 m) without unpinning for fast and easy transport. The standard attachment is completely interchangeable and compatible with the standard boomhoist cylinders.



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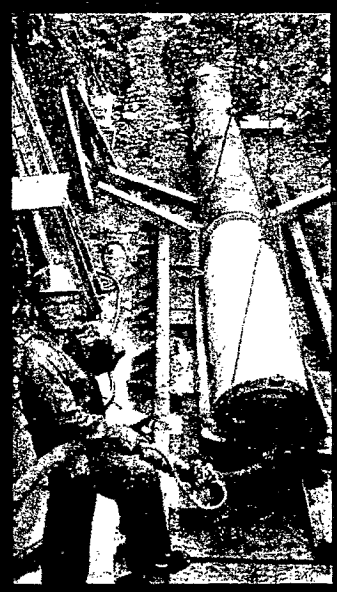

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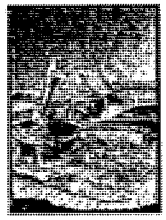
UNDERGROUND CONSTRUCTION

The 75-metric-ton-class Caterpillar® Cat 375 excavator features a new design with increased performance capabilities, new electronic controls and versatility through a wide range of options. Its electronic power control (EPC) system manages the engine and hydraulic system, putting power where and when it's needed most. The EPC balances engine speed and hydraulic pump output and utilizes up to 98% of available engine power to drive the pumps. A micro computer controls engine underspeed to prevent lugging under load and controls a back-up system with machine diagnostics to minimize downtime. Two pilot-operated, adjustable joysticks control all front end and swing functions. Low sound levels, smooth low-effort controls, and excellent all-around visibility minimize operator fatigue. And, a nearly infinite range of seat and control adjustments on either of two seat options allow operators of any size to work in their most desirable position.



Circle # 110 on Reader Service Card

The Gradall Co.'s new XL4000 series excavators are equipped with high pressure hydraulics which increase productivity with faster cycle times and higher digging forces. Plus, they can greatly reduce fuel costs by making full, efficient use of horsepower with twin load sensing piston pumps which automatically adjust to meet changing job requirements, while a third piston pump powers the fully independent closed loop swing circuit. Reach and range extend to a full 30 ft 6-in. at grade, or to over 45 ft with a Telestick attachment. Its versatility is improved with Gradall's famed boom which can increase attachment productivity as it telescopes, raises, lowers, digs, swings and tilts up to 360 degrees. And, all boom movements and tilt speed are easily controlled with convenient joysticks built into a new operator compartment.



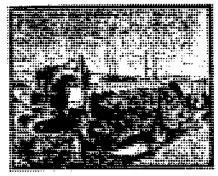
Circle # 111 on Reader Service Card



The Vangaurd drive panel system manufactured by Kundel Industries is a shoring system that is designed for use in unstable soil when excavating along side existing utilities, underground and above ground structures. The waler system that is used in connection with the Vanguard panel system has a modular design, and it can be pre-assembled before starting an excavation. This guide pocket box system is designed to hold and guide drive panels. When using this guide pocket system, trenches can be excavated up to 5 ft deep; then the guide box can be inserted in the trench.

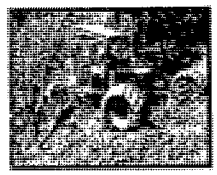
Circle # 112 on Reader Service Card

Kubota Tractor Corporation has added the new KX-Series excavators to its expanding line of compact construction equipment. Ranging from 22.2 to 42.7 horsepower, the new KX-41, KX-71, KX-101 and KX-151 models deliver powerful performance for a variety of digging applications. Each of the KX-Series models feature a commanding, power-up hydraulic system; walk-through design on four-post models for increased operator mobility and auxiliary hydraulic lines extending to the end of the dipper arm to provide a wider range of uses and enhance attachment applications.



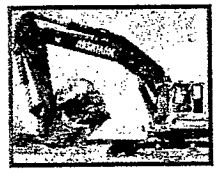
Circle # 113 on Reader Service Card

The HS 40 D Walking Excavator by Schaeff Inc. is a problem solver for all operations which are not possible with any conventional wheel-and track-type excavator. Its areas of operations include rough terrain; embankments; slopes; mountainous terrain; roads with heavy traffic; river courses; terrace construction and more. This excavator is powered by a water-cooled 38kW (52 HP) supercharged diesel engine for mountain operation with altitudes up to 6500 ft without a drop in output. The HS 40 D's working hydraulic system is an energy saving, but powerful and fast hydraulic circuit with Schaeff specific horsepower summation control via a dual-axial piston pump. A variety of tools and optional attachments make the HS 40 D's operating spectrum wider, e.g. buckets from 140 to 340l contents and 350-900 mm width, ditch-cleaning bucket, tilt bucket, and profile buckets. Optional attachments range from hydraulic hammer to swamp attachment, ripping tooth and towbar.



Circle # 114 on Reader Service Card

Akerman model EC300 excavator by VME Americas, Inc. features a 209 hp direct injection, turbocharged Volvo engine; an operating weight between 66,200 to 68,400 lbs.; an Akerman three-circuit computerized multilevel priority hydraulic system and a long undercarriage for high stability. Its new comfort cab contains a computerized control and warning system; an ergonomic environment; low level sound and filtered air. Plus, it has high flexibility for extra equipment/ hydraulics.



Circle # 115 on Reader Service Card

John Deere's 690E-LC excavator features an advanced engine and hydraulic control system called Quadtronics. The 130 net hp, 45,120 lb. unit features a low-profile engine hood, giving visibility to the rear, a roomy comfortable cab and many

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R0013602

CertainTeed

CertainTeed Corporation, Pipe & Plastics Group

SOMETHING

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CertainTeed has the experience and proven success with over 20 years in manufacturing restrained joint piping systems.

SOMETHING

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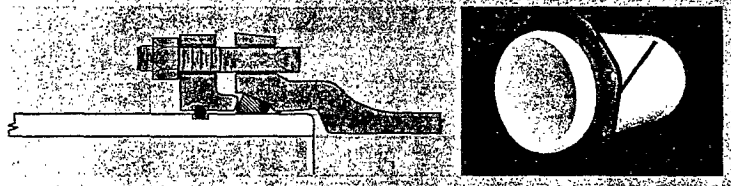
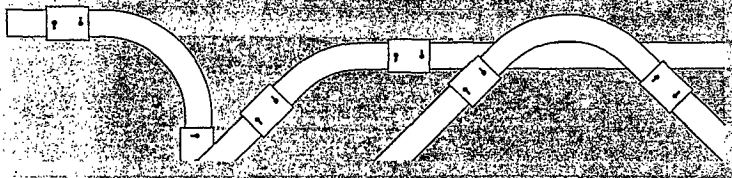
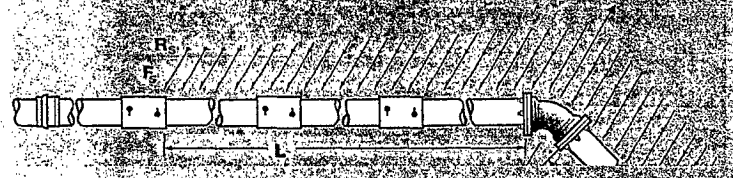


Certa-Lok • VIP • GLANDS adapt Certa-Lok VIP to mechanical joint cast iron fittings.



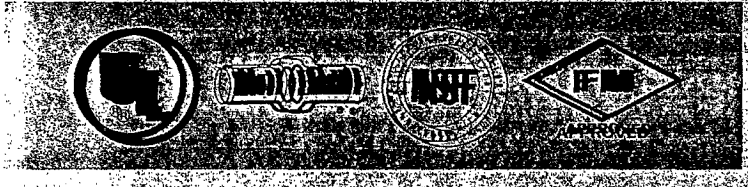
Certa-Lok • VIP • SWEEPS are designed to provide change in direction of pipeline, available in 90°, 45°, and 22-1/2°.



Certa-Lok • VIP • SOFTWARE provides easy calculation of restrained length required under various conditions.

SOMETHING

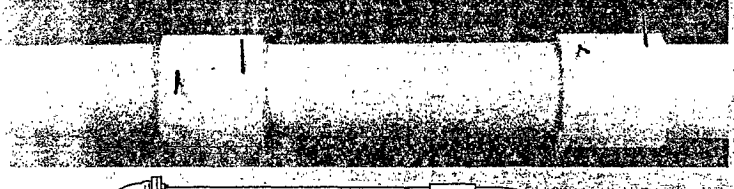
TESTED



The list of agency approvals & listings includes: Underwriters Laboratories Inc., Factory Mutual, National Sanitation Foundation, and Uni-Bell. In addition Certa-Lok VIP meets the performance requirements of AWWA C900.

SOMETHING

TRUE



Certa-Lok VIP is manufactured with precision machined grooves on the pipe and in the coupling, and with the spline lock provides a fully circumferential restrained joint. A gasket in the coupling provides a hydraulic seal.



CertainTeed

CertainTeed Corporation
PIPE & PLASTICS GROUP

P.O. BOX 860 VALLEY FORGE, PA 19482
Phone (215) 341-6820 Fax (215) 341-6837

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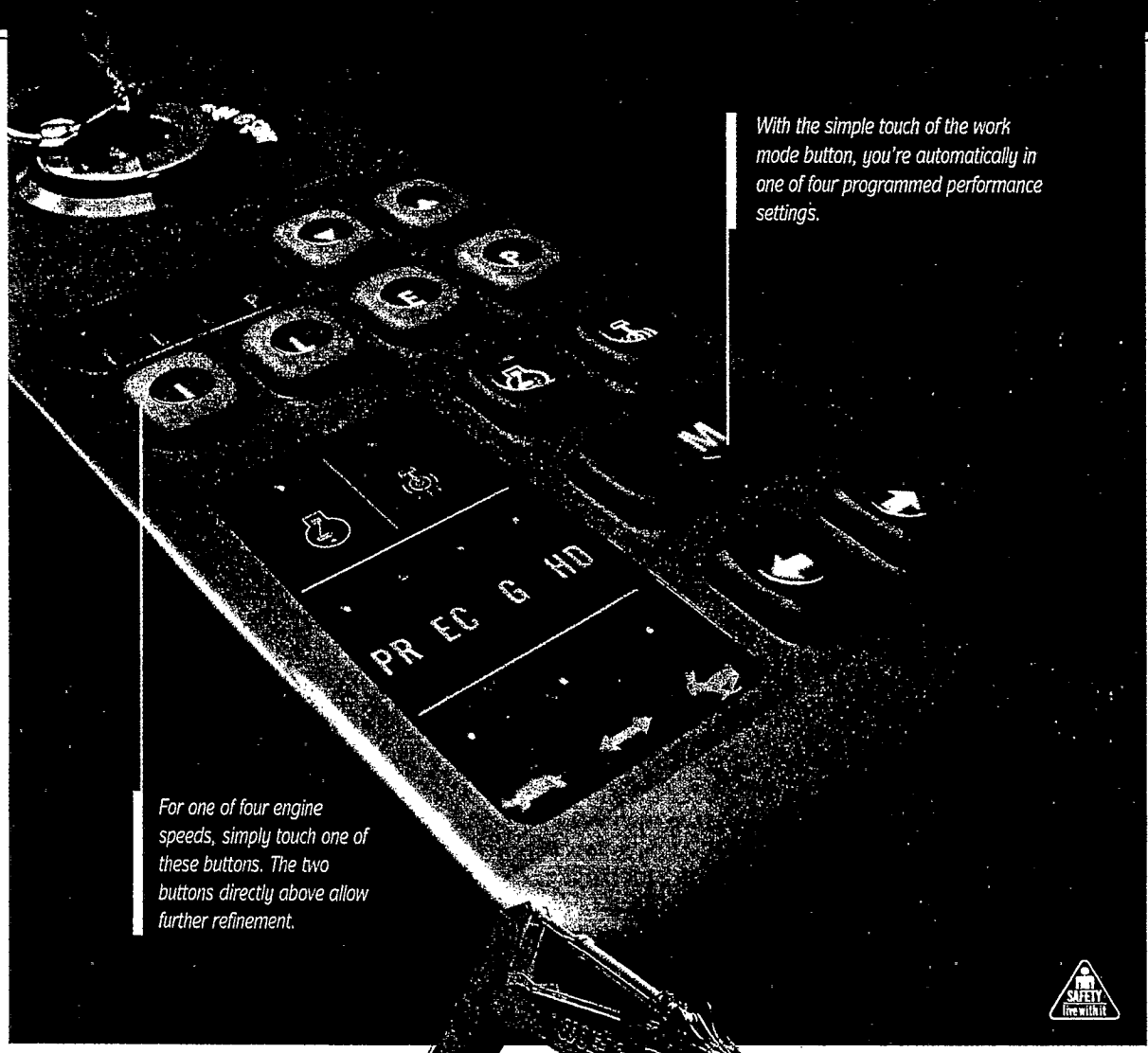
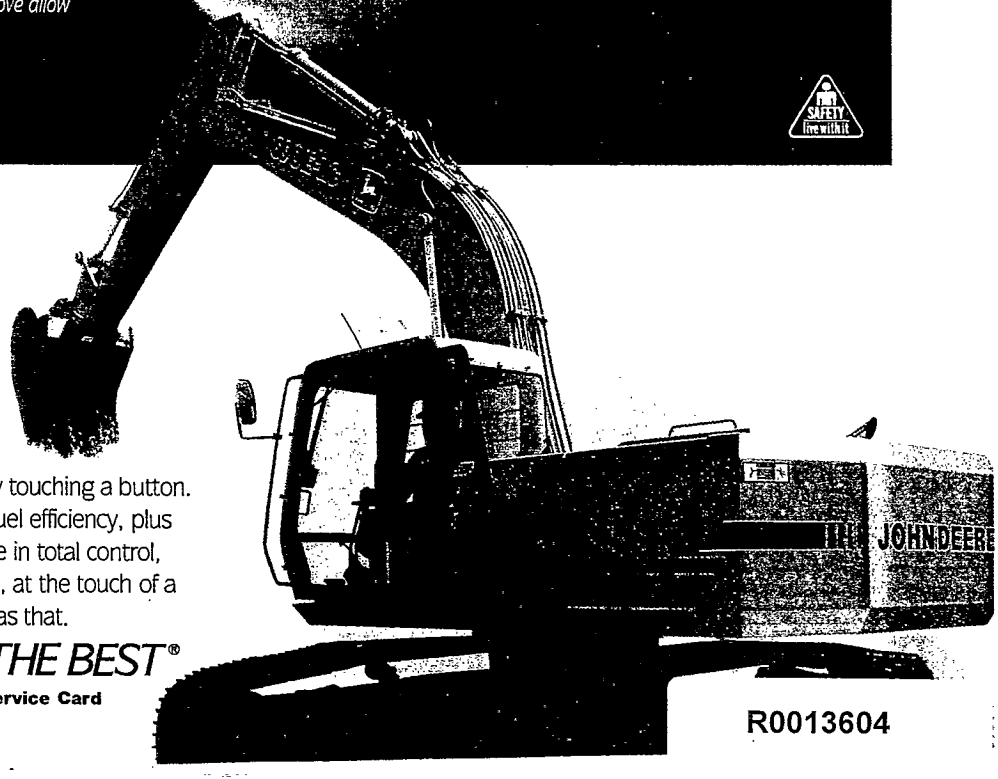
R0013603

SIMPLY MORE EFFICIENT



With the simple touch of the work mode button, you're automatically in one of four programmed performance settings.

For one of four engine speeds, simply touch one of these buttons. The two buttons directly above allow further refinement.



With its new E-Series Excavators, John Deere can make your operation more efficient. QUADTRONICS, a microprocessor engine/hydraulic management system, lets the operator set up the machine's engine and hydraulic system by simply touching a button. You get optimum production, better fuel efficiency, plus performance tailored to the job. You're in total control, and more efficient too, at the touch of a button. It's as simple as that.

JOHN DEERE

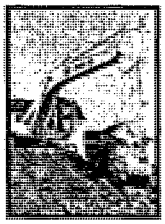
RUN WITH THE BEST®

Circle 71 on Reader Service Card

R0013604



production-oriented features. Its digging depth is 21 ft 8-in. with a lifting capacity of 14,300 lbs. An optional arm digs at 19 ft 4-in. The Quadtronics system by John Deere allows the operator to select the machine performance he wants by choosing combinations of four hydraulic work modes and four engine power modes. The system consists of the main hydraulic pump, the controller or microprocessor, an engine throttle proportional solenoid and a pump displacement proportional solenoid. The microprocessor/controller is located behind the operator's seat and responds to easy-to-use keypad commands from the operator for hydraulic work modes and engine power levels. Work modes include precision, economy, general and heavy duty.



Circle # 116 on Reader Service Card

A new hydraulic hammer product line by **Link-Belt Construction Equipment Co.** has recently been introduced. Designated the "RP Series," 13 models are offered ranging in size from 250 to 11,000 ft /lb. impact energy class. These high performance hammers feature a nitrogen cushion chamber that not only absorbs shock from the hammering action, but also stores the piston recoil energy and applies it to the next blow for increased productivity. The elongated piston and dual retainer pin design provide alignment of the piston and tool for maximum energy per blow and ease of tool placement.



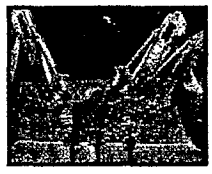
Circle # 117 on Reader Service Card

Shieldco Trench Safety Systems has added their new "R-Series" shields to their line of Trench Shielding systems. Designed and certified by their staff of registered professional engineers, "R-Series" shields optimize strength, while minimizing weight and sidewall thickness. Shieldco special features include: replaceable hardwood pounding blocks to protect the integrity of the structure; steel wear plates for added strength and puncture resistance in the critical spreader socket areas; and a variety of industry options that are Shieldco standard features.



Circle # 118 on Reader Service Card

JCB Inc. has introduced a range of new hydraulic breakers, the HammerMaster 60 Series. Three different breakers in the 400 ft lb. to 1000 ft lb. size classes comprise the range, which was developed to perfectly complement the weight distribution and hydraulic systems of JCB's 200 series of backhoe loaders. The breakers can be directly mounted to the dipper or picked up by JCB's backhoe bucket quick coupler. JCB offers a three breaker range that offers sizes for applications in road building, demolition, quarrying, metallurgy and utility work. They have been engineered with constant blow energy to ensure maximum breaking power, while supply pressure damping is used for smooth reliable operation.



Circle # 119 on Reader Service Card

Kubota Tractor Corporation has introduced three new KXB hydraulic breakers for its KX-Series excavator line—the KXB400, KXB500 and the KXB600. These hydraulic breakers have an integral pressure adjusting valve that guarantees constant blow energy by utilizing 100% of available power. Ultra-high blow rates are achieved by the high-volume distributor valve and all blows are at full power and maximum



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References on request.

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We'll do the rest!

Doing business with LaBarge is just about that simple. When you call us, we will help you determine your pipe needs, assure availability, give you a quote, and set up a delivery date. All with the attention to detail, expertise and quality that have become associated with the LaBarge name. You can also be assured of receiving first grade product, whether you order ERW, Seamless, DSAW or X-Grade pipe. That's why LaBarge continues to be the largest stocking distributor of line pipe in North America.

It's time to do business with the best. Call LaBarge. We'll do the rest!

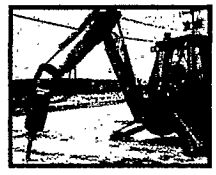
LaBarge pipe&steel company
901 North Tenth Street
St. Louis, Missouri 63101

Circle 74 on Reader Service Card

frequency. This translates into maximum productivity by utilizing full oil flow and pressure supplied by the KX compact excavator. Compatible with the Kubota KX-41 excavator, the KXB400 hydraulic breaker has an impact energy classification of 200 ft lbs. and operates at 1100 blows per minute (bpm). Designed for Kubota's KX-71 and KX-101 excavator models, the KXB500 hydraulic breaker is included in the 500 ft-lbs.impact energy class and operates at 1100 (KX-71) or 1275 (KX-101) bpm. The KXB600 hydraulic breaker is suited to Kubota's KX-151 excavator. Featuring a 750 ft-lbs. impact energy classification, KXB600 offers a powerful breaking force with a frequency of 875 bpm.

Circle # 120 on Reader Service Card

Hanix America, Inc. offers ten models of hydraulic mounted breakers with leading-edge technical improvements to match any model wheel loader backhoe. Replaceable tool bushings and simplified design with only two moving parts reduce maintenance requirements and repair costs. Hydraulic mounted breakers produce hard hitting, long-piston design which deliver maximum productivity and minimum vibration and heat to the tractor. The three breaker models to match any wheel loader backhoe, have 550, 850 and 1400 ft-lbs. class ratings and are available with customized ready-to-mount brackets.



Circle # 121 on Reader Service Card

Trencor Jetco, Inc. offers a side-shifting option on their five smaller trenching attachments, from the 460 through the 1060. The patented, hydraulically operated side-shift option was developed over two years ago to laterally move the entire digging boom left or right in tight operating spaces without affecting the machine's digging performance. Easy to use and control, Trencor Jetco side-shift option allow the operator to easily set the machine for digging, and the boom can be moved left to right during digging. The side-shift options allows a contractor to work right up to a wall, follow an existing right of way while digging, and avoid obstacles without deviating from the established course.



Circle # 122 on Reader Service Card

BGIS Systems Company announces the debut of its revolutionary software system, StreetSmarts, designed for the management information needs of the highway/heavy/ utility contractor and material producer. The multi-user system which operates in a full color, user-friendly, graphical environment is a comprehensive system integrating job cost, equipment management, accounting, payroll, estimating/bidding, contract processing, scale ticketing and office automation. BIGS offers complete training and post installation support programs.

Circle # 123 on Reader Service Card

Tramac Corporation's pushing method for installing steel pipes provides an economical alternative to open-cut trenching or auguring. Tramac's steel pipe pushing machines are driven

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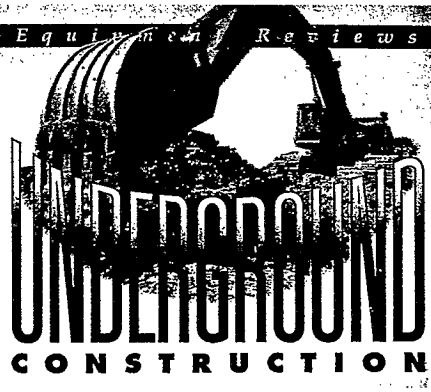


with compressed air. With the correct choice of machine and proper adapter, 12 to 54-in. diameter pipe can be driven into most types of soil. The soil plug inside the pipe keeps the pipe level and on course. When the pushing process is complete, the soil can be removed by means of compressed air or water, depending on soil conditions. The



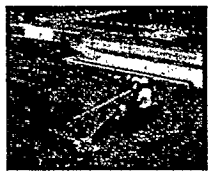
pipe pusher applications included crossing under streets, railroad tracks, embankments and rivers; to install gas water sewer and electric utilities. With Tramac's steel pipe pushing machines, jacking from fixed abutments is not required, set up time is minimal, labor is reduced, and no expensive augers are needed.

Circle # 124 on Reader Service Card

Trench Shoring and Shielding Association offers a handbook which provides an overview of soils, site conditions, and a variety of trench shoring and shielding devices, plus information on selecting the appropriate protection method. Trench Shoring and Shielding Association is located in Tarrytown, New York and promotes trench safety and the proper use of trench shoring and shield equipment. Phone 914 332-0040 to order the booklet, or circle the reader service number for more information.

Circle # 125 on Reader Service Card

The Navigator, a new directional, wet-boring system from Vermeer Manufacturing Company is designed to produce clean, trenchless underground service installations and to eliminate site damage and restoration costs. This wet-boring system is very accurate and is capable of boring straight ahead or in any direction, to within inches of its underground target destination, says the manufacturer. The Navigator's specially-formed drill head can be directed along winding streets or walkways, around buildings, under streams and rivers, laterally or vertically. It features a locator which digitally reads the location of the drilling action (down to 16 ft) by means of a long-life (150



hr), battery-powered sonde which transmits from the drill head to the locator. And, the Navigator includes an optional remote locator that allows the operator to see and hear everything that the locator sees and hears.

Circle # 126 on Reader Service Card

Melroe Company's Bobcat 225, a small but powerful mini-excavator, works where larger machines are not practical because of limited access. The Bobcat 225's 360° rotating cab allows the operator to efficiently work in confined areas. And, an independent boom swing provides additional versatility for all types of digging. Its offset boom capability also permits a contractor to dig a square hole with a minimum amount of machine re-positioning.



Circle # 127 on Reader Service Card

Mitsui Machinery Distribution's Kato Exceed series hydraulic excavator line ranges in size from 26,000 to 100,000 lb. and in bucket capacity from .5 cu. yd. to 3 cu. yd. These excavators are powered by Mitsubishi's turbo-charged diesel engines and feature the automatic power control (APC) system, an advanced computer system developed by Kato, that matches engine and pump output to ensure the maximum combination of speed, power, and control. Other excavator features include an automatic engine warm-up system for efficient start-ups in cold weather; a synchro control system that provides dual speed boom and dipper stick functions and two-speed propel system that matches travel speed and power to job requirements.



Circle # 128 on Reader Service Card

"The Koehring 6644 hydraulic excavator has a working weight of 101,000 lbs. and delivers superior productivity and operating efficiency," says the manufacturer. Features include an independent swing circuit, Mechatro Power Control, variable width undercarriage and hydraulically



removable counterweight and effective digging and lifting forces. A 50 gpm, 5000 psi capacity pump provides uninterrupted swing torque and speed permitting simultane-

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NASTT, founded in 1990, is a multiple disciplinary society of individuals and organizations with professional, utilitarian or environmental interests in Trenchless Technology. NASTT's mission is to advance the science and practice of Trenchless Technology for the public benefit; to develop standards; to promote education, training, research, development and information; and to promulgate through public forms the improvements and status of Trenchless Technology. NASTT is affiliated with the International society for Trenchless Technology and shares the same basic concerns for the environmental and social costs of utilities trenching. An NASTT member is automatically affiliated with ISTT. Membership in NASTT is available to a broad spectrum of those individuals, agencies and companies involved or concerned with providing gas, water, sewerage, communications and electrical services. Members include contractors, engineers, consultants, researchers, manufacturers and developers interested in underground systems and the application of Trenchless Technology. *Circle # 167 on Reader Service Card*

The National Utility Contractors Association
4301 North Fairfax Drive, Suite 360
Arlington, VA 22203
Phone (703) 358-9300

The National Utility Contractors Association (NUCA), based in Arlington, VA., comprises 40 local groups of underground utility construction contractors and suppliers throughout the United States. Its nearly 2,000 members provide the materials and necessary manpower to build and maintain our nation's network of sewer, water, gas, and other underground utility systems. Founded in 1964, NUCA is the industry's voice in Washington, D.C., vigorously promoting a stronger federal commitment to water and wastewater infrastructure. NUCA strives to enhance jobsite safety with comprehensive safety programs and services, while also working to ease the regulatory burden on construction businesses. NUCA disseminates information throughout the underground construction industry via The National Utility Contractor magazine, legislative and safety newsletters, and an annual convention and exhibition, which will be held march 2-6, 1994, in Reno, Nevada.

Circle # 168 on Reader Service Card

R0013607



ous multi-function cycles with no swing circuit interference. Regenerative swing braking adds power availability to other functions when applied. *Circle # 129 on Reader Service Card*

Komatsu Dresser Company's PC300LC-5 hydraulic excavator uses microprocessors with a revolutionary design and performance, says the company. By utilizing microprocessors in hydraulic excavators, an operator can tailor the machine's performance to the job. Microprocessors serve as mechanical "nerve centers," using computerized "brains" to optimize efficiency and ultimately, increase profit for equipment owners. Equipped with a Komatsu SA6D108 six-cylinder engine, the PC300LC-5 delivers a flywheel horsepower of 207 h.p. at 1,950 rpm. And, it has a bucket digging force of 41,450 lbs., a bucket capacity of 1.0-2.5 cu. yd. and an arm crowd force of 31,080 lbs. *Circle # 130 on Reader Service Card*

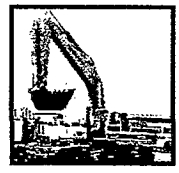


Liebherr-America, Inc. has introduced the new 107,000 lb. R 954 HD Litronic hydraulic excavator. To make "Litronic" perform to its fullest potential on the R 954, all key components were redesigned to fully match each other. "Litronic" not only improves the machine's efficiency, but also protects the power train from overloads, thereby extending the life expectancy of all machine components. This excavator is powered by the turbo-charged and after-cooled Liebherr D 926 Ti diesel engine, with an output of 282 SAE net horsepower. The engine operates at a low 200 RPM in the "High" mode setting, for extended life, improved fuel consumption and lower emission and noise levels.



Circle # 131 on Reader Service Card

The new **DH320 hydraulic excavator** by Daewoo Machinery Corporation has an operating weight of 68,800 lbs. With a digging force of up to 42,500 lbs., the DH320 has the highest available force per horsepower available for the 70,000-lb. weight class, claims the manufacturer. A 217-horsepower, turbo-charged Daewoo diesel engine drives two variable-displacement axial piston pumps to power both propulsion and digging systems. Daewoo's unique Electronic Power Optimizing System monitors and controls engine and hydraulic power for optimum output and operating efficiencies over a wide range of digging and lifting applications. A 9-spool monoblock design allows for both independent and combined operations of all functions.



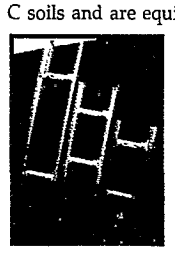
Circle # 132 on Reader Service Card

Earthline Coporation's SUPERLINER™ trenchless relining system requires no excavation, structurally restores pipe to a strength which meets or excees original pipe specifications, is three times stronger than standard felt cured-in-place liners, improves hydaulic flow, significantly reduces infiltration, and provides excellent strain corrosion properties. There is zero annular space in the final product. Less expensive than other lining processes, the final product fits all shapes sizes and navigates bends. The SUPERLINER™ product is available in all 50 states.



Circle # 133 on Reader Service Card

Westar Manufacturing Company's Quick-Shor vertical hydraulic shores are available in 2 ft, 3-1/2 ft, 5 ft, 7ft, 9 ft, 12 ft and 16 ft rails. These vertical hydraulic shores are used for type A, B, and C soils and are equipped with finger guards and oversleeves as standard equipment. Westar offers contractors the option of heavy duty or standard duty rails. The Quick-Shor cylinders and rails are all interchangeable—extension kits to enlarge cylinder length are available in sizes ranging





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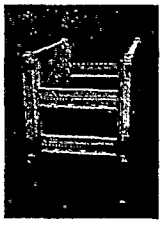
from 9-in to 63-in. Other advantages 4f the Quick-Shor vertical hydraulic shore is its capability of one-man installation and removal, and safe above-ground installation and removal.
Circle # 134 on Reader Service Card

A new aluminum shoring shield system, the HydraShield from Efficiency Production, Inc. consists of aluminum sidewalls with hydraulic cylinders to accommodate varying trench widths. Other features include: telescoping steel pinnable spreaders to convert it to a static shield and an economical hand pump with 5-gal.can, hose, and pressure gauge. It is available in eight sidewall sizes ranging from 6 ft high by 6 ft long, to 8 ft high by 12 ft long. Spreader sets, which include hydraulic cylinders, telescoping steel spreaders, return springs, and locking pins. Exclusive smooth wall design prevents dirt build-up, reduces friction when pulling the shield forward in the trench, and makes it easier to handle in and out of excavations. Double wall aluminum cavities are filled with foam to prevent dirt and moisture build-up, and its double-wall construction adds strength without increasing weight.



Circle # 135 on Reader Service Card

"Felco Industries, Ltd. bedding conveyor delivers bedding materials in the trench fast, safely and economically," says the manufacturer. Felco's bedding conveyors can be placed on any type of crawler excavator. Other bedding conveyor benefits include a standard bedding conveyor which will fill a two cu. yd. bucket in 10 to 20 seconds; standard components are readily available and require little maintenance; operator visibility remains unchanged due to the hopper's slant profile and pinned mounting connection on backhoe permits 15 minute removal and installation. By using Felco's bedding conveyor, bedding material waste is reduced by almost 10%. Less equipment is needed on the job site, and fewer employees are needed on the project.



Circle # 136 on Reader Service Card

The new models 15, 21, 25, & 40 trenching attachments from Lowe Manufacturing Co., Inc. are designed to add capability to skid loaders. The trenching attachments feature quick and easy mounting, side shift capability, and only two hydraulic connections to the loader. Models 21, 25, and 40 are available in three to five foot digging depths, and six to 12-in. trench widths. Included with the trenching attachments are a 50,000 lb. anti back flex digging chain; removable spoil auger; greaseable tapered roller bearings and a 3,000 psi continuous operating pressure capability.



Circle # 137 on Reader Service Card

Iseki, Inc., San Diego, California, announces the development of new rock excavation disc cutter systems. While the disc cutter has proven its worth on large diameter rock excavators of all types, due to the high thrust forces necessary to break hard rock, its use has been restricted to only large diameter equipment. Their physical size prevents standard disc cutters from being used on small diameter cutter heads. After nearly two years of development, a small 5.0 inch disc cutter was produces, capable of withstanding a sustained thrust load of up to 30,000 lbs. These mini-cutters are cantilever mounted and can be serviced with simple hand tools. The mounting methods developed permit their use in closely spaced patterns and on cutterheads as small as approximately 12.75 inches. A full scale cutterhead, 32 inches in diameter mounted with 12 of the mini cutters performed well on both 9,000 psi and 24,000 psi UCS rocks. Iseki no offers the new high production, long distance hard rock tunnel machines, in the range of outside diameters from 18 inches to 84 inches, complimenting its existing range of tunnel systems.



Circle # 138 on Reader Service Card

Takeuchi Manufacturing, Ltd.'s model TB015 compact excavators feature synchronized bucket and arm cylinder speeds to make flat bottom trenching easier; two-speed travel for increased mobility; and simultaneous digging functions for faster cycle times. A wrap around counterweight helps to protect the engine compartment from

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For details, contact:

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Circle 76 on Reader Service Card

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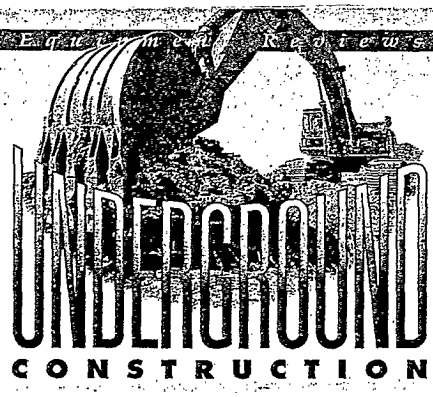
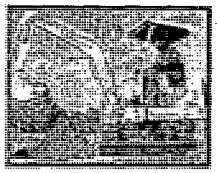


damage when slewing. The excavator's track frame can be expanded or contracted hydraulically in a range from 51-in. to 38-in. And, the narrower width lets the TB015 negotiate small openings or operate in very tight job conditions. The expanded track frame provides greater stability for heavy digging and working on uneven terrain. The TB015 weighs only 3,418 lbs., making it easily transportable. A 16HP engine delivers 2,415 lbs. of bucket digging force. Maximum digging depth is 7 ft 3-in. with a maximum reach at ground level of 12 ft and 1-in.



Circle # 139 on Reader Service Card

Barnes Pumps, Inc. offers a complete line of Prosser® submersible dewatering pumps that are constructed of hard-anodized aluminum for durable performance and lightweight portability. They feature a slim-line design—operates in any position; 3/4 to 50 horsepower; ability to handle a 2-in. to 6-in. discharge; in-line suction and a discharge capability and electric or hydraulic power source options.



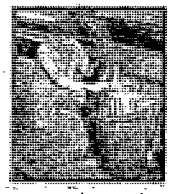
Circle # 140 on Reader Service Card

The compaction bucket from Felco Industries, Ltd. allows an excavator operator to backfill, position and control the depth of lifts. This advantage eliminates one man and machine from backfilling spoil. The compacting bucket allows a compacting excavator to follow closely behind pipelaying activities. This reduces the possibility of cave-in when a trench box is relocated. Felco's compaction buckets also increase safety by keeping unprotected men out of the trench and a majority of the trench closed. With optional bolt on teeth, compaction buckets can be used to excavate without changing attachments.



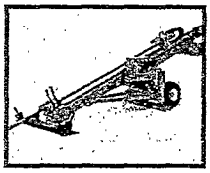
Circle # 141 on Reader Service Card

ITT Fluid Technology Corporation's model BS-2400 is a 140 HP high head/high volume submersible pump. It features high head pumping for open pit mines and can be completed in a single (two stage) pump unit. The Poly-Life version is equipped with polyurethane lined wear parts for prolonged life, especially when pumping highly abrasive liquids. Its main applications include mines or open pit mines.



Circle # 142 on Reader Service Card

StraightLine Manufacturing, Inc. has introduced Directline™, an extended-range directional boring system for trenchless drilling for landscaping, freeways, rivers and other obstacles without site damage or restoration expenses. It features a PowerWrench™ break-out system to change drill stem faster, easier, and safer; an easy-to-use master control panel; a variable solution pressure control and a unique priority-flow control valve to maintain optimum drill rack performance. It is designed with a TaperLok™ drill stem which is available in 1 and 1/2-in. and 1 and 7/8-in. sizes. It also delivers fast trouble-free operation in rigorous drilling and backreaming operations.



Circle # 143 on Reader Service Card

AGL Corporation has announced a new remote alignment system for its GradeLight pipelaser. Called AutoLine, the system uses an enhanced infrared signal to align a laser beam up to 600 ft away from the laser instrument when used through-the-pipe. It makes setting up much faster and safer as trips into the ditch to align the laser could be reduced. Other GradeLight features include compact size for easy setup inside a pipe or

Helping You Get the Most Out of Trenchless!

Why NASTT? Because it's the only society in North America dedicated to advancing the science and practice of Trenchless Technology for the public benefit.

Whether you're new to the industry or an experienced veteran in the field, you need NASTT and NASTT needs you.

Membership in NASTT is open to a broad spectrum of individuals, agencies and companies involved or concerned with Trenchless Technology.

You will benefit from direct involvement and participation in a vital and active organization right here in North America.

We invite you to call us at 312/644-0828 to talk about membership or to write NASTT, 435 N. Michigan Ave., Suite 1717, Chicago, IL 60611-4067 for an application.

NASTT membership provides:

- an automatic affiliation with the International Society for Trenchless Technology
- information exchange at conferences and exhibitions, such as the upcoming NO-DIG '94 in Dallas this April
- opportunities to network
- technological information
- industry recognition
- subscriptions to various industry publications

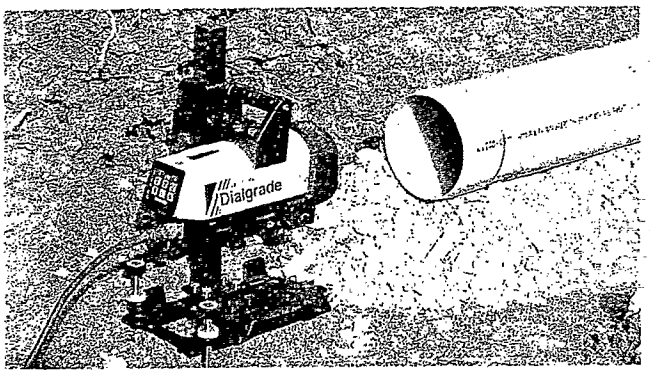
Circle 77 on Reader Service Card

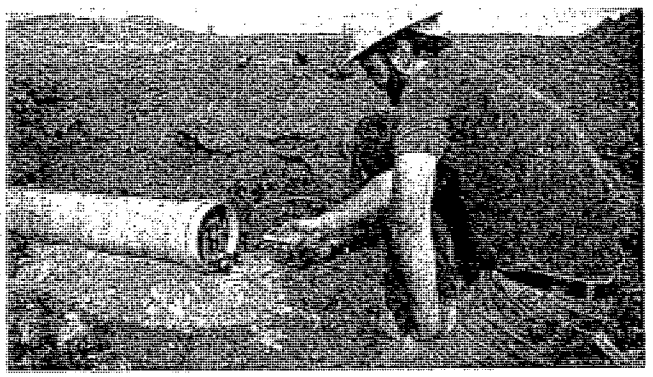
R0013610

Still Wasting Time & Manpower on Laser Setups?



Step Up to Wireless Line Control.

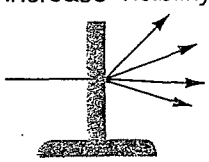




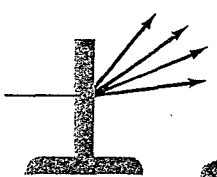
The 1165 Dialgrade® Pipe Laser leads the industry with:

- 500′ wireless line remote control for ***"one man"*** setups
- Setup in 6-15″ pipe, with no special foot sets to lose
- Get **up to $3000 in trade** for your working self leveling pipe laser

Enhanced targets DOUBLE your range and visibility by reflecting the beam upward to increase visibility.

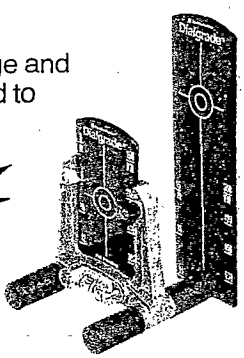


STANDARD TARGET



ENHANCED TARGET

U.S. Patent 5,095,629





Spectra-Physics

5475 Kellenburger Road
Dayton, OH 45424-1099
(513) 233-8921
Fax: (513) 233-9004

Circle 78 on Reader Service Card

R0013611

When it's time to replace old pipelines, it's time for...

TRENCHLESS WARFARE!

Used to be that the only way to replace old pipelines was to dig huge trenches smack in the middle of major roads. It was noisy, inconvenient for commuters and local residents, and expensive.

Now there's a new technology available—the TRS trenchless replacement system — that makes it a cinch to win the war against the spiralling costs and environmental damage of conventional pipeline replacement methods.

Steel, ductile and cast iron, concrete and clay pipelines, even semi-collapsed sewers, can be replaced with new *standard specification* PVC, PE, steel, and other pipes. Use the TRS system to replace with full same size or LARGER than original pipe, while reducing road traffic by only one lane!

Better still, our powerful system works with a smooth, non-impact, hydraulic force minimizing hazard to adjacent structures.

Find out more about TRS; call us today! Contractors' inquiries welcomed.

(403) 279-9876



TRS

TRENCHLESS • REPLACEMENT • SYSTEMS

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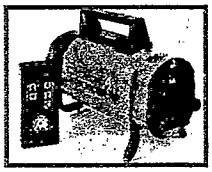
A Subsidiary of Precision Drilling Corporation

Circle 79 on Reader Service Card

R0013612

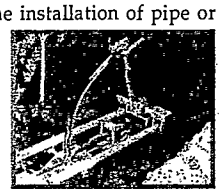
UNDERGROUND CONSTRUCTION

tightly curved invert, a "SpeedLevel" display system for super-fast self-leveling, -10% to +40% grade range with separate digital counters, wide 11.5 degree line adjustment range, height-adjustable legs for quick centering of the beam, full-function tactile response control pad, and a complete range of setup hardware.



Circle # 144 on Reader Service Card

The Power Mole model PD-6 hydraulic pusher/puller from Petersen Underground Equipment, Inc. is designed for under-road crossings that require additional driving force. Its features include a shoring box to provide blocking and operator safety in unstable soil conditions and a steerable system which provides depth, position and the ability to change direction upon demand. Its jaw system is positive locking, non-slip, and hydraulically actuated. The PD-6's solid steel push rods are top loaded which allow operation from excavations less than 5 ft long. With a maximum driving force of over 84,000 lbs. per sq. in., the PD-6 is used for the installation of pipe or cable from 1/2-in. to 8-in. with an outside diameter, and double pipes up to two 4-in. pipes on the pull-back operation in most compressible soils.



Circle # 145 on Reader Service Card

The 42316 hydraulic backfill tamper by Greenlee Textron, Inc. delivers 1200 blows per minute with a 3-in. stroke to a large 6-in. diameter foot. It can also be driven by an open center hydraulic system capable of delivering a flow of 7-9 gpm. Its actuator valve is mounted on the end of the tamper tube, and it is 53-in long and weighs only 39 lbs. The 42316 hydraulic tamper's light weight and blow power, give it efficiency when setting poles and compacting asphalt patch or backfill. It features a choice of in-handle or hose-end valve location and replaceable kidney-shaped (for around poles), rectangular or round tamping feet (for general backfill).

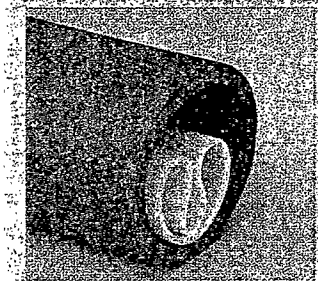


Circle # 146 on Reader Service Card

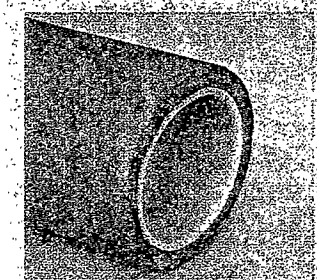
Griswold Machine & Engineering has introduced the new AMH series of lightweight aluminum manhole shields that are designed for worker protection while setting or repairing manholes. These new shields are lighter than GME's comparable

AM-LINER®
PATENTED

the cost effective system for sewer rehabilitation without excavation



Folded AM-Liner is inserted through the existing pipeline.



AM-Liner is expanded to form a tight molded fit against the walls of the existing pipe.

AM-Liner,® a strong, seamless, jointless PVC pipe, allows you to repair broken and leaking underground sewer lines without costly and time-consuming excavation. A sewer line 300-400 feet long can be installed and back in service in less than 2 hrs.

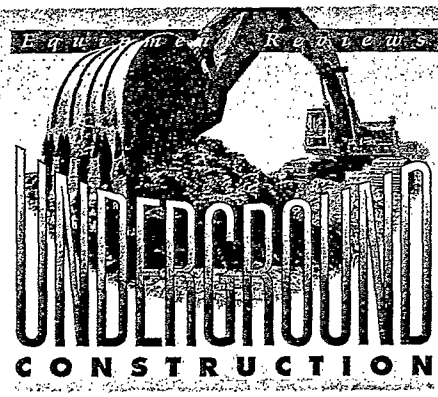
- No excavation
- Faster installation
- More economical
- Jointless interior
- Stronger than original pipe
- Resistant to sewer gases and chemicals
- Resistant to corrosion and abrasion
- Increases liquid flow

For more information or the name of the licensed AM-Liner installer in your area contact:

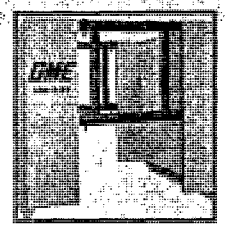
AM-LINER
American Pipe & Plastics, Inc.
P.O. Box 577
Binghamton, N.Y. 13902
Phone: 607-775-4340
FAX: 607-775-2707

Circle 81 on Reader Service Card

R0013613



steel-constructed shields. They are easier to transport and handle at the job site and are all certified by a certified engineer to meet OSHA requirements. The AMH manhole shield features a patented non-rigid design; patented hardwood inserts; a honey-comb inner structure; clear-view spreaders; an 8-in. reinforced knife edge and a 5-in diameter Schedule 80 spreader pipe.



Circle # 147 on Reader Service Card

The new Ken-Jet Industries Still Worker hydraulic piling system is utilized for the installation and extraction of sheet piles and h-piles and is an environmentally-responsible alternative to conventional piling systems. The Still Worker eliminates vibration and minimizes the risk of damage to nearby structures, equipment and sensitive soil formations. With its compact size and the ability to self travel, the Still Worker excels in limited access situations. Unlike auger-cast systems, the Still Worker does not require the removal of soils. So there are no voids to fill with concrete and no mess to clean up.



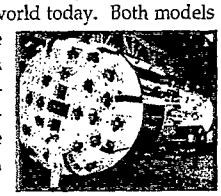
Circle # 148 on Reader Service Card

The Borpak Model 1200 blind hole drilling system developed by the Robbins Company is a remote operated, self propelled drilling machine mounted on a crawler for high mobility and launched out of a starting tube for quick collaring. The BorPak is capable of boring raises at angles from 30o to 90o from horizontal in sizes ranging from 1.2m-2m diameter without the use of a drill pipe. Some of its applications include use for drilling shafts in mines and transfer shafts in a hydro power plant. The BorPak features a crawler undercarriage for adding higher mobility and more efficient collaring; a launching tube anchoring system is used for mine drilling for more efficient setup and an electric drive system achieves easier hose and cable-handling and a more power-efficient drive system.



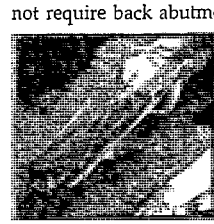
Circle # 149 on Reader Service Card

The Robbins Company's Model 167-266/267 open gripper tunnel boring machine consists of three major components, the cutterhead\cutterhead support, gripper and main beam assemblies. The cutterhead is the front end of the machine which excavates rock. The cutterhead support houses the main bearing and the cutterhead drive systems. These are electrical motors, gear reducers and hydraulic clutches. The main beam assembly involves the main beam and rear support. The main beam can move up, down or sideways relative to the tunnel axis throughout the full working stroke. The main beam is also involved in the machine's steering. Currently, the Robbins models 167-266/267 are being used for the Lesotho Highlands Water Project, one of the largest ventures in the world today. Both models are working on separate sections of the 45 km transfer tunnel stretching between Katse intake and 'Muela in the Republic of South Africa.

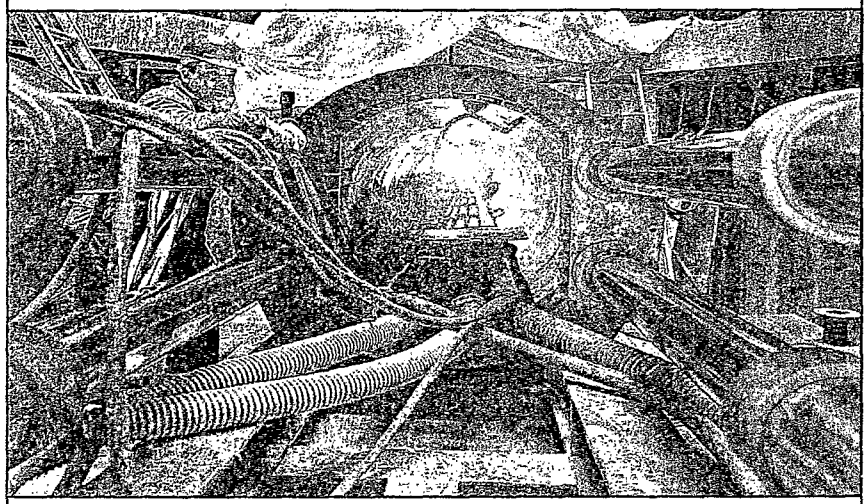


Circle # 150 on Reader Service Card

The Grundoram® pipe rammer from TT Technologies, Inc. is capable of trenchless casing installation from 4-in. to 80-in. in diameter. Powered by compressed air, the tool requires minimal working depths, has a short set-up time, does not require back abutments, and is easy to operate. This pipe rammer is made from high-grade alloy steel and uses replaceable Teflon® coated rings at internal wear points. Its only moving part is the piston itself. Eight



THE CUTTING EDGE



E.E.Cruz & Company is a recognized leader in trenchless excavation with its microtunneling capabilities.

Using laser-guided *microtunneling*, obstacles such as traffic, water courses, surface structures or contaminants can be avoided. Projects successfully completed by E.E.Cruz & Company include 48"O.D.Concrete, 63"O.D.GRP Fiberglass and 48"O.D.Steel pipelines installed including *a world single drive record of 1,560' at depths over 80 feet.* If you are looking for a clean, cost-effective, and non-disruptive method to substitute for your conventional open cut plans, you should consider *microtunneling.*

Let us put the cutting edge to work for you.

E.E. CRUZ / CO. INC.
CONTRACTORS / ENGINEERS

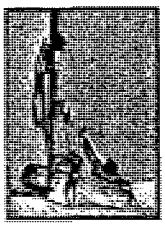
Cruz Plaza, Holmdel, New Jersey 07733
Contact: George Coss for Capabilities Brochure
(908) 946-9700 Fax (908) 946-7592

Circle 82 on Reader Service Card

R0013614

models of Grundoram are now available, including a line of attachments for additional functions.
Circle # 151 on Reader Service Card

Sullivan Industries, Inc. now offers their new redesigned extendable boom, mediumweight track drill developed for line drilling, production work and development drilling in mining, quarrying, or on heavy construction projects. This drill can be equipped with the 360 or 361 continuous rotation pneumatic hammer for hole sizes from 2-1/2-in. to 4-1/2-in. in mining construction or quarry projects. This newly redesigned ram drill features a long wide low chassis design for stability for tramming and setting up. Hydraulic oscillation has been added for rough terrain conditions. In addition, it has a 5ft hydraulic boom extension.



Circle # 152 on Reader Service Card

Spectra-Physics Laserplane, Inc. Model 1165 Wireless Line Dialgrade® with wireless remote line control monitors line and grade to improve straightness and reduce friction and spalling of pipe. The wireless remote line control provides instant line adjustment to a distance of 500 ft (150m) for pipe laying projects. Dialgrade's visible red laser beam can be clearly seen on translucent targets attached to the fixtures or components being installed. With applications in open excavations and over the top setups, the Dialgrade's easy setup is combined with stability in these applications, with the model 1135 vernier adjuster, the model 1051 (wood) or 2051 (aluminum) tripod, and the model 1133 scope handle. In manhole applications, Dialgrade sets up easily, even in manholes with tight precast inverts, because of its small size, wide pitch and roll leveling range and simple mounting systems.



Circle # 153 on Reader Service Card

McLaughlin Manufacturing Company and Markham & Company Ltd. of Chesterfield England have entered into an agreement to introduce Markham Technology's microtunneling equipment to North America.

Innovations that place Markham Technology in a class above other microtunneling machines include the use of temporary pipes on the initial drive for improved steering accuracy, greater thrust loading in difficult soil, reduced joint makeup time and the ability to retrieve the machine in the event of an emergency. A patented reamer is available for use with the temporary pipes, enabling a wide range of sizes from a single machine. Other microtunneling equipment from Markham Technology and McLaughlin include road headers, excavator shields, and earth pressure balanced (EPB) machines with computer-aided steering and rock crushing capabilities.



Circle # 154 on Reader Service Card

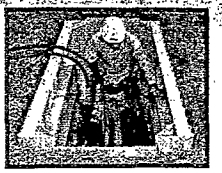
TT Technologies has introduced a 2-in. piercing tool to the Grundomat line. The new Grundomat piercing tool incorporates a number of significant design and operational features including TT Technologies patented reciprocating head and replaceable stepped cone that contributes to its accuracy. Plus, it's easy to operate with the ability to reverse the tool with just a quarter turn of the air hose. Applications include uses for pulling steel or plastic pipe as well as driving steel castings. Ten sizes of Grundomat piercing tools are available, ranging from 1-3/4-in to 7-in.



Circle # 155 on Reader Service Card

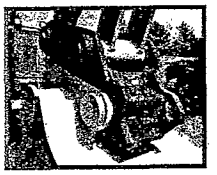
The 5000 series pipe jacking system by Akkerman Equipment, Inc. is unique because its main jacking cylinders and the hydraulic system are both housed in the pump unit. This system is one of the most versatile, since it easily adapts for any jacking pipe (RCP, steel, or composite) in any length. The pump unit has two distinct hydraulic systems powered by electric motors. A high pressure system supplies oil for the two main jacking cylinders, which have 400 tons of thrust, and any intermediate jacking stations.
Circle # 156 on Reader Service Card

Poweram Corporation's Model 2020 Power Ram hydraulic pipe pusher/puller offers 98,000 lbs. of push power, its own optional safety shoring box and special connector tools which expedite the smooth return of attached utility pipe. The Power Ram generates exceptional power from twin hydraulic cylinders, and a patented jaw system which permits full hydraulic force to be applied to the drive rod.



Other Poweram pipe pusher/pullers are the Mini-Ram II with 62,000 lbs. of pushing force and the Mini-Ram I, with 35,000 lbs. of pushing force.
Circle # 157 on Reader Service Card

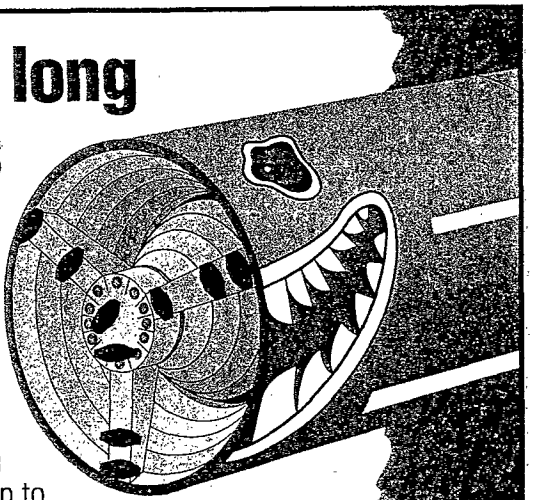
The new piggyback style coupler by Wain-Roy®, Inc. is unlike other couplers since it does not require the use of bars, ratchets, springs, or any tools to engage and disengage. A simple rear hand lever is all that is required, and is adjustable. Its capability allows contractors to use OEM buckets, and is available at this time on most late model excavators.



Circle # 158 on Reader Service Card

A new model of the DDU-10 directional drill from Augers Unlimited has just been introduced. Named Model DDU-10T, the drill carriage is now offered on a track carriage. Its tracks are powered by independent hydraulic drive motors for accurate maneuvering. The hydraulics are driven by a carriage mounted engine for completely independent mobility. Featuring special pad designs, the tracks also minimize ground disturbance while positioning. The DDU-10T's hydraulic drilling

How to go long distances without getting shafted.



Our proven experience in completing long drives up to 3,000 feet insures your success. Minimize tunneling risks and reduce your costs with Iseki.

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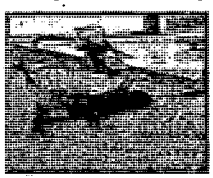
UNDER-GROUND SERVICES

Circle 80 on Reader Service Card

R0013615



systems are powered by the trailer-mounted 80 horsepower diesel engine. And, pressure compensating pumps are standard for both the torque and thrust circuits which supply only the volume and pressure demanded by the operator.



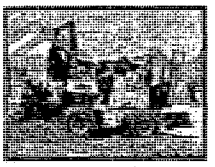
Circle # 159 on Reader Service Card

The McMillen Division has introduced its new "X' series hydraulic earth drill attachments which are designed for commercial and industrial applications. Mounting brackets are available for skid steer loaders wheel loaders, backhoes, excavators, cranes, tractor loaders or 3-point hitches and other hydraulic machines. All "X" series hydraulic earth drill attachments feature heavier-duty drive components and are rated to 3000 psi continuous operating pressure All McMillen 'X' series hydraulic earth drill attachments are engineered with an "In-Line" drive design.



Circle # 160 on Reader Service Card

JI Case has introduced the new rigid-frame, ride-on trencher Model 460. With 37 horsepower, the new 460 trenches to depths up to 60-in. It is equipped with a four-cylinder, liquid-cooled diesel engines and features a field-tested Kubota V1505-B engine. Other key features include hydrostatic transmission and attachment drives; heavy-duty axles; ease of operation and versatility. Its hydrostatic ground and attachment drives increase reliability and productivity. In addition, the 460 is available with a heavy-duty flywheel drive trencher attachment or an economical direct drive trencher attachment. The 460 is scheduled for production in January 1994.



Circle # 161 on Reader Service Card

The PowerTilt bucket swing positioner by Helac® Corporation is a hydraulically powered and when mounted between dipperstick and tool, it hydraulically swings buckets and attachments up to 70° to either side from center. PowerTilt's added dexterity means greater versatility and improved productivity from a backhoe or excavator and is ideal for sloped trenches; excavating under and around foundations, sidewalks, underground pipes, and cables; cleaning roadside ditches; picking and moving rocks; and more. PowerTilt is designed to fit various excavator models, and original standard buckets. Its other features include a sliding helical spline concept which generates powerful rotation and permits precise positioning; a quick coupler as standard and a 180° rotation (90° to each side) can be provided as an option to permit trenching and backfilling with the same bucket.



Circle # 162 on Reader Service Card

The Poly-Lined excavator bucket by Sabine® Metal & Machine is available with poly-lining on Sabine standard and heavy duty excavator buckets. Sabine's poly-lining excavator bucket features 1/2-in. of poly-lining which completely covers the inside of bucket wrapper and sides plus welded steel retaining rings to hold the poly-lining in place. The poly-lining's smooth, low friction surface results in faster and cleaner dumping of sticky materials.

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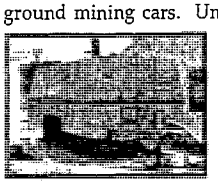
LeROI International, Inc.'s 125-1600 CFM portable rotary screw air compressor features safe chasis design; rugged power for efficient, continuous performance; large fuel tanks and air ends which provide greater capacities. LeROI air compressors provide air power for the underground operation of hand-held drills and miscellaneous air tools and roof bolting stolpers. And, they supply the required air for air motors and underground mining cars. Underground laboratories and permanent work stations benefit from the industrial-sized units for any requirement of air power beneath the earth.



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Microtunelling machines by Herrenknecht Tunnelling Systems have the ability to handle all types of ground, with varying conditions, even beneath the water table. Herrenknect micro-tunneling machines are powerful, easily operated and serviced and incorporate the latest technology, says the manufacturer. Unexpected cobbles can be reduced in size in the micro-tunnelling machine's cutting wheel, while larger boulders can be excavated by the cutting wheel itself, directly driven with 60 hp installed power. With pumped removal of the excavated material as slurry, it is possible to tunnel beneath the water table without the need for compressed air.

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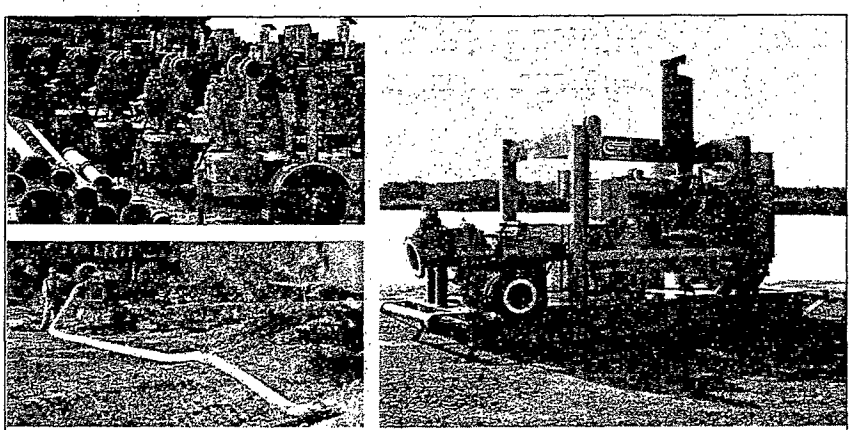

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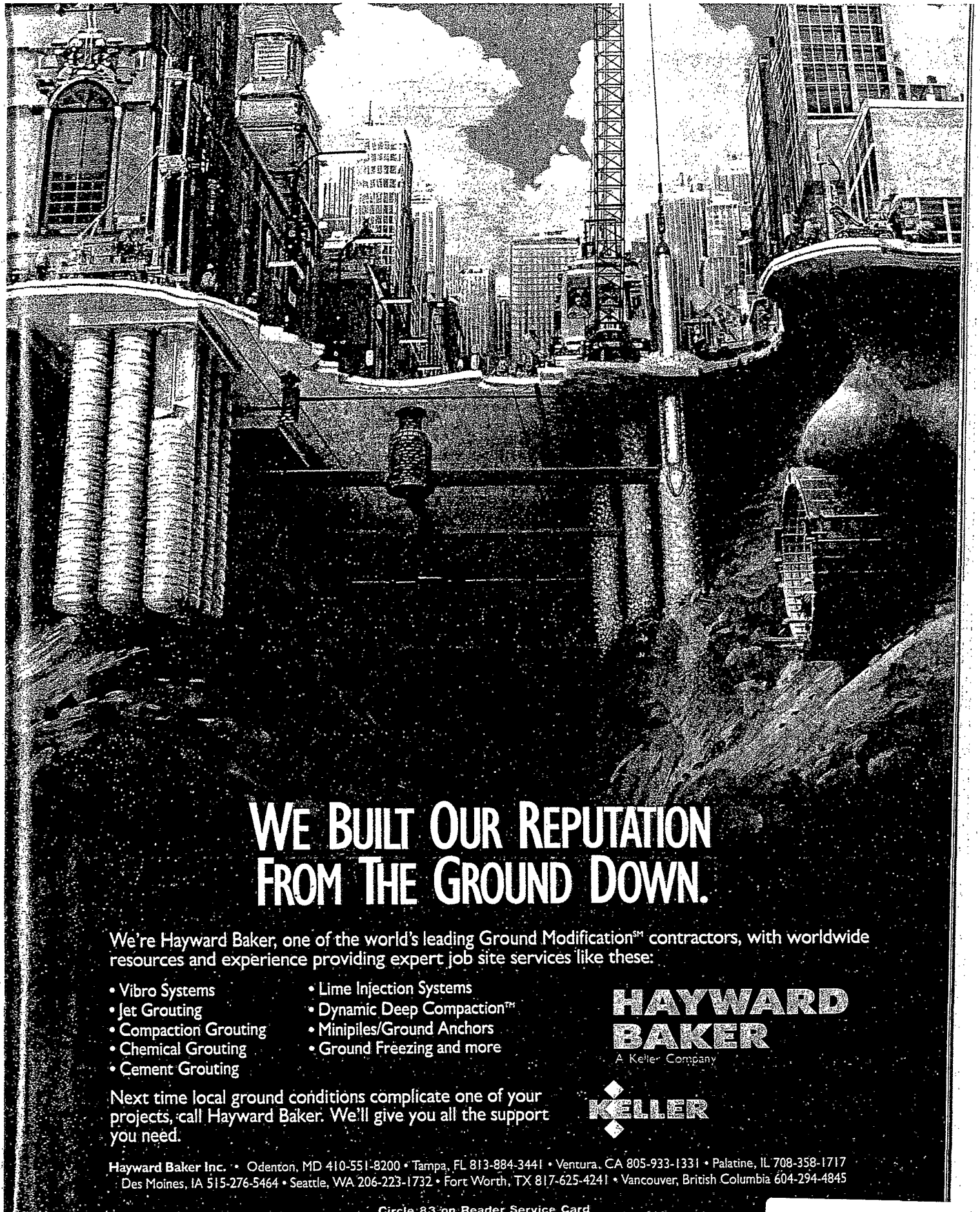

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R0013617

Profit By Association!

My name is Gerry Dorfman, and I am an underground utility contractor from California. My company has been a member of NUCA for many years, and if you have any involvement in the underground utility construction industry, you should be a member as well.



The National Utility Contractors Association (NUCA) is our voice in Washington, working to represent our industry. Issues, such as OSHA reform, Clean Water Act reauthorization, and striker replacement, top this year's priority list. These issues affect contractors and suppliers every day. NUCA also provides safety training information and seminars. We keep our members abreast of new and emerging construction methods and technologies through *The National Utility Contractor*, our monthly newsletter, and monthly safety newsletter. By joining with your peers from across the country, you can become part of a force that empowers you as a business person. By increasing our membership, we increase our strength.

Experience membership at the 1994 NUCA convention in Reno, Nevada, March 2-6. The show will include the largest–ever heavy equipment exhibition exclusively for the underground utility construction industry—over 150,000 square feet of exhibit space, including the latest innovations in equipment, supplies, and services available to our industry.

To learn more about NUCA and the benefits of belonging, I recommend that you talk to a NUCA contractor or supplier member. There's no one better to tell you about the benefits of membership than one of your peers. It is the best investment you will ever make for your business. Experience belonging. Join the NUCA team.

Sincerely,
Gerry Dorfman
NUCA President

For further details on NUCA membership or Convention and Heavy Equipment Show, call (703) 358-9300, fax (703) 358-9307, or write NUCA at 4301 N. Farifax Dr., Suite 360, Arlington, VA 22203-1627.

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R0013618

ENR WORLD PROJECTS FEATURE

Odebrecht: Brazil's giant beats adversity

Brazilian contractor takes philosophical approach to business and political crises at home and abroad





Norberto Odebrecht (left) has passed on the torch to his son Emílio.

If U. S. contractors think the 1990s have been rough, they should hear what Brazilian construction giant Odebrecht S.A. has had to contend with.

In 1992 alone the international conglomerate had to orchestrate an emergency airlift to get 5,500 of its workers out of war-torn Angola just months after moving its Florida contracting subsidiary out of the path of Hurricane Andrew. It also had to maneuver through political chaos caused by a coup in Peru and an attempted overthrow of the Venezuelan government.

And things were no better at home where political scandals last fall toppled Brazil's president and implicated many in the construction industry. Meanwhile, domestic building markets wallowed in a deep slump as the nation's runaway inflation continued to soar.

"All told, the organization has probably never experienced so many devastating events," says Renato Baiardi, chief operating officer of general contracting subsidiary Construtora Norberto Odebrecht S.A. (CNO).

Fortunately, the Odebrecht group succeeded in facing down the adversities. It emerged from last year's crucible with $1.9 billion in contract awards and $51 million in profits. Though down considerably from 1991, $612 million in foreign work was good enough to place Odebrecht 57th on ENR's top international contractors list (ENR 8/23 p. 34).



Odebrecht workers are treated as partners and delegated much authority in the field.

"Our goal is to increase turnover by 50% in the next two years to $3 billion," says Emílio Odebrecht, president and chief executive officer of parent company Odebrecht S.A.

Roots. Based in the port city of Salvador, in the northern state of Bahia, Odebrecht oversees operations in 18 countries and employs nearly 42,000 worldwide. Despite its mammoth size, the entire organization still lives by the weighty management philosophies espoused by its founder, Norberto Odebrecht.

He has written five books on the subject, enough to make him a veritable business guru in Brazil. Calling his concepts "entrepreneurial technology," he preaches decentralization and planned delegation of decision-making authority to workers who are entrusted to be partners and invited to participate in corporate profits.

At 72, he still chairs the holding company's board of directors, while his 48-year-old son, Emílio, serves as president. The first Odebrechts came to Brazil from Germany in the mid-1800s. In 1919, Norberto's father started a concrete contracting business that was later forced into bankruptcy during World War II, a victim of inflation and materials shortages.

Inheriting no assets other than his father's employees, a young Norberto made a pact with them to start a new company of partner-entrepreneurs. Together, they founded CNO in 1945 and slowly began mapping a strategy for growth within Brazil. From those humble beginnings, an international action plan for expansion has evolved, picking up steam in the last 15 years.

"We realized a long time ago that we

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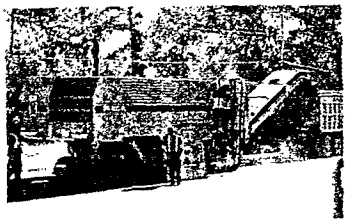

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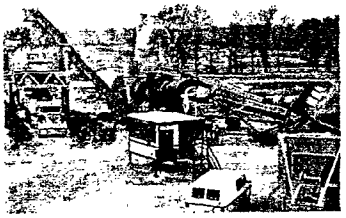

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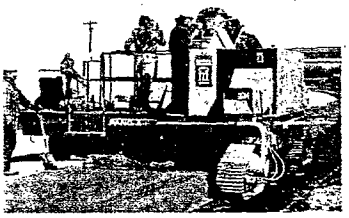

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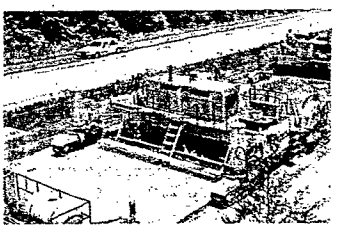
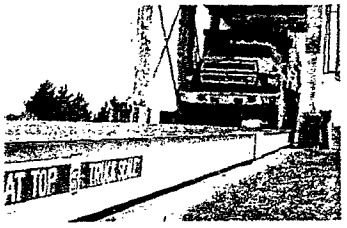
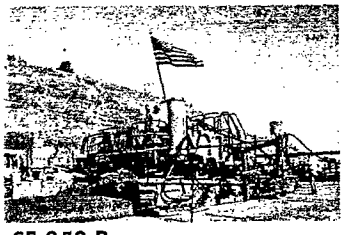


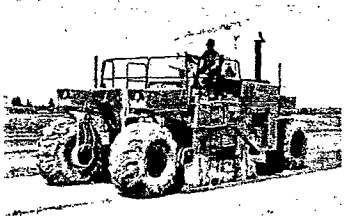
SF-450 Paver



PIT SAVER II



SF-350 Paver



RS-500 Reclaimer/Stabilizer



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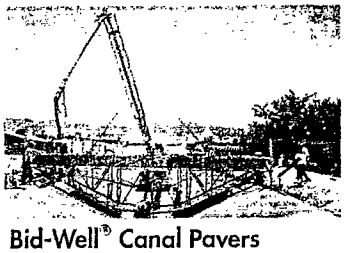

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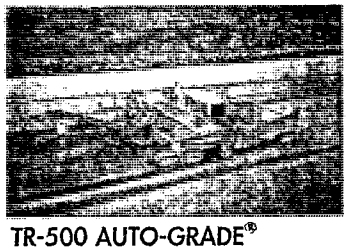

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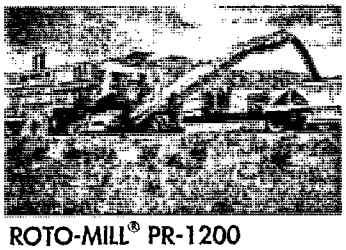

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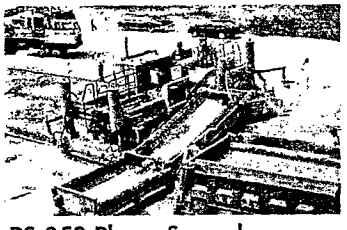
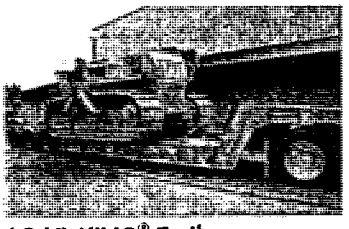


PS-350 Placer Spreader



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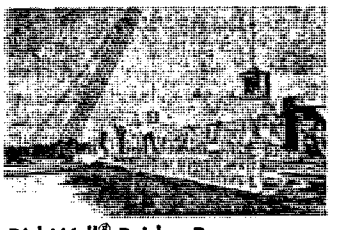

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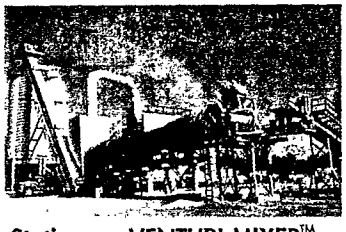

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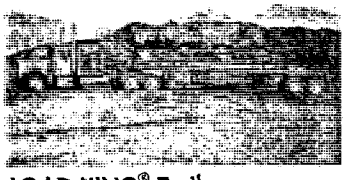

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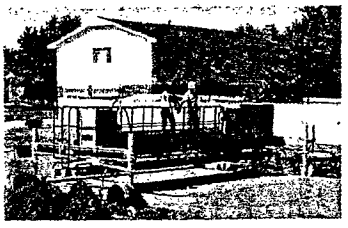

TC-250 Texturing Curing



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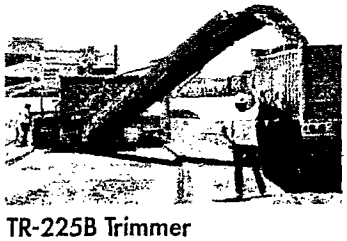
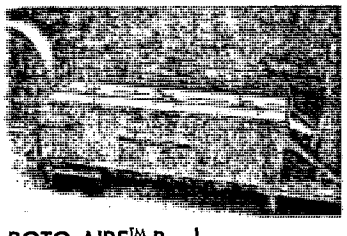


TR-225B Trimmer



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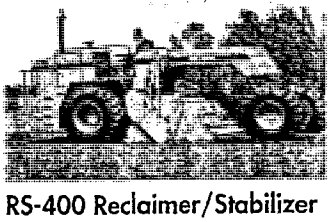

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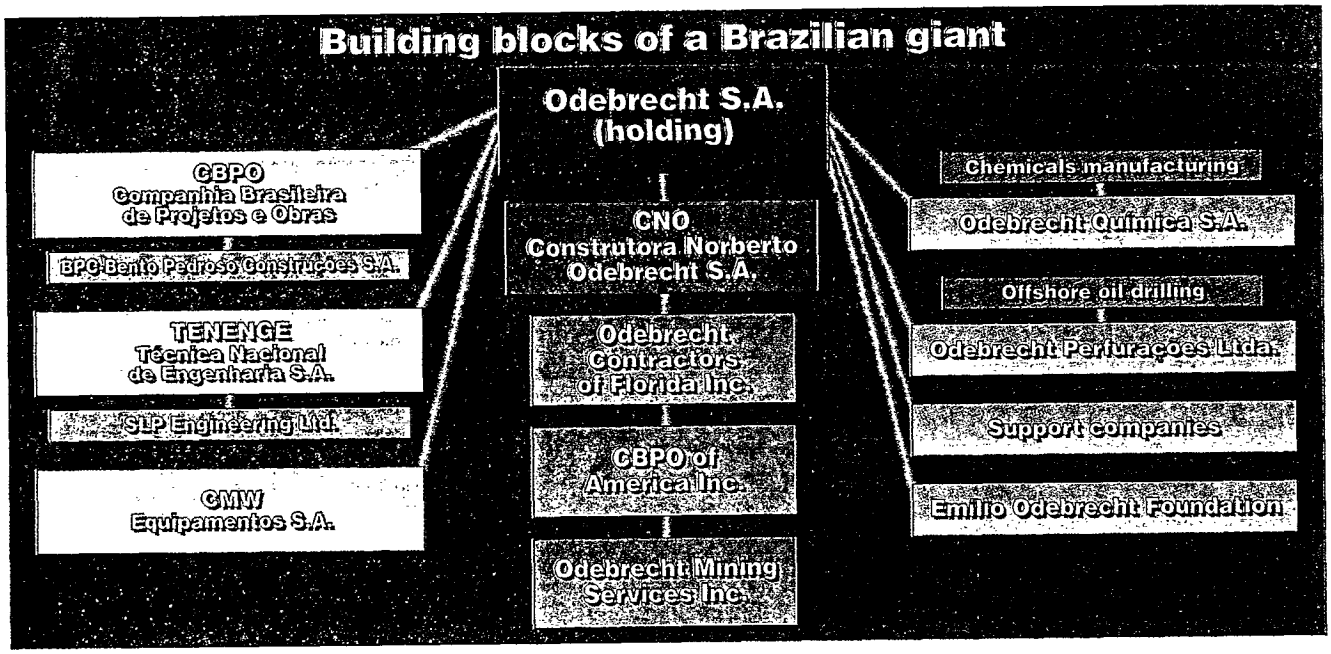


must learn how to operate worldwide, if only to know how to fend off our international competition in Brazil," says Sergio Foguel, vice president of corporate planning and development. "By the 1990s, we wanted to have half our work abroad and by the end of the decade, we also want to have half our net worth (currently $1.1 billion) outside of construction." So far, the firm is on schedule to meet its goals, he notes.

Diversity. Today, Odebrecht's capabilities are widely varied. Although highways, subways and dams have accounted for some of its biggest contracts, the company also has been very active in general building, petrochemical and other industrial work, electronics and telecommunications. Non-construction investments include chemicals manufacturing, offshore oil drilling and pulp and paper production.

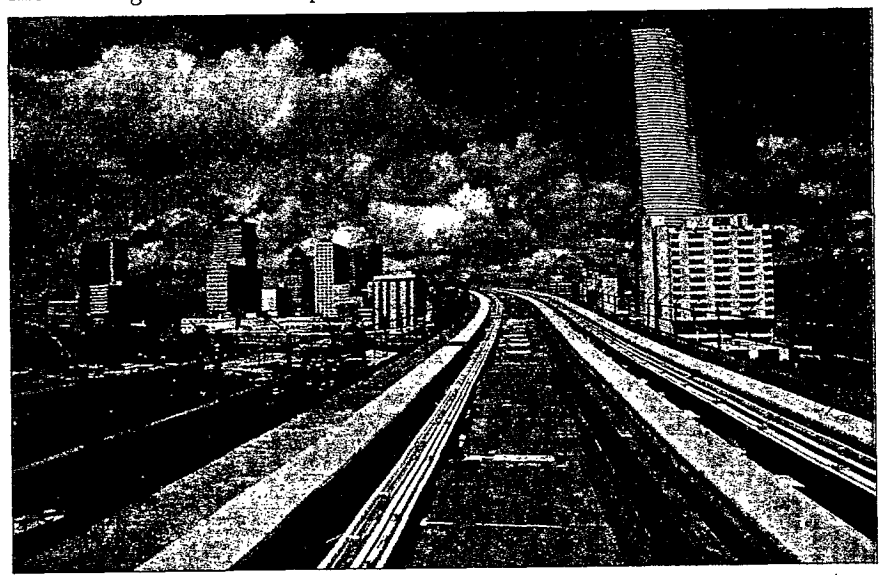
Along the way, Odebrecht has made benchmark acquisitions to propel it from one goal to the next. By far the biggest was the 1980 purchase of Companhia Brasileira de Projetos e Obras (CBPO) for $100 million. Founded in 1931, the São Paulo-based heavy contractor immediately gave Odebrecht access and clout in the markets of southern Brazil. This paid off immediately with work on the world's largest hydroelectric project at Itaipú. One of CBPO's biggest domestic projects is the Red Line, a $225-million expressway currently under construction in Rio de Janeiro.

In 1988, CBPO acquired Portugal's Bento Pedroso Construções S.A., a heavy contractor now working on a new Lisbon subway project. Odebrecht's other most significant acquisition was industrial contractor Técnica Nacional de Engenharia S.A. (Tenenge), which joined the group in 1986. The firm is joint-venturing with a Singapore contractor on a $270-million deepwater offshore oil rig. Construction passed the midway point in May when the rig was transported from Singapore to Brazil for its final phase.

To establish a presence in Europe, Odebrecht two years ago teamed Tenenge with British petrochemical contractor SLP Engineering Ltd., which had been acquired earlier by Odebrecht.

Aiming for North America in the late 1980s, Odebrecht set up Odebrecht Contractors of Florida Inc. in Miami. It has a $25-million contract to extend the city's people mover and a $32-million contract for an interchange.

The Metro-Dade Transit Agency says the people mover project is ahead of schedule and under budget. Ronald Steiner, the Florida Dept. of Transportation's district construction engineer in Miami, says the interchange is also on schedule. He adds that the agency has had an excellent relationship with Odebrecht and says it was "extremely cooperative" a year ago



Miami Metromover was Odebrecht's first major U.S. job. It is under budget and ahead of schedule.

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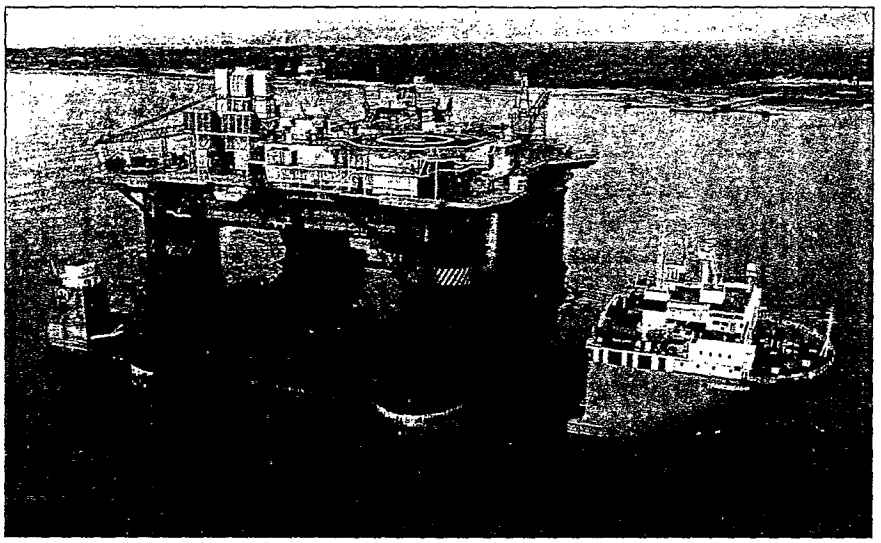


Offshore oil rig arrived in Brazil from Singapore last May. Tenenge will finish building it in 1994.

when he asked the firm to help clear state roads after Hurricane Andrew struck.

But in California, a cloud is hanging over Odebrecht's subsidiary, CBPO of America Inc. in Sherman Oaks. In July, it was apparent low bidder for a $168-million earthfill dam project being let by the Corps of Engineers (ENR 7/19 p. 16). As CBPO's bid was $29 million under the next bid, the Corps is deciding whether to accept CBPO's rationale for the low-ball bid. Last month, the second-low bidder alerted the Corps to Odebrecht's alleged involvement in Brazil's recent political scandals.

But the firm has been, "very responsive to the charges and it looks like they're going to be okay on this bid," concedes David Coon, a spokesman for the Corps' Los Angeles district office. "We feel fairly positive about our relationship with [CBPO]."

Damage control. The political situation at home has been a nagging problem for Odebrecht since last summer. Indeed, there still are repercussions all over Brazil from last fall's spectacular collapse of President Fernando Collor de Mello's short-lived "reform government."

Now renowned as perhaps the most corrupt administration in Brazil's tattered political history, the Collor presidency featured a consulting firm established by a presidential aide for the sole purpose of collecting bribes from construction companies. The firm collected about $55 million.

Such embarrassing revelations cast aspersions on virtually every major construction company in Brazil. Odebrecht initially declined comment on the matter and got hammered in the national press. It responded by beefing up its public relations department and hiring one of Brazil's foremost business journalists to run it.

"In spite of all the noise being made by the press, we have never been indicted nor have any allegations against us ever been supported by proof," says Emílio Odebrecht.

Reform. Although Odebrecht's record is clean, few truly believe that it was able to remain totally unsullied while operating in such a grossly corrupt environment. For a time during Collor's regime, it was a commonly held belief that the only way to get public work was to buy it.

"Of course we paid," confides one Odebrecht executive. "Here, either you pay or you get out of the market. And sometimes, you have to pay twice—once to get the contract and then again to get paid."

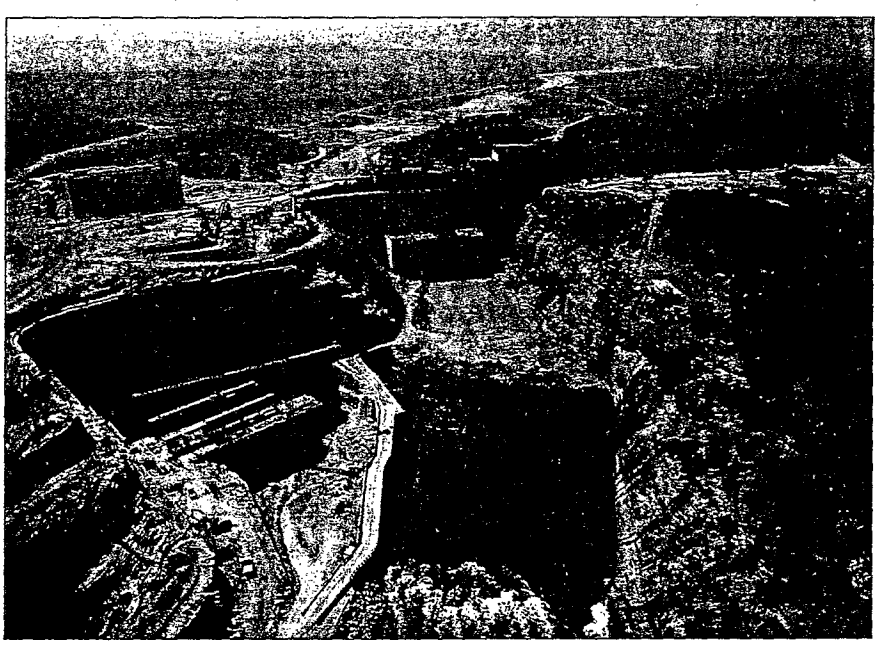
To put an end to such perversion and ensure it never returns to public contracting in Brazil, Odebrecht and other major firms lobbied the Brazilian Congress hard earlier this year to pass new federal legislation requiring government contracts to be awarded to the lowest bonded bidder.

"That is the most significant step we can take to end corruption," says João Baptista M. de Paiva Chaves, director of Odebrecht's corporate relations.

In June, the lobbying effort paid off with federal enactment of a new law mandating a low-bidder contracting system. However, citing concern for smaller firms, President Itamar Franco used his line-item veto to kill the measure's performance bond requirement. That element of the bill was "the key," laments Paiva.

Efforts are now under way to renegotiate the law and restore the bonding provision. Beyond that, Odebrecht also has put political campaign finance reform high on its lobbying agenda, hoping to force changes before Brazil's pivotal elections in October 1994. ■

By Rob McManamy in Rio de Janeiro and Salvador, with Armin Schmid in São Paulo



Angola dam project had to shut down last fall when the site fell into the hands of guerrillas.

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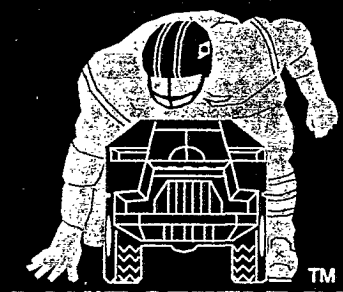

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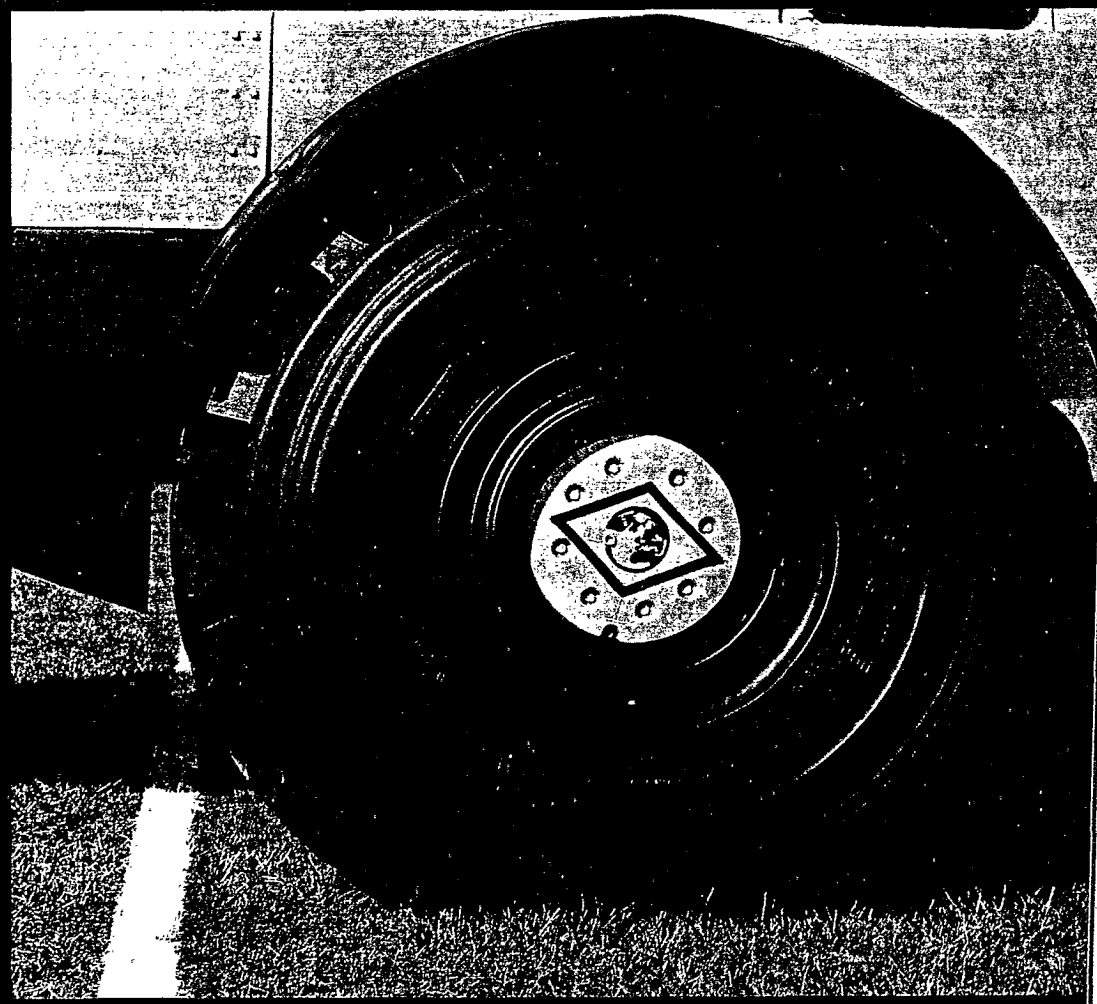

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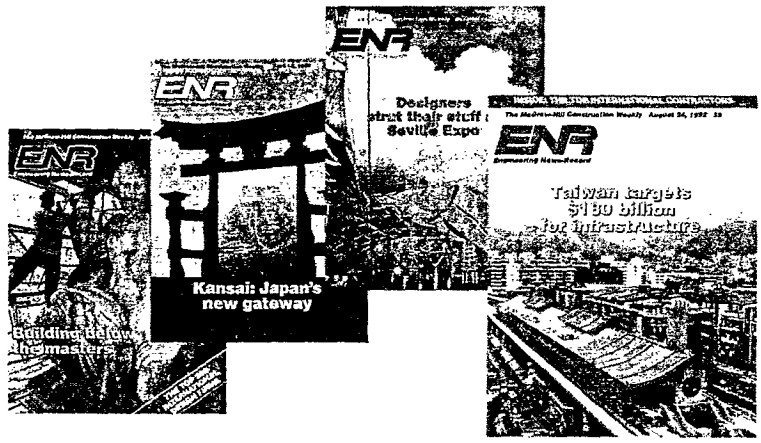

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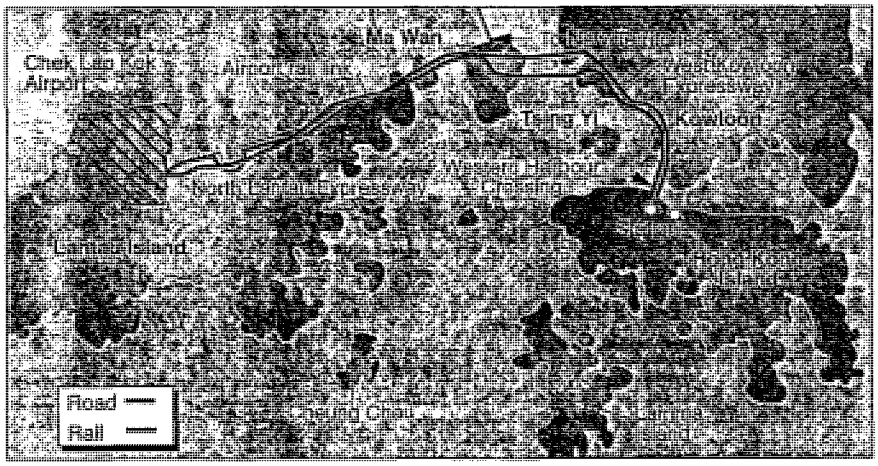
ENR WORLD PROJECTS NEWS

Hong Kong contracts will total $10.5 billion



Chek Lap Kok Airport and new highway and railroad require massive reclamation projects.

During the next 48 months a French-Japanese consortium will reclaim 50 acres of harbor fronting Hong Kong Island to expand the colony's Wanchai district and provide 15 acres for the terminal of a rail line to the new airport now under construction.

The Dragages/Penta/BSG consortium, comprises Dragages et Travaux Publics and Bachy Soletanche Group, France, with Japan's Penta-Ocean Construction Co. The group has to dredge 1.3 million cu yd of marine sediment and place 3.9 million cu yd of sand.

The $222-million Wanchai reclamation is the 25th contract awarded by the Hong Kong government in the Airport Core Program (ACP) to build an airport on Chek Lap Kok Island. Publicly funded contracts now total $3.6 billion, about 68% of the government commitment to ACP.

Another significant ACP contract signed this month is for an immersed tube vehicle tunnel between Hong Kong Island and Kowloon. But that contract differs from other airport-related projects because Western Harbour Tunnel Co. (WHTC) signed the first build-operate-transfer agreement under the airport-related program. WHTC awarded a $740-million, 48-month construction contract to Nishimatsu Kumagai, a Japanese joint venture.

Meanwhile, the Provisional Airport Authority (PAA) has separately awarded four contracts worth $1.3 billion. This brings the total of airport-related construction to $5.7 billion and there is another $4.8 billion yet to be awarded.

Chek Lap Kok Airport, the reason for all the construction activity, is currently at the center of a dredging and earthmoving operation to create a 3,100-acre platform.

PAA awarded a $1.2-billion contract to a six-company consortium comprising a marine group and an earthmoving group. The marine group, led by Jan de Nul N.V., Belgium, completed 21% of its platform last month. The civil group, including Morrison Knudsen Corp., Boise, leveled 126 acres of the 766-acre onshore platform. ▣

First tower up on Tsing Ma Bridge

Linked slipformers will finish casting the first twin-legged 659.5-ft-high tower of Hong Kong's Tsing Ma suspension bridge later this month. At the end of last month, another set of equipment started casting legs of the second tower at a rate of 10 ft a day.

The double deck bridge is a major component of a new highway and railroad extending from Chek Lap Kok Airport to the mainland. Designed by the Hong Kong office of Mott MacDonald Group, the 7,119-ft-long bridge will include a 4,518-ft main span.

A joint venture of Mitsui & Co. Ltd., Tokyo, and Costain Civil Engineering Ltd, London, is building the towers. The companies are members of Anglo Japanese Construction, the consortium constructing the $936-million bridge (ENR 8/17/92 p. 17).

The towers' oval-section legs, linked at four levels by beams, are a constant 19.7 ft wide and taper in the other direction from 59 ft to 33 ft. Slipformers will place 80% of the towers' concrete leaving the top 36 ft to be cast conventionally. Each twin tower contains over 30,000 cu yd of concrete, incorporating blast furnace slag, micro silica, retarding admixtures and ice.

To cast the towers' deep cross beams, the contractor combines steel trusses with post-tensioned concrete. Crews install steel trusses, 23 to 39.4 ft deep and up to 118 ft long after the slipformers pass. The trusses are prefabricated with bottom forms, rebar and post-tensioning ducts. When they are in place, the contractor erects side forms and encases the trusses in concrete before prestressing the beams. ▣



Oval tower legs are slipformed at 10 ft a day.

R0013625

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R0013626

INFRASTRUCTURE

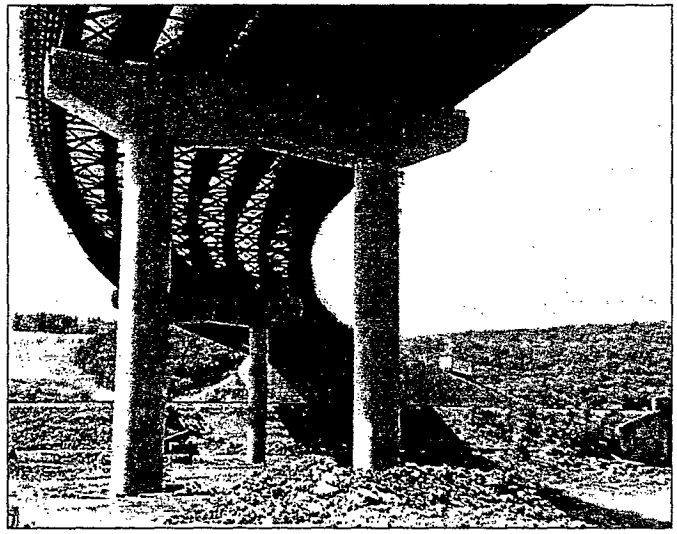
State builds road to last 50 years

New York State builds highway with 48-in. roadbed based on European design

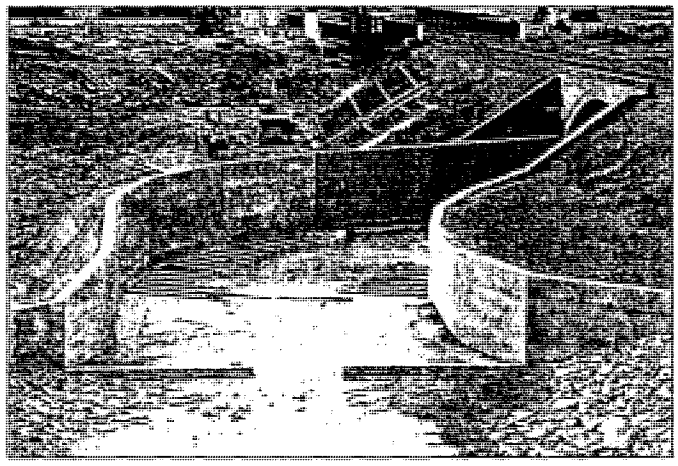
By the year 2045, engineers will know whether New York State's investment in a 50-year design life for a 2.8-mile segment of highway paid off. Based on the so-called European design, the roadway is 48 in. deep instead of the conventional 21 in. and incorporates an open-graded subbase under 11 in. of unreinforced concrete paving. The additional cost is modest, compared to the overall cost of the $56-million project.

The state Dept. of Transportation's chief engineer, Michael Cuddy, was on last year's field trip sponsored by the Federal Highway Administration to find out why roads lasted so much longer in western Europe. Cuddy was impressed enough to try the European method in the Corning Bypass, designed by Bergmann Associates, Rochester, N.Y.

New York is one of the first states to try long-life road construction and is currently building a segment with a bituminous concrete surface in Saranac Lake. And Cuddy says all state road reconstruction projects over one mile long will now be built for a 50-year life.



Corning Bypass includes 11 major structures in the 2.8-mile-long highway.



New flume redirects creek flowing through old tunnel under railroad.

Departing from normal construction, the bypass roadway beneath the concrete paving is 4 in. of open subgrade to drain water, 12 in. of stone subgrade and 21 in. of select subgrade comprising excavated materials, says Brian Dougherty, Bergmann's project designer.

The cost is higher than a conventional 21-in. roadway since the contractor has to excavate deeper and lay much thicker subbases. Dougherty says the 48-in.-deep roadway added $2.5 million to the cost of the project.

Ray Gemme, associate soils engineer at NYSDOT, says the superior drainage under the pavement will help to eliminate joint faulting. The agency specified 20-ft-long pavement slabs and called for some 15-ft test slabs for wear comparison.

And following the European pattern, the agency specified shoulder slabs to be 8 ft wide and the adjacent lanes to be 14 ft wide. However, the striping demarcates a 10-ft shoulder, reducing the wear on longitudinal shoulder joints

For the elevated sections of the route, Bergmann followed NYSDOT specifications to space bridge girders to suit the span of an 8.5-in.-deep reinforced concrete deck. The agency subsequently increased the specified depth to 9.5 in. but the change doesn't affect the Corning contract.

Split package. NYSDOT split the bypass construction into two contracts so that a complicated interchange and realignment of another state route could get under way, leaving a clear run at the major length of roadway. Cold Springs Construction Co., Akron, N.Y., started the first part in June 1992 under a $26-million contract. This month it laid the first section of its 850 ft of highway pavement. Lane Construction Corp., Meriden, Conn., is building the rest of the bypass under a $30-million contract.

Between the two jobs, the contractors will build 11 structures, two pedestrian tunnels and several flood control facilities. The bypass skirts the edges of two floodplains so segments of it have to be built on embankments varying between 35 ft and 60 ft high. ▣

By Peter Green

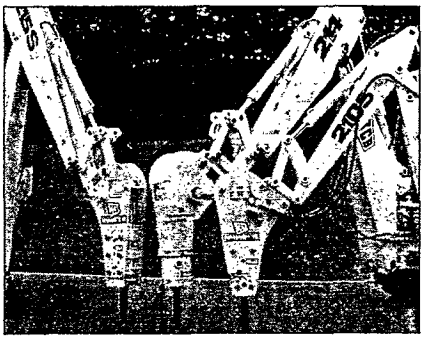
R0013627



Excavator line expansion
Company has added two new hydraulic excavators to its E-Series line. The 190E is a 16,300-lb, 55-hp unit. The 67,450-lb, 220-hp 892E-LC is a heavy-duty production excavator. Both feature an operator-oriented cab and quadtronics, a microprocessor-based engine and hydraulic control system providing ease of control to make the excavators strong performers in close-quarter foundation work, lifting and placing pipe and trenching. DEERE & CO. 169

Mass excavator attachment
These excavators have a bucket range of 3.75 to 5.5 cu yd and an engine output of 300 hp/2,000 rpm for high-production jobs. Features include the independent travel mode that separates the travel and attachment circuits to ensure steady travel speed. KOBELCO AMERICA INC. 170

Excavator series leader
The newly designed Cat 375 excavator enters the 75-metric-ton-class with increased performance capabilities, new electronic controls and versatility through a wide range of options. Digging depths range from 24 ft 7 in. to 37 ft 7 in. CATERPILLAR INC. 171



Hydraulic breakers
Three different breakers in the 400 to 1,000 ft-lb size classes have been designed for use in road building, demolition, quarrying, metallurgy and utility works. The breakers can be directly mounted to the dipper or picked up by the company's backhoe bucket quick coupler. They are engineered with constant blow energy to ensure maximum breaking power. JCB INC. 172

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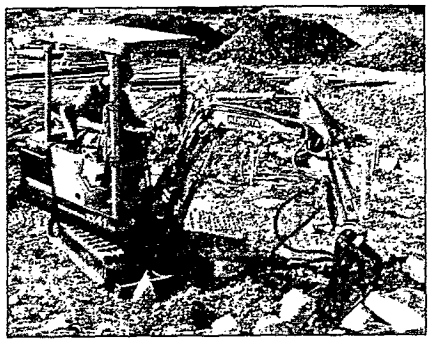
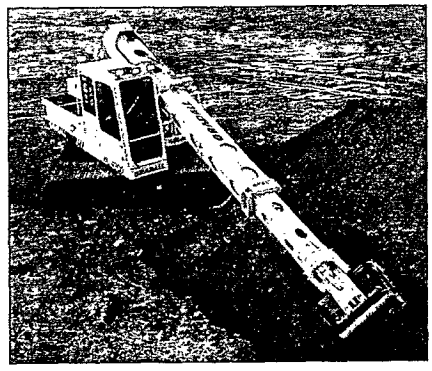
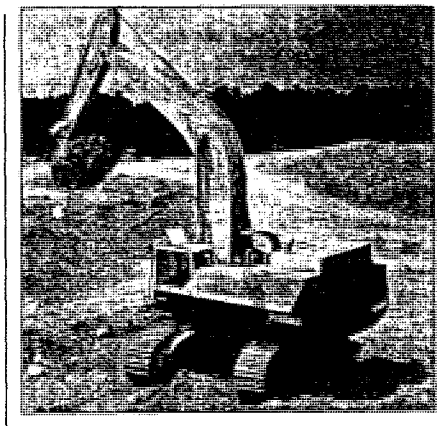


Breakers
Equipped with a range of special performance features, the KXB400, 500 and 600 hydraulic breakers have been designed for a variety of construction applications. The KXB400 has an impact energy classification of 200 ft lb and operates at 1,100 blows per minute.The KXB500 is included in the 500-ft-lb impact energy class. The KXB600 is included in the 750-ft-lb impact energy class and offers a powerful breaking force with a frequency of 875 blows per minute. KUBOTA TRACTOR CORP. 173

On-grade processor
This excavator attachment is for use in a wide range of on-grade applications such as road and bridge reconstruction projects in which on-grade slab removal and processing is needed. It features a lower jaw design that allows the attachment to slip under slabs or decks, raise them and easily guide material to the throat of the attachment for processing. LABOUNTY MANUFACTURING 174



XL 4000 series excavator
A line of hydraulic excavators, known as the XL 4000 series, increases productivity with faster cycle times and higher digging forces, says the manufacturer. Reach and range of the models extend to a full 30 ft, 6 in. at grade, or to over 45 ft with a telestick attachment. The boom tilts up to 220° with a 360° option. All boom movements are easily controlled with joysticks. THE GRADALL CO. 175



Hydraulic excavator improvements
The PC650-5 hydraulic excavator features improved hydraulics for better work capabilities such as three operating modes for heavy, standard and light duty; a soft-dig system that allows the operator to select either a smooth or power mode; and 404 hp at 1,800 rpm for high-production digging and loading operations such as cross-country pipeline jobs. KOMATSU DRESSER CO. 176

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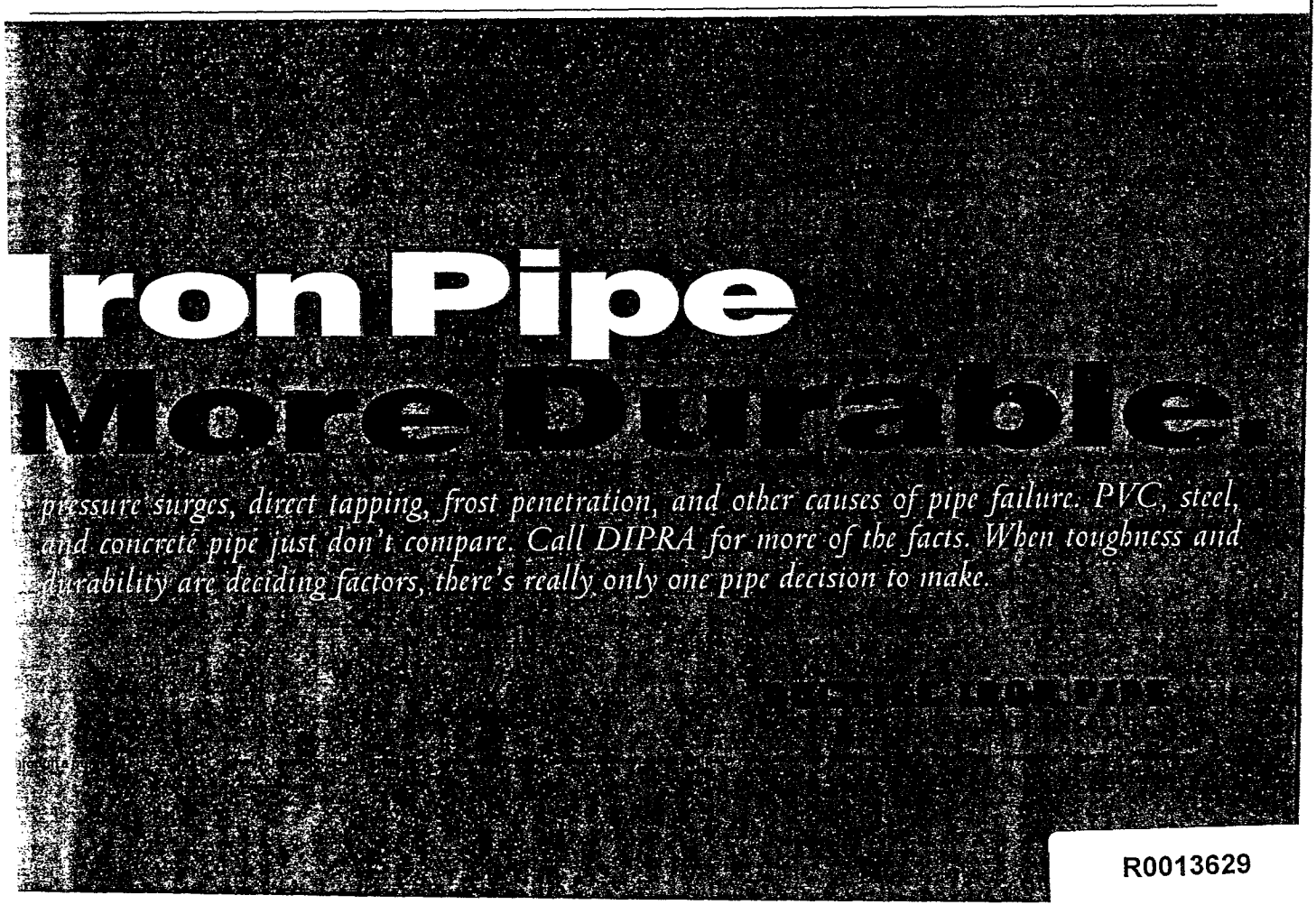


Road ramp rebuild required

The New York State Dept. of Transportation had the power to require a developer to relocate a highway ramp, even after the local municipality removed that requirement from its site plan approval, according to a state appeals court.

In 1985, Westage Business Center Associates sought permission to build a commercial development at the intersection of Interstate 84 and state Route 9 in the Town of Fishkill, N.Y. An environmental impact statement was prepared as required by the New York State Environmental Quality Review Act. Among the concerns listed was the increased traffic at the intersection of I-84 and Rt. 9. The Fishkill Planning Board issued its final site plan approval, conditioned on Westage relocating the existing westbound access ramp from Rt. 9 to I-84, if required by the New York State Dept. of Transportation.

In September 1987, after Westage began construction, DOT issued a highway work permit. The permit is required by state law before anyone can construct or improve an entrance to or connection with any state highway within the right-of-way. It is required "notwithstanding any consent or franchise granted by any town or county superintendent or other municipal authority." The permit required Westage to realign the ramp.

Westage sued the state, challenging this requirement, but the suit was dismissed because it was filed too late. Nevertheless, the Fishkill Planning Board deleted the ramp-moving requirement from its final site plan approval.

As a result, Westage did not build the access ramp. DOT then sued to enforce the terms of its permit. Westage argued that it did not have to relocate the ramp because the requirement was deleted from Fishkill's site plan approval.

The New York trial court ruled for Westage, but the appellate division of the state Supreme Court reversed. It held that DOT could condition its permit on Westage relocating the ramp.

Under state law, DOT had the power to require an owner to perform work needed to "facilitate safe and unimpeded traffic flow," noted the court. "The DOT's authority to impose such conditions in [Westage's] highway work permit was in no way affected by the planning board's addendum removing such conditions." *White v. Westage Development Group Inc., 595 N.Y.S.2d 507 (N.Y. App. Div. 1993).*

Supplier sues over missing bond

A public benefit corporation and the developer of a cogeneration plant were liable to an unpaid supplier because they failed to obtain a payment bond as required by New York State law, a state trial court ruled.

In the late 1980's, Indeck Energy Services of Silver Springs Inc. was developing an energy cogeneration plant in Silver Springs, N.Y. In order to obtain financing at low tax-exempt rates, Indeck signed an agreement with the Wyoming County Industrial Development Agency, a public benefit corporation. Under the agreement, Indeck would transfer title to WCIDA at the beginning of construction and WCIDA would transfer it back at the end of the project. This arrangement allowed WCIDA to sell industrial development revenue bonds to finance the project.

Indeck hired National Energy Production Co. as the general contractor and it subcontracted steel work to Fels Co. Inc. Fels bought $137,000 worth of steel from Davidson Pipe Supply Co. Inc. When Davidson was not paid, it sued WCIDA and Indeck.

Under New York State's Finance Law, a public benefit corporation involved in construction of a public improvement must require a bond guaranteeing payment to all persons furnishing labor or materials on the job. The trial court, the New York State Supreme Court, ruled for Davidson because WCIDA and Indeck were responsible for obtaining a payment bond. Although the statute does not state what remedies are available if a required bond is not obtained, the court held that Davidson had a direct claim against WCIDA and Indeck for their breach of the law. *Davidson Pipe Supply Co. v. Wyoming County Industrial Development Agency, 595 N.Y.S.2d 898 (N.Y. Sup. Ct. 1993).*

Owner can't stiff sub over alleged mob ties

A concrete contractor's alleged membership in a Mafia "club" was not suitable grounds for an owner's refusal to pay the contractor for services on a project, a New York appellate court has ruled.

In 1983, X.L.O. Concrete Corp. contracted to do the concrete work on a Manhattan high-rise apartment building called Rivergate. The price was $16.5 million. X.L.O. performed the work under its contract. In May 1991, it sued Rivergate Corp., seeking payment of $844,135 that it claimed was due on its contract.

Rivergate argued that the contract was unenforceable, asserting that X.L.O. was a member of a Mafia-run "club" of concrete contractors that dominated the concrete trade in New York City. According to Rivergate, its contract with X.L.O. violated state and federal antitrust laws.

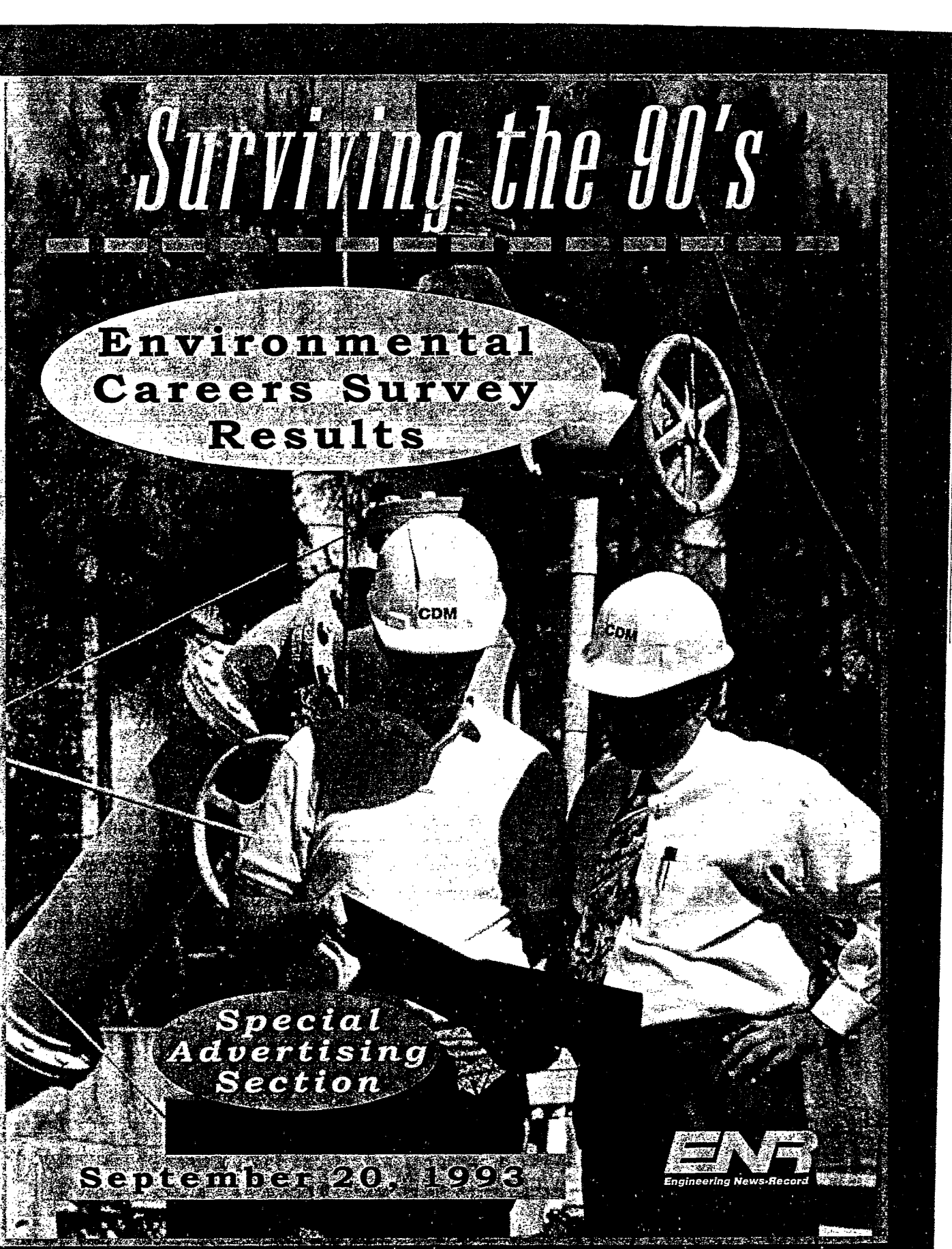
The New York trial court dismissed X.L.O.'s lawsuit. However, the Appellate Division of the state Supreme Court reinstated it, holding that X.L.O. had a right to sue for payment. The court noted that the antitrust laws invalidate contracts and combinations in restraint of trade, but do not void "every contract for services or goods entered into by a person or entity which is a member of such illegal arrangement or combination."

"We conclude that X.L.O.'s membership in the club was collateral to the contract it negotiated and entered into with Rivergate and that the contract and its performance can be proved without reference to the illegal arrangement known as the club; i.e. that the contract constitutes an intelligible economic transaction in itself," said the appeals court. *X.L.O. Concrete Corp. v. Rivergate Corp., 597 N.Y.S.2d 302 (N.Y. App. Div. 1993).*

R0013630

Surviving the 90's

Environmental Careers Survey Results



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How Environmental Employers and Employees Are Adapting

Employees are seeking more autonomy, independence, and a greater say in how they do their work. The days of rapid growth, a job for life and limitless career opportunities are today a distant memory for employees in many environmental firms. Although some firms are still growing, many have had to resort to downsizing, relocation of staff, and streamlining of operations to maintain their profit levels. The results of the 3rd Annual Environmental Career and Employer Preference Survey provide insight into how employees are surviving this difficult period and how their employers are helping them adapt by empowering them.

About the Survey

The Environmental Career and Employer Preference Survey was conducted to gain a better understanding of why employees entered the environmental field, what they like and dislike about working in the field, and how satisfied they are with various aspects of their work life. Respondents were also asked to rank their most preferred employers in the field.

The survey appeared in this year's May 10 issue of Engineering News-Record. Additional copies of the questionnaire were mailed separately to 4,000 subscribers in the environmental field. The results were tabulated by The Discovery Group, a Sharon, Massachusetts-based firm specializing in conducting employee and customer opinion surveys.

About the Respondents

A total of 1,076 completed surveys were received, up from 800 in last year's study. The majority of the respondents work in the private sector (72%) and over half have been with their present employer for at least 3 years. Approximately 50% work for companies whose primary business is environmental engineering while another are 30% are with firms involved in environmental engineering to some extent. Eighty-five percent of the respondents are males. The median age is 39 and the median annual salary is $50,000 to $60,000. The largest segment of the group is employed as either Project Engineers, Directors or Managers (44%). Administrative Managers (13%), Environmental Engineers (14%) and Civil Engineers (13%) comprise the balance of the sample.

The Results

For the third straight year, CH2MHill, Denver, CO, was ranked as the most preferred employer in the environmental field. Twenty-three percent of the respondents ranked CH2MHill as either their first, second or third choice. (See Table 1). It should be noted that CH2MHill employees comprise only 2% of the eligible votes.

Once again Camp, Dresser & McKee Inc., Cambridge, MA, drew runner-up honors with 14% of the vote, followed by a newcomer to the top three, the U.S. Environmental Protection Agency, with 5%.

CH2MHill has adopted a number of on-going programs to bolster employee morale and commitment. As a result, turnover among professionals has only been 5% over the past several years. The company is highly committed to their employee opinion survey process. They conducted a survey last year and do so periodically. Darell Nepil, Corporate Staffing Manager, says that employees have embraced their quality improvement program. "Even the skeptical ones have become believers. Most have received training and are now beginning to work on quality improvement projects."



Two U.S. Environmental Protection Agency wetland scientists working together at Sapelo Island, GA. Photo: S.C. Delaney/U.S. EPA.

Bob Card, Director of Business Development and Planning at CH2MHill, attributes the favorable ratings received by the firm to several factors. "Our matrix organization enables us to communicate effectively throughout the organization. The growth of employees is limited only by their skills and flexibility, not by the organization. I can also count on only one hand the number of our 5,700 employees where people won't talk to each other."

Assigning the right people to the right assignment has helped buoy employee attitudes at Camp, Dresser & McKee. According to Charlene Allen, Corporate Human Resources Manager, "We restructured a few years ago to move away from traditional home room type project teams. This has enabled us to provide more career growth for our employees. All employees are assigned to Resource Pools which enables us to match their skills, experiences and track record to the appropriate new project. As a result, although employees must travel more between our different offices, they are able to develop their skills more rapidly."

A number of factors may have contributed to the positive ratings of the U.S. Environmental Protection Agency.

Cover photo: Camp Dresser & McKee is implementing a mentoring program, designed to pair senior and junior engineers.

R0013633

Environmental Careers Survey Results

"Our employees have not been impacted by the concern for job security found in many public sector firms," says Maureen Delaney, Director of Human Resources for the U.S. E.P.A.'s Office of Air and Radiation, Washington, D.C.. "Many of our employees choose to work for the E.P.A. over private sector firms because they are interested in public service and feel they can have more of a direct impact on the environment."

What Do Employees Want Most From Their Job?

For many engineering professionals, the environmental field represented an oasis in the drying engineering employment market. Although employees entered the field for a variety of reasons, the majority were attracted to the abundant opportunities for personal and career growth.

As shown in Tables 2 and 3, personal growth is the leading reason why employees entered the environmental field and is also what they like best about their current job. Thirty-two percent say they were seeking a feeling of personal pride and accomplishment from their work. Employees like the autonomy and independence their current jobs provide. They also like the actual type of work they are conducting as well as the level of responsibility their jobs require. In addition, they are happy with the high degree of variety and challenge their jobs provide.

In addition to the intangible of personal growth, employees seek tangible career advancement (See Table 2). Approximately 4 out of 10 survey respondents say they entered the field for career growth opportunities (22% sought more alternative career paths and 17% were attracted to the better chances for advancement).

TABLE 1
TOP 10 PREFERRED ENVIRONMENTAL EMPLOYERS
(N=548*)

Ranking '93	'92	'91	1993% Respondents (0 10 20 30)	Company
1	1	1	23.2%	CH2M Hill Cos. Ltd.
2	2	2	14.1%	Camp, Dresser & McKee, Inc.
3	8	7	5.3%	U.S. Environmental Protection Agency
4	7	8	3.8%	Black & Veatch
5	10	3	3.5%	Bechtel Group
	5	4	3.5%	Metcalf & Eddy
	17	16	3.5%	U.S Federal Government (Unspecified)
6	12	7	3.1%	Ebasco Services
7	6	6	2.9%	International Technology Corporation
		9	2.9%	Roy F. Weston
		12	2.9%	Waste Management Inc.
8			2.7%	Fluor Daniel Inc.
	9	10	2.7%	Woodward-Clyde Group Inc.
9	4	5	2.6%	Montgomery Watson
10	15	15	2.4%	Brown & Caldwell Consultants

**Note - Only non-photocopied completed surveys were included in the analysis of the 1993 responses. A small number of firms had sent in a significant number of photocopied surveys. If the photocopies had come from a diverse number of firms, we could have comfortably attributed this to our pass-a-long readership. However, since this was not the case, and the photocopies dramatically affected the rankings, it was felt the fair and statistically reliable decision was to eliminate the photocopies for this specific question.*

Are Employees Getting What They Want?

In the face of restructuring, downsizing, and a shrinking job market, career advancement opportunities in the industry have declined. Not surprisingly, employee satisfaction with career opportunities has suffered. As shown in Table 4, only 27% are very satisfied with their advancement opportunities and only 23% are very satisfied with the alternative career paths offered by their company.

Although concerned about their advancement, the overwhelming majority of employees have no immediate plans to leave their job. Seventy-four percent plan to stay with their current employer. (See Table 5) However, lack of career

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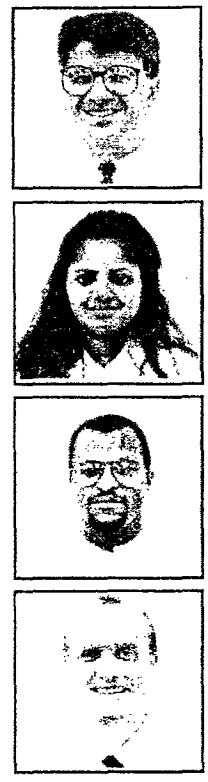

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advancement is the leading reason why employees might consider leaving. (See Table 6) Thirty-three percent say lack of career advancement might lead them to leave.

Job security is another major concern of employees today. Most firms, even those still growing, have had layoffs. As shown in Table 4, only 33% are very satisfied with their job security.

Instead of wondering about the next promotion, many employees are now wondering about what they can do to expand their job skills and maintain their job security. Jim Krug, Manager of Training and Development at Woodward-Clyde, Denver, CO, recommends a strategy many have been adopting to survive the 90's, "when you get up in the morning to go to work, you should view yourself as an independent con-

TABLE 2
WHY DID YOU ENTER THE ENVIRONMENTAL FIELD? (N = 1,076)

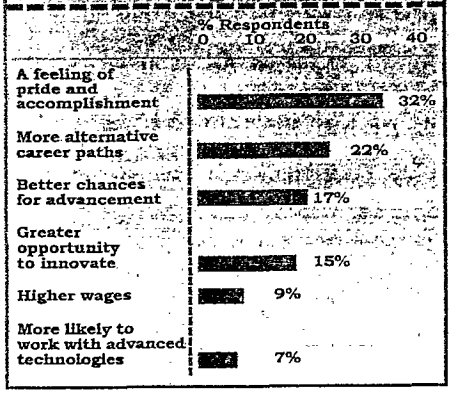
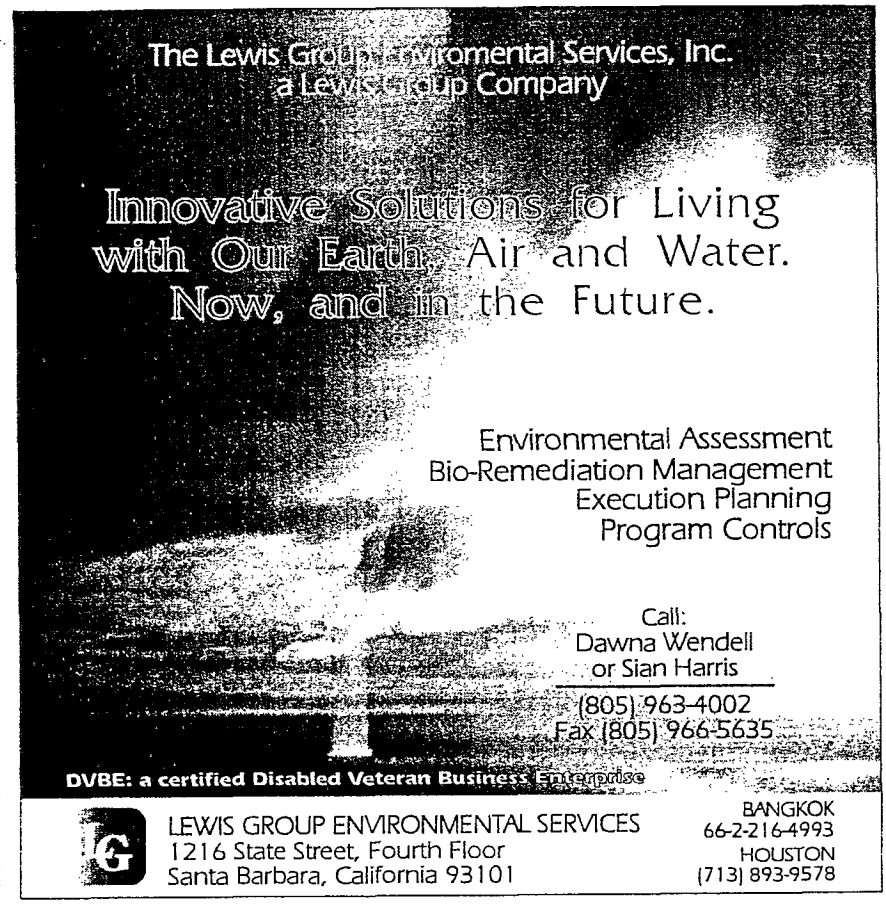


TABLE 3
WHAT DO YOU LIKE MOST ABOUT YOUR CURRENT POSITION? (N = 1,076)

Rank	
1	Autonomy/independence flexibility
2	Variety/diversity of projects
3	Job duties/responsibilities/types of projects
4	Job Challenge
5	The people/coworkers
6	Learning/gaining experience
7	Innovation
8	Corporate culture/coworkers
9	Location
10	Working to improve the world/ enhance environment





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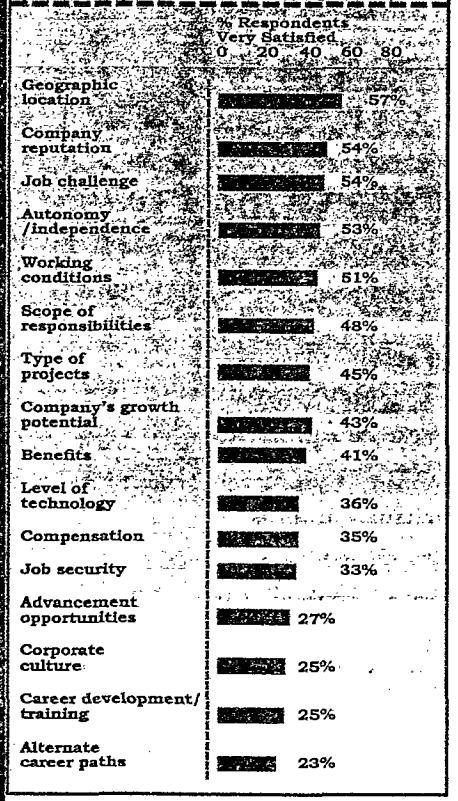
sultant. If you look at your job that way, it can help you deal with the uncertainties of the economy and the lack of job security."

How Employers Are Responding

In today's challenging economic environment, employers have had to ask employees to work more independently, do more varied type of work and assume more decision-making authority. Fortunately, as the survey reveals, this is precisely why employees entered the field in the first place and what they are looking for from their jobs today.

The key has been for environmental firms to increase employee empowerment. A variety of strategies have been used to empower employees. They range from abandoning traditional hierarchical management structures to providing employees with more personal responsibility for their own careers. "The environmental consulting type of business lends itself quite well to empowerment," says Audrey Hausmann, Regional Human Resources Manager at McLaren-Hart, Philadelphia, PA. "The way work groups are structured into project teams allows employees a good deal of independence and responsibility to develop solutions to meet clients' needs."

TABLE 4
LEVEL OF SATISFACTION WITH KEY JOB FACTORS (N = 1,076)



Changing the Corporate Structure

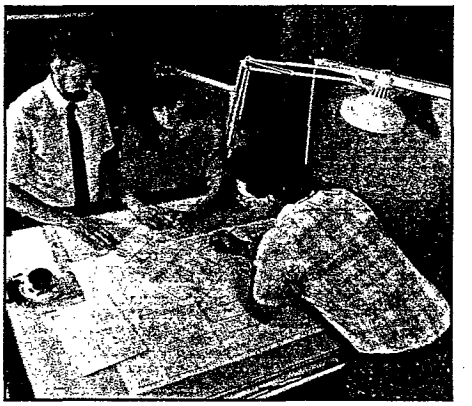
In an effort to empower employees and move decision-making authority lower in the organization, many environmental firms have restructured in the past few years. Their efforts have been complicated by the fact that many of the firms are very large, offer a wide diversity of services, and are spread throughout the country.

Not unlike many other environmental firms, CH2MHill continues to make changes to simplify its organizational structure. According to Darell Nepil, "The key to our structural changes has been to make certain we are best serving our customers."

Empowering employees to best serve their customers is the guiding principle for restructuring at Science Applications International Corporation (SAIC), San Diego, CA, as well. "We want our customers and employees to have easy access to each other," says Howard Pratt, Group Senior Vice President of Environmental Services. "For example, since many of our customers are in Washington, D.C., we have eight offices there."

Once they are appropriately staffed and given the proper tools, firms have been empowering their local offices. "We have tried to keep the organization relatively flat to facilitate decision-making, says Jim Krug at Woodward-Clyde. Our 45 local offices are fairly independent so they don't have to refer many questions to corporate headquarters."

Reducing layers of management has also helped empower employees at Dames & Moore, Los Angeles, CA. "We have tried to flatten the organization to give employees better access to significant decision makers," says Ann Toepker, Chief



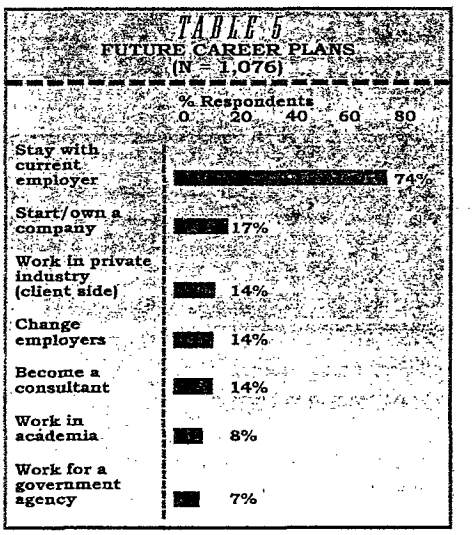
Teaming approach at O'Brien & Gere Engineers facilitates input from multiple disciplines to best serve clients and employees. Photo courtesy: O'Brien & Gere Engineers, Inc.

Human Resources and Communications Officer.

"At ABB Environmental Portland, ME, we flattened our structure to three levels of management: team leaders, service center managers and senior managers," explains Bob Sansone, Vice President of Human Resources. "We also increased signature authority so that people don't have to chase four other people for signatures. The person signing is the person who has the responsibility."

"A rigid hierarchical approach doesn't work in our industry," says Nick Masucci, Senior Vice President of U.S. Environmental Services for Louis Berger, East Orange, NJ. "We want people to be creative and contribute to the solution. We try to break up projects into sub tasks so that instead of just collecting data, employees have a sense of accomplishment when they complete a task."

TABLE 5
FUTURE CAREER PLANS (N = 1,076)



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Redefining the Job of Supervisor

Some companies have realized that empowering employees requires managers with greater people skills. At ABB Environmental, "Employees helped us develop a competency based model of the job of manager," says Bob Sansone. "We then removed all of our managers from their positions and refilled the positions with the more people-oriented managers and reassigned others to senior technical positions. We also coached the new managers to continually ask employees how they can help them to do their jobs better."

Many firms have also made empowering employees an important part of the supervisor's responsibilities. In fact, some organizations evaluate supervisors based on how well they empower others.

Reducing Paperwork

A major concern of many employees is the huge amount of paperwork and bureaucracy with which they must contend. What firms have been trying to do is provide employees with the autonomy and independence they need to maintain their entrepreneurial spirit while still maintaining some degree of control. "A certain amount of bureaucracy is inevitable," says Audrey Hausmann of McLaren-Hart.

The many forms and signatures required by both their own companies and regulatory agencies often paralyze rather than empower employees. "After you've completed the paperwork, there is often no time left at the end of the day," says Crystal Cruise, Human Resource Supervisor at Canonie Environmental, Porter, IN.

In an attempt to untie the hands of their employees, some environmental firms have automated while others have conducted extensive internal analyses of the paperwork trail.

"We've tried to reduce paperwork by conducting an internal systematic analysis of who receives what reports and memos and who really uses them," says Martin Reynolds, of the Marketing and Public Relations group at Stone and Webster, Boston, MA. Woodward-Clyde through their TQM program, called Leadership Through Client Satisfaction, is also looking at their internal procedures and asking if they really need all of their existing forms.

Several firms including TRC Environmental, Lowell, MA and McLaren-Hart are moving toward

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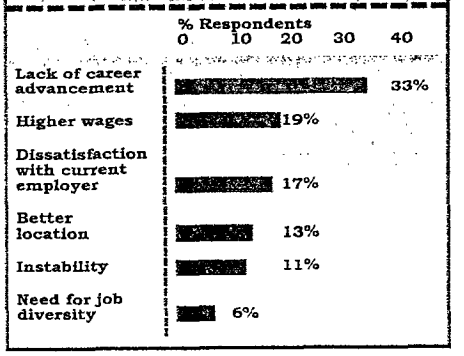
TABLE 6
WHY MIGHT YOU DECIDE TO LEAVE YOUR CURRENT EMPLOYER?
(N = 1,076)



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real time project management systems that allow employees to know the status of projects at any point in time. Others are computerizing commonly used internal documents. "We have aggressively reduced internal paperwork by computerizing our client report and cost reports," says Marge Adler, VP of Organization Development at Roy F. Weston.

Empowerment Through Quality Improvement

Many environmental firms have initiated quality improvement programs. The goal of these programs is to continuously improve the ability of the firm to meet the expectations of their customers. One major by-product of these efforts, however, is increased employee empowerment. Front line employees are major contributors to identifying problem areas, developing solutions and then implementing the improved processes.

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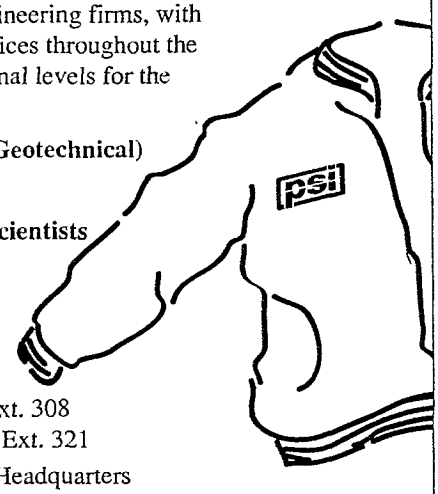

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As part of these quality initiatives, many firms have instituted customer satisfaction assessment programs. "We ask our clients directly how we are doing through individual interviews and surveys," reports Howard Pratt of SAIC. "That's been very helpful to us."

A similar client survey at ABB Environmental showed that their clients were concerned about their billing process. "With less work internally, we were able to cut our receivables by half and greatly reduce our billings over 60 days old," says Bob Sansone.

As part of their Continuous Performance Improvement program (CPI), Fluor Daniel, Irvine, CA, has instituted a policy called "The Alignment Process" which has empowered employees to better serve their clients. Mike Burnett, Director of Communications in their Greenville office, says, "All new projects must have an alignment process. It begins before the actual meeting and requires looking at the culture of our client and our own culture. We then jointly develop a common vision of a successful project and then assign responsibility for each key result area."

Are Employees Satisfied?

The survey indicates that for the most part, efforts to empower employees are working. Despite reduced career opportunities, the overwhelming majority (74%) of employees plan to stay with their current employer, up from 60% last year. Also, this year only 14% plan to switch employers which is down from 19% last year. (See Table 5)

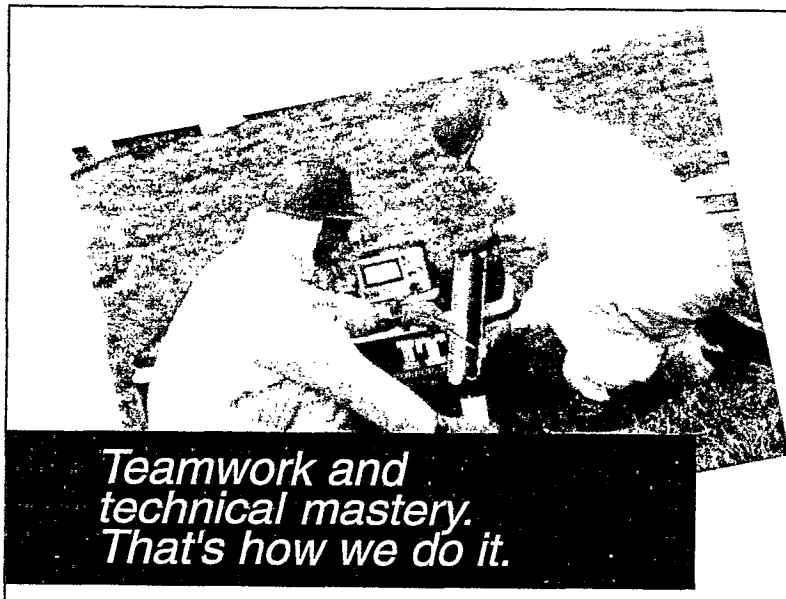
Table 4 shows that employees are generally very satisfied with their jobs' challenge, autonomy and independence. However, far fewer are very satisfied with the corporate culture, job security, and advancement opportunities.

Many workers are seeking even more autonomy and independence than their current employers are able to provide them. Seventeen percent desire the freedom of starting or owning their own company, 14% would like to become an independent consultant and 8% would like to work in an academic setting.

Continuing to provide opportunities for engineers to broaden their skills is one of the our major employee relations challenges facing environmental firms. In addition to empowerment strategies, a number of career management approaches have been used to help employees



TRC Environmental Corporation has instituted a project management training program which emphasizes quality, completion schedule, cost management and effective client communication. Photo courtesy: TRC Environmental.



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U.S. EPA's Superfund workers at hazardous waste clean-up site. S.C. Delaney/ U.S. EPA

attain their career goals. Audrey Hausmann, however cautions that "Career management is the responsibility of both employee and manager. Employees must begin to develop short and long term career goals and actively plan actions to achieve these goals as early in their career as possible."

One approach used by a number of firms is the use of dual-career paths. "We have a two-tiered approach," says Nick Valkenburg, Vice President at Geraghty and Miller, Plainview, NY. "You don't have to get stuck doing one thing. You can move in and out of administrative and technical jobs so that you can pursue your own specific interests."

The Future

Human resource professionals are poised for a flurry of activity in the upcoming year, which may ease employee concern about job security and open up new advancement opportunities. This activity will require continuing to move employees into areas of the firm where they may be needed as well as additional hiring.

"The government and the public have begun to lose patience with studying the problems and want to move on with the clean-up," says Glenn Zimmerman, Regional Human Resource Manager at ABB Environmental. "Remedial design and engineering have started to grow already."

Others also foresee big growth in waste minimization, air quality management, municipal infrastructure, process changes in industrial facilities, reduction of emissions before they are produced, and environmental management and program design.

In addition to experienced personnel in these areas, many firms are also looking for "people-oriented" project managers. "Project managers are needed that can communicate how and why decisions are made," says Crystal Cruise of Canonie Environmental. "You don't find them walking the streets. A good project manager might interview with as many as 6-8 firms".

"People with strong project management skills are worth their weight in gold," agrees Bob Sansone. "We're looking for people with good people skills, technical knowledge, and financial awareness."

Why are "people-oriented" managers so critically important? The answer is empowerment. It takes a special type of manager to be able to continually empower others. Empowerment is vital for the growth of environmental firms and their employees.

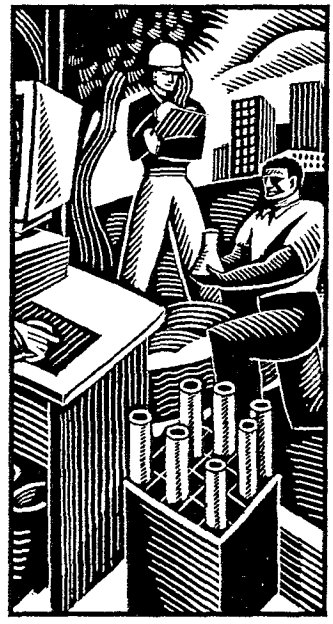


Engineers conducting inspection of sewage treatment facility for the U.S. Environmental Protection Agency. Photo credit: S.C. Delaney/U.S. EPA.

Written by Dr. Bruce Katcher

Dr. Katcher is an Industrial/Organizational psychologist and President of The Discovery Group, a consulting firm based in Sharon, MA specializing in employee opinion and customer satisfaction surveys.

If you would like a complete copy of the "Environmental Career & Employee Preference Survey analyses booklet, please send $47.50 for each copy to Yvette Weiters, ENR, P.O. Box 900 NY, NY 10108 or call 212-512-2159.



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PLANS

Florida—Nix Mann Yiehman Architects Inc., Atlanta, has been selected architect by Walker Memorial Hospital for **addition and alterations to hospital** located on U.S. Highway 27 N. in Avon Park. Estimated cost, $15 million.

Georgia—Diedrich Architects & Associates Inc., Atlanta, is negotiating a design-construction management contract with an unnamed owner for Stone Mountain **incline railroad** located at Stone Mountain Park. The project will consist of cable-driven electric rail cars, computer systems, and replacement of buildings on top of the mountain. Estimated project cost, $13 million. Construction start hopeful for late 1994. Completion targeted for September 1995.

Hawaii—GMP Associates, Honolulu, is preparing working drawings for **secondary wastewater treatment plant facility** located at Honouliuli Wastewater Treatment Plant in Honolulu. Planned by City and County of Honolulu. Estimated cost, $40 million.

Illinois—Hammond Beeby & Babka, Chicago, has been selected architect by Fourth Presbyterian Church for **renovation and restoration of church** at 126 E. Chestnut St. in Chicago. Estimated cost, $12 million.

Maine—Symmes Maini & Mckee Associates Inc., Cambridge, Mass., is preparing plans for a four-story, 240,000-sq-ft **office building** located at 2211 Congress St. in Portland. Planned by UNUM Life Insurance Co. of America, Portland. Estimated cost, $19 million. Further progress pending Dept. of Environmental Protection approvals.

Massachusetts—Joint venture of Hoskins Scott & Partners Inc., Boston, and Hammel Green & Abrahamson Inc., Minneapolis, Minn., has been selected architectural team to design the **Medical City Complex**, which will include a nine-story, 379-bed hospital, Fallon Clinic offices, an atrium and medical office building, retail space and adjacent parking structure, to be built on a 22-acre site in downtown Worcester. Planned by an unnamed owner. Plans scheduled to start soon. The facility is targeted to be operational by late 1998.

Massachusetts—Homart Development Co., Chicago, has selected ADD Inc., Cambridge, to provide architectural services for the proposed rebuilding of Shoppers World **retail mall** located on Rte. 9 in Framingham. The project will consist of demolition of existing 760,000-sq-ft shopping center and construction of new shopping center to house 15 value-oriented retailers and approximately 50,000 sq ft of specialty space. Further action pending August 1994 completion of the Natick Mall project.

Missouri—Promus Cos. Inc., Memphis, Tenn., is planning to build the Harrah's St. Louis **casino and entertainment complex** located at southwest quadrant of I-70 and Earth City Expressway in the Maryland Heights section of St. Louis. The estimated $82-million project will include a 43,000-sq-ft riverboat casino-entertainment complex with dining areas, retail space and lodging. Further progress pending license approval.

Missouri—Arnhold & Associates, Hermann, is in early planning stage for the proposed Bavarian Hills **shopping mall**, which will include eight to ten stores and parking facilities for 1,000 cars, located at Highways H, 19 and I00 in Hermann. Estimated cost, $25 million. Further action pending results of market analysis.

New York—Greenman-Pedersen Inc., Babylon, is architect for 175,000-sq-ft **retail shopping center** to be built on a 108-acre site at southeast corner of Commack Rd. and Grand Blvd. in Deer Park. Planned by R.G. Partners, Great Neck. Estimated cost, $13 million to $14 million. Feasibility studies are in progress.

Ohio—Deaconess Society/Hospital/Family Home, Cleveland, is preparing preliminary plans for a $14-million outpatient **medical center**, which will include indoor swimming pool at Northcliffe Rd. in Brooklyn.

Texas—Southwest Properties, Dallas, is planning to build a 200-unit **apartment complex**, the old Santa Fe Building located at 1122 Jackson St. in Dallas. Estimated cost, $17 million. Further information within 30 days.

Virginia—Gary Weaver Inc., Indianapolis, Ind., is completing plans for the nine-building, 264-unit Deer Cross **apartment complex**, including swimming pool, clubhouse, health spa, and racquetball and tennis courts, located on Colonia Ave. at Ogden Rd. in Roanoke. Planned by Occidental Development Ltd., Indianapolis, Ind. Project to be advertised for sub-bidding late 1993. Construction start scheduled for spring 1994.

Wisconsin—HSR Associates Inc., La Crosse, is preparing design. Toltz, King, Duvall, Anderson & Associates Inc., St. Paul, Minn., is structural engineer for a **combined support and military vehicle maintenance shop** to be built on a 13-acre site at Volk Field, Camp Douglas. Planned by U.S. Property and Fiscal Office, Camp Douglas. Estimated cost, $11 million.

CONTRACTS AND LOW BIDS

Alabama—The results of a recent bid opening by Jefferson County Commission, Birmingham, shows Brasfield & Gorrie Inc., Birmingham, as the lowest bidder at $13,021,000 for a **wastewater treatment facility** located on Ala. Highway 119 in Leeds.

California—The University of California at Berkeley, Planning Design and Construction Dept., is reviewing bids received at a recent bid opening where McCarthy, Sacramento, was the apparent low bidder at $24,333,720 for **chemistry unit III and service access improvements** located west of Latimer Hall and north of Gilman Hall in Berkeley.

Information for Pulse is derived primarily from Dodge Reports prepared by the F.W. Dodge Div. of McGraw-Hill Inc. For more details on these and other construction projects or to learn more about Dodge Reports, call (800) 541-9913.

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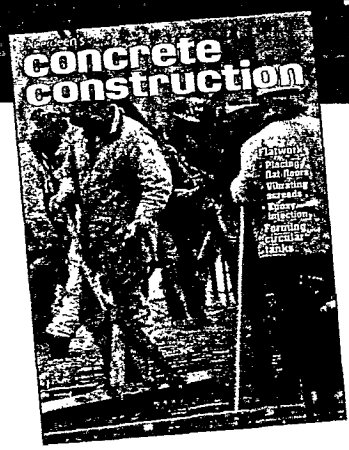

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California—Hensel Phelps Construction Co., Santa Clara, was the apparent low bidder when the Sacramento Municipal Utility District opened bids for a new four-building **customer service center**, which will include a 163,800-sq-ft multistory office building, a 4,300-sq-ft fitness center, 2,100-sq-ft food service building and a 14,200-sq-ft HVAC central plant located at 6251 S St. in Sacramento. Estimated project cost, $37.5 million. Contract award pending results of Board of Directors meeting.

California—The U.S. Dept. of Veterans Affairs, Central Office of Acquisition and Material Management, Washington, D.C., has awarded a general contract to Dillingham Construction, Long Beach, for **VA hospital**, Bid Pkg. A, building #126, located at 5901 E. Seventh St. in Long Beach. Work will consist of fabricating, testing and installing seismic base isolation system that will support a 12-story reinforced concrete shear wall building. Estimated project cost, $17.5 million.

California—Clean-Up Technology, Santa Monica, has been awarded a contract by Chevron USA Products Co., El Segundo, for a **bioremediation facility**, including support areas, located at the former Todd Shipyard in San Pedro. The project will include five bioremediation cells, offices, lunch and lab trailers, low temperature thermal oxidizer, a decontamination area, and truck scale and storage area. Coastal permit has been granted. Construction and set up of cells expected within three months.

California—Morley Construction Co., Burbank, has begun construction on a $12.5-million six-story **parking structure** in vicinity of Olive Ave. and the Los Angeles River in Burbank. Contract was awarded by Warner Brothers Inc., Burbank.

California—Brutoco Engineering & Construction Inc., Fontana, has been awarded a general contract by the City of Irvine for **Culver Dr. improvements**, including underpass and pedestrian overcrossing and water and sewer facilities in Irvine. Estimated project cost, $10.3 million. Work scheduled to start within 30 days.

California—California Corridor Constructors, Irvine, has awarded a contract to FCI Constructors, San Diego, for Moulton Parkway Toll Highway **bridge** located in Lake Forest. Estimated cost, $10 million.

Connecticut—A contract to build the 37-building, 302-unit Prentice Place **apartment complex** was awarded to Great West Contractors, Denver, by Simpson Housing Corp., Denver, Colo. The estimated $21-million project, including parking garages, outdoor swimming pool and clubhouse is located near Prentice Place and S. Ulster St. in Greenwood Village.

R0013644

Florida—The City of Homestead has awarded a general contract to Gilbert Southern, Miami, for Homestead **motorsports complex** located east of the Homestead Sports Complex. Estimated project cost, $37 million. Project completion scheduled for February 1994.

Florida—A low bid of $33,890,000 was made by Andrade Gutierrez Construction, Miami, when the Dade County School Board, Miami, opened bids for **state school,** Barbara Goleman Senior High School, at N.W. 89th Ave. and 142nd St.

Florida—Greenhut Construction Co., Pensacola, has been awarded a general contract by Sacred Heart Hospital, Pensacola, for **addition to hospital** located at Ninth Ave. and Bayou Blvd. in Pensacola. Estimated project cost, $15 million.

Florida—The Metro-Dade County Dept. of Aviation, Miami, has released results of a recent bid opening which show State Paving Corp., Fort Lauderdale, as submitting a low bid of $12,452,417 for **improvements to runway 12-30 and extension of runway 9R/27L,** Bid Pkg. 2, at Opa Locka Airport. Contract award expected within 60 to 90 days.

Florida—The results of a recent bid opening by the Miami-Dade Community College shows DCC Constructors Inc., with corporate offices in Orlando and Plantation, as the low responsive bidder on a $9.2-million, five-story, 580-car **parking garage and central utilities plant** located on the south campus of Miami-Dade Community College. Groundbreaking is scheduled for October 1993, and construction is expected to take 14 months.

Hawaii—A low bid of $16,248,000 was made by G.W. Murphy Construction Co. Inc., Honolulu, when University of Hawaii, Honolulu, opened bids for UH Manoa **faculty housing,** phase 2, 173 units, including parking for 325 cars, located on Kalawaa at Woodlawn and Lowry in Manoa Valley. Contract award possible by end of September and completion targeted for January 1995.

Massachusetts—The Massachusetts Highway Dept., Boston, is reviewing bids received at a recent bid opening where M. Dematteo Construction Co., North Quincy, submitted the lowest bid at $19,165,637 for **ventilation building #7** located at Boston Harbor and Logan Airport through Bird Island Flats.

Massachusetts—A contract for the 126,800-sq-ft Massachusetts state **track facility** was awarded to a joint venture of Suffolk Construction Co. Inc., Boston, and J.B. Cruz Construction Corp., Roxbury, by the State of Massachusetts Division of Capital Planning & Operations. The new state-of-the-art facility with a total seating capacity of 3,000, constructed under the design-build method, will serve high school track athletes, Roxbury Community College students, faculty and staff, and the local community. The estimated $14-million project, is located on the campus of Roxbury Community College at the corner of Tremont and new Dudley Sts. in the Roxbury section of Boston. Construction start scheduled for October 1993.

Minnesota—HBE Corp., St. Louis, Mo., has been selected general contractor for **addition and alterations to Cambridge Medical Center** located at 725 S. Delwood St. in Cambridge. Estimated project cost, $11 million. Construction start targeted for September 1993.

Mississippi—Roy Anderson Corp., Gulfport, has been selected general contractor by Maritime Corp., Biloxi, for the Palace **casino** to be built on an existing barge at Howard Ave. and Cadet St. in Biloxi.

Nevada—McCarran Constructors, Las Vegas, has submitted a low bid of $17,329,000 when Clark County Dept. of General Services, Las Vegas, opened bids for **extension of runway 7L/25R,** including construction of new taxiway, drainage improvements, removal and replacement of taxiway lighting, McCarran 2000 phase 3 project located at McCarran International Airport in Las Vegas. Contract award expected by end of September 1993.

Nevada—Clark County Dept. of General Services, Las Vegas, has released results of a recent bid opening which lists Meadow Valley Contracting, Moapa, as submitting the lowest bid at $14,062,581 for McCarran International Airport north portal **roadways and guardhouse,** McCarran 2000 phase 3 project located in Las Vegas. Estimated project cost, $14 million. Contract award expected by end of September 1993.

Nevada—The Nye County Board of Commissioners, Tonopah, is reviewing bids received at a recent bid opening where Steed Brothers Construction Co., Las Vegas, was listed as the apparent low combined base bidder at $10,792,791 for a **criminal justice complex,** phased construction, which will consist of a 78,000-sq-ft, 48-bed jail facility including sheriff's department, court facilities and district attorney's office at Radar and Globemallow in Tonopah; and an 8,500-sq-ft sheriff's department with eight holding cells and court facilities, located at Second and Third St. in Beatty. Further action within 30 days.

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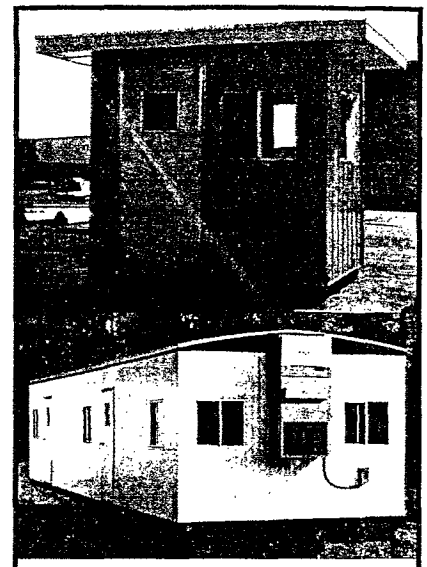

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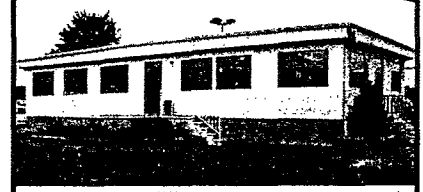

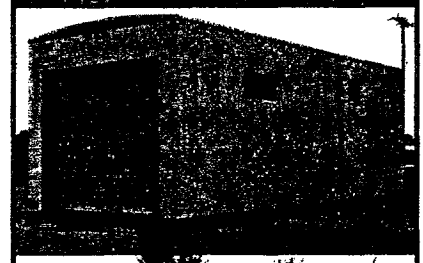

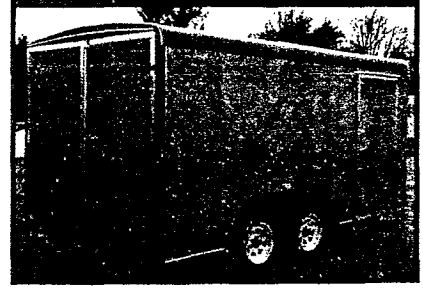

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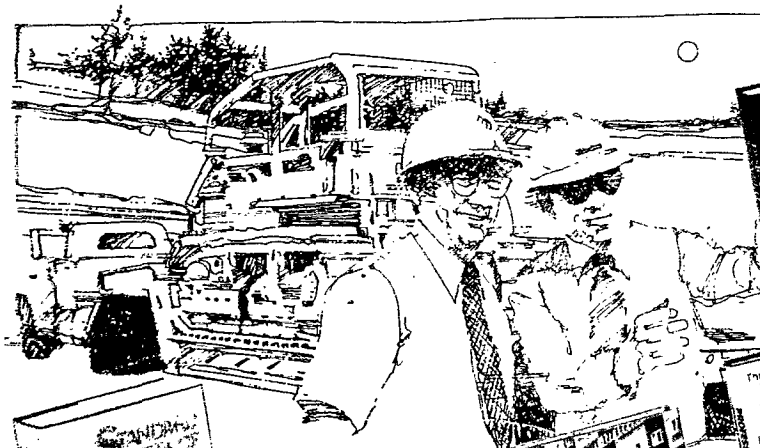

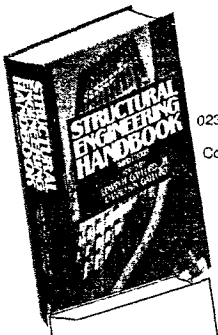

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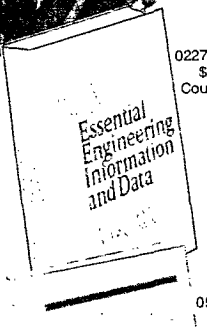

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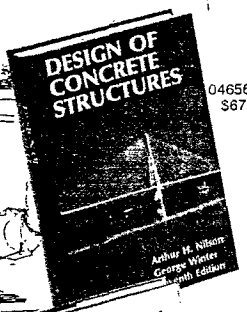

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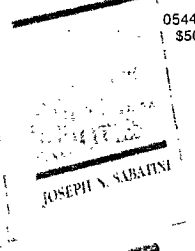

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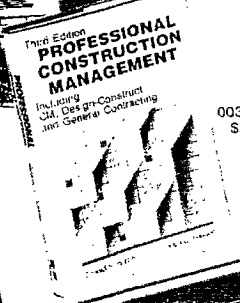

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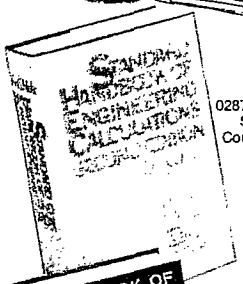

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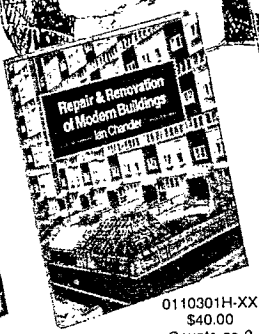

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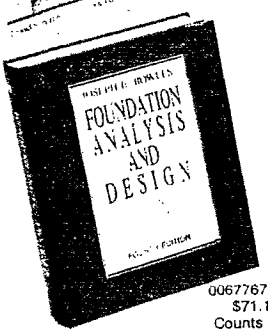

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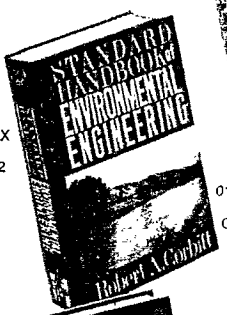

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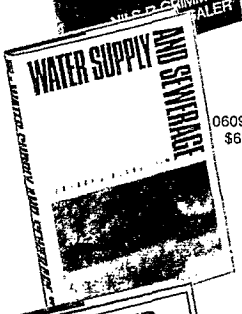

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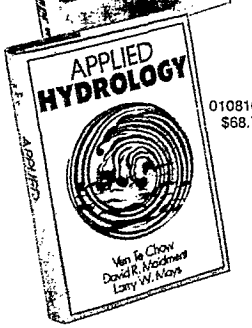

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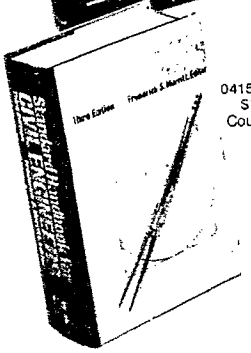

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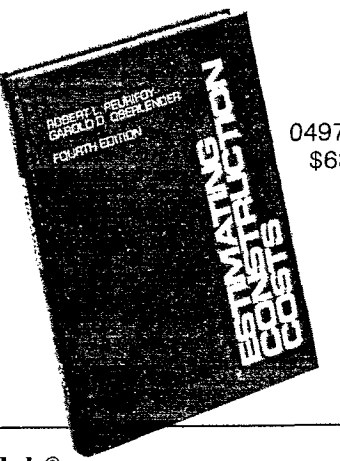

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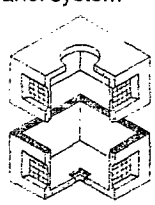

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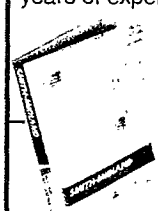

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New Hampshire—McCarthy, St. Louis, has been awarded contracts to build three projects at Exeter Hospital in Exeter. The projects include a $6-million, one-story, 61,000-sq-ft **skilled nursing facility** to house 125 beds, dining and laundry rooms; a $5.5-million, three-story, 57,000-sq-ft **physical rehabilitation and exercise facility**; and a $2.4-million, 308-car, three-level **parking structure**. Construction is under way for the skilled nursing facility and is scheduled to be completed by October 1994. Construction will begin September 1993 on the Exeter Life Center physical rehabilitation and health club facility, and be completed by November 1994. Construction on the third project, a design-build parking facility, will also start in September and is scheduled for an August 1994 completion.

New Jersey—The Iselin office of Morse Diesel International was the apparent low base bidder on a general contract at $187,887,000 when the New Jersey Sports and Exposition Authority, Atlantic City, opened bids for a four-story, 2-million-sq-ft **convention center**, Contr. #7, which will include parking for 1,576 cars and a sports complex located on Beach Thoroughfare at Atlantic City Expressway and Kirkman Blvd. in Atlantic City.

New Jersey—The Bristol Myers Squibb Co., Syracuse, N.Y., has awarded a general contract to Binsky & Snyder Inc., Plainfield, for **expansion of pilot plant**, building #53, located on Rte. 1 in New Brunswick. Estimated project cost, $40 million.

New Jersey—Torcon Inc., Westfield, has been selected general contractor on a design-and-construct basis by the New Jersey Building Authority, Trenton, for the statehouse **underground parking garage** located on E. State St. in Trenton. Estimated project cost, $28.6 million. Construction start targeted for November 1993.

New Jersey—The New Jersey Transit Corp., Newark, is reviewing bids received at a recent bid opening where Prismatic Development Corp., Parsippany, submitted the lowest bid at $23,132,500 for a 210,000-sq-ft **bus maintenance garage** located in vicinity of Rte. 80 W. and Rte. 23 N., lot 1, block 402 in Wayne.

New Jersey—Arthur J. Ogren Inc., Vineland, has been awarded a general contract by Cumberland County Purchasing Dept., Bridgeton, for 77,000-sq-ft **addition and renovation of courthouse**, which will include four additional courtrooms and associated judges' chambers on Broad St., next to county jail in Bridgeton. Estimated project cost, $10.5 million.

New York—The New York State University Construction Fund, Albany, is reviewing bids received at a recent bid opening where Merritt-Meridian Construction Corp., Beacon, submitted the lowest bid at $19,487,000 for two new **academic buildings and a research greenhouse** located at SUNY Binghamton campus. Contract award is expected within two months. Construction start is scheduled for October 1993 and completion is targeted for February 1997.

Oklahoma—Smith & Pickel Construction, Oklahoma City, has begun construction on phase 2 **addition to hospital** located at 1011 14th Ave. N.W. in Ardmore. Contract was awarded by Memorial Hospital of Southern Oklahoma, Ardmore. Estimated project cost, $16 million.

Oregon—The results of a recent bid opening by the City of McMinnville show Contractors Inc., Tualatin, as submitting a low bid of $25,577,700 for a **wastewater treatment project**, which will include a new wastewater plant, a new pump station at existing site and pipelines between new and existing plants, located at end of Colvin Court in McMinnville. Project completion is targeted for October 1995.

Oregon—A contract to build the new two-story, 180,000-sq-ft Nordstrom **department store** at Washington Square Mall in Tigard, was awarded to R.E. Bayley Construction Co., Seattle, by Nordstrom, Seattle. Estimated project cost, $15 million to $18 million.

Oregon—An apparent low bid of $14,694,000 was made by a joint venture of S.D. Deacon and J.R. Roberts Corp., Portland, when the West Linn School District, West Linn, opened bids for a two-story, 140,000-sq-ft **high school** located on Wilsonville Rd. in Wilsonville. Construction scheduled to start soon.

Pennsylvania—Thomas P. Carney Inc., Langhorne, was the apparent low bidder on general contract, design-and-construct basis, at $48,800,168 when the Southeastern Pennsylvania Transportation Authority (SEPTA), Philadelphia, opened bids for the new Midvale **bus maintenance facility**, Luzerne replacement facility, located at 4301 Wissahickon Ave. in Philadelphia. Contract award expected by late September and construction start possible by November.

Utah—Jacobsen Construction Co. of Salt Lake City has been selected by the Salt Lake City School District as construction manager for the $22-million **addition and remodeling of East High School** located at 800 South 130 East. The project includes the construction of a new sports stadium, 200,000 sq ft of new laboratory and classrooms, and the demolition of existing classroom buildings. Construction is scheduled to start in early 1994.

R0013648

Washington—The results of a recent bid opening by the U.S. Navy Contracting, Pacific Northwest Borough, Silverdale, list PCL Construction Services Inc., Bellevue, as the lowest bidder, design-and-construct basis, at $14,234,000 for **commissary/exchange building, and auto hobby shop** located at the Navy Support Complex on I-5 and 116th St. N.E. in Everett.

BID DATES

Arizona, Oct. 12—Rock Point Community School, Navajo Reservation, Rock Point, **junior/senior high school** on Navajo Indian Reservation at Highways 191 and 35 in Rock Point. $7 million to $7.3 million. Wyatt & Rhodes Architects, architect, Phoenix.

Arizona, Oct. 12 (tentative)—U.S. Army Corps of Engineers, Phoenix, **direct fire, and artillery and mortar ranges** located at Yuma Proving Grounds. $1 million to $5 million. Mason & Hanger Engineering Co., architect, Lexington, Ky.

Ohio, Oct. 12—City of Centerville, Yankee Trace golf academy **clubhouse** at 1000 Yankee St. in Centerville. Architects Associated, Dayton, is architect.

California, Oct. 13 (tentative)—U.S. Army Corps of Engineers, Sacramento, **addition to support equipment shop, and new covered storage facility** located at March Air Force Base. Grillias Pirc Rosier Alves, architect, Irvine.

Nebraska, Oct. 13—U.S. Property and Fiscal Office, Lincoln, **fuel system maintenance facility** located at Lincoln Air National Guard Base. $5 million to $10 million. Dana Larson Roubal & Associates, architect, Omaha.

Ohio, Oct. 13—U.S. General Services Administration, Chicago, **alterations to U.S. Post Office and Courthouse** located at Main and Walnut Sts. in Cincinnati.

South Dakota, Oct. 13—Rapid City Area School District 51-4, **addition and renovation of North Middle School** on Maple Ave. in Rapid City. $4 million to $5 million. Galyardt Associates, architect, Rapid City.

Texas, Oct. 13 (tentative)—U.S. Army Corps of Engineers, Albuquerque, N.M., Bluff **channel**, phase 2, located in southeast part of El Paso. $10 million. The project consists of 13,000 ft of trapezoidal and rectangular flood control channel along with four drop structures, 1,000 ft of concrete box culverts and eight overflow weirs.

Information for Pulse is derived primarily from Dodge Reports prepared by the F.W. Dodge Div. of McGraw-Hill Inc. For more details on these and other construction projects or to learn more about Dodge Reports, call (800) 541-9913.



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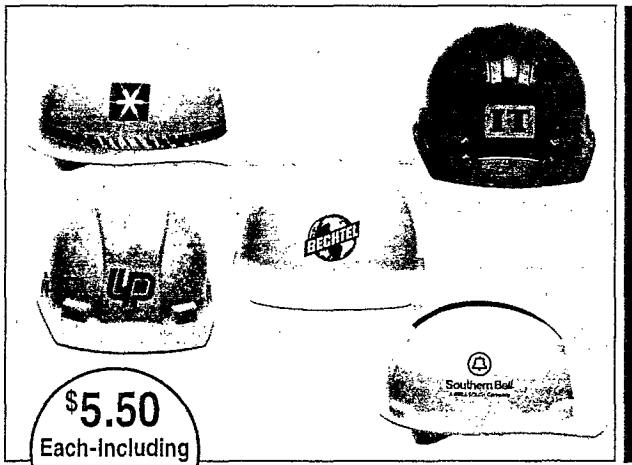

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MODEL 4100	5.50	5.10	4.80
MODEL 5100R	7.75	7.50	7.25
MODEL 4100R	7.75	7.50	7.25
MODEL 3000	7.50	7.30	7.25
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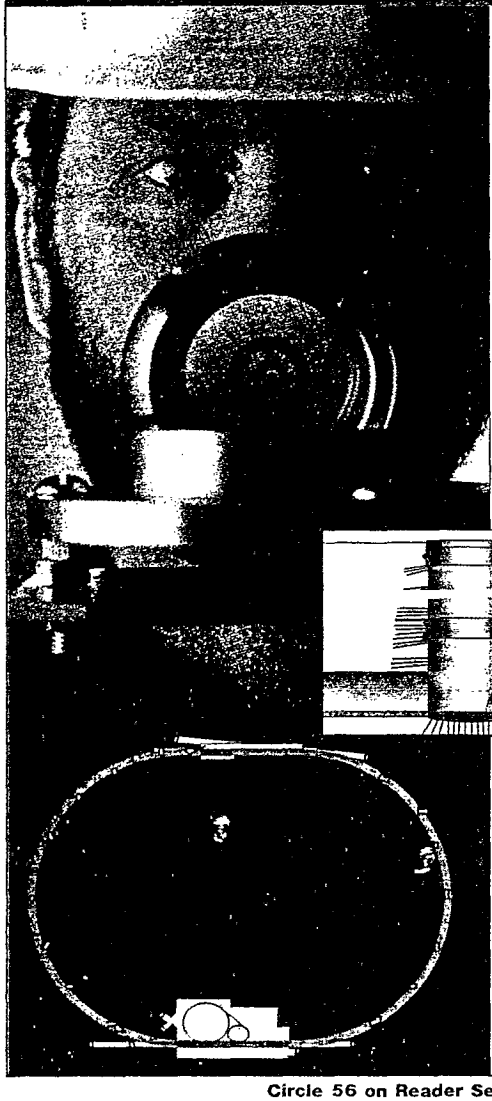
Circle 55 on Reader Service Card

R0013649

For Accuracy of 1 in 10,000,000 On The Superconducting Super Collider, Control Was Best Left To Chance.

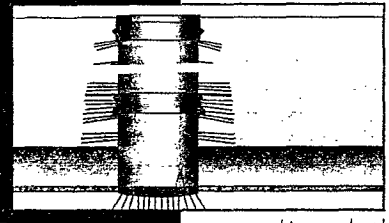


When the Parsons Brinckerhoff/Morrison Knudsen Team was looking for a firm to provide precise horizontal and vertical control for boring the tunnel for the Superconducting Super Collider, nothing was left to chance.

PB/MK selected John E. Chance & Associates(JECA) to be a member of its design team to establish a highly stable horizontal and vertical control network covering a 322-square-mile area.

Using dual frequency GPS satellite receivers, JECA surveyors achieved a positional accuracy of 1:10,000,000 for the horizontal network. More than 750 miles of precise differential leveling was run to establish the vertical network.

The high precision surface networks, shaft transfers and tunnel traverses have enabled tunnel excavation breakthroughs of 1.8 inches in the horizontal and vertical planes in 2 1/2 miles of tunneling. The tunnel survey control was surveyed to 1/2" for the horizontal and 1/4" for the vertical.



For basic control networks, mapping control, cadastral, geophysical surveys, marine surveys or precise engineering surveys, things are best left to Chance.

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Engineering News-Record

thanks all of its readers who participated in the 1993
Environmental Career &
Employer Preference Survey.

A special congratulations to

Laurie Rodriguez,

Staff Scientist/Geologist of Geraghty & Miller

whose name was chosen in the drawing.

She will receive $500!

Official Proposals

City of New York Department of Environmental Protection Bureau of Water Supply and Wastewater Collection

Notice to Engineering Consultant firms to submit a Statement of Qualifications for Engineering Services.

The New York City Department of Environmental Protection, Bureau of Water Supply and Wastewater Collection, hereby invites Engineering Consultant firms to submit a Statement of Qualifications to perform Resident Engineering Inspection (REI) services for the reconstruction of twelve East of Hudson dams, three controlled lakes and two pumping stations located in the Croton Watershed.

The estimated construction costs of the contracts are in the range of $6,000,000 to $50,000,000.00. The Department intends to award seven (7) or more separate REI contracts each having a period of performance of 24 to 30 months.

Interested Engineering Consultants, who wish to be considered for these projects, are invited to submit Federal Standard Forms 254 and 255, and a New York City Vendex Questionnaire. These submittals will be used to formulate a Pre-qualified List of candidates.

The completed forms (10 copies of each Federal Form and 1 copy of the Vendex form) must be received no later than 4:00 p.m. on October 20, 1993 by:

Joseph W. Iannuzzi, P.E.
Acting Chief, Planning and Programs
Department of Environmental Protection
Bureau of Water Supply &
Wastewater Collection
59-17 Junction Boulevard
3rd Floor (Low Rise)
Corona, New York 11368

Copies of the Vendex Questionnaire may be obtained at the above address from 10:00 A.M. to 4:00 P.M., Monday-Friday, except holidays. Requests may be made in writing, in person or by telephone. Telephone requests should be made to Ms. Ingrid Weseman at (718) 595-5472.

The services to be provided under each contract shall include, but not be limited to:

1. Resident Engineering Inspection of the reconstruction of one or more dams, controlled lakes and/or pumping stations.
2. Evaluation of contract changes and the preparation of change orders.
3. Checking of record drawings.

A minimum of 8 randomly selected firms from the Pre-qualified List shall be asked to submit a technical and separate cost proposal for each contract based on a detailed scope of work prepared by the Bureau. It is anticipated that the seven contracts will be awarded within a 24 month period beginning in 1994.

The Contracts to be awarded under this Request for Qualifications (RFQ) are expected to be funded 100% by the City of New York. The Federal Standard Forms requested are to facilitate the establishment of a Pre-qualified List only.

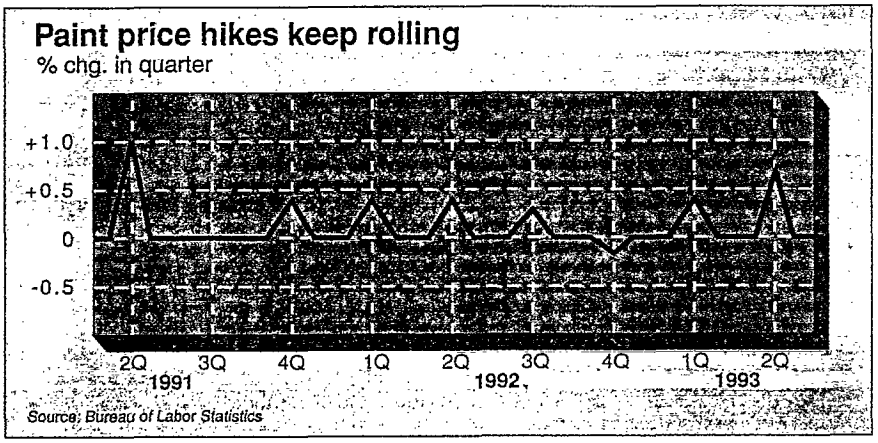
Final selection for the contracts shall be based on a combination or the best Technical and Cost Proposals.

The REI Contracts will be subject to the utilization requirements for participation of certified Minority and Women Business Enterprises (M/WBE).

The City of New York's Department of Environmental Protection is not responsible for costs incurred in the preparation of any documents relative to this advertisement.

For Additional Official Proposal Advertising, See Pages 89-90

R0013650



Lumber prices: + 21.6%

Average price change for softwood lumber for July 1993 versus a year ago. Softwood lumber prices posted a monthly decrease of 5.0% in July. Source: Bureau of Labor Statistics, Washington, D.C.

Western softwood shipments: – 9.1%

Shipments in western woods (12 region western states) through August 28 versus same period in 1992. Shipments in 1993 total 11,425 billion board-ft. Source: Western Wood Products Association, Portland, Ore.

Plywood prices: + 13.3%

Average price change for plywood for July 1993 versus the same period a year ago. Plywood prices posted a monthly decrease of 1.0% in July. Source: Bureau of Labor Statistics, Washington, D.C.

See the following ENR issues for other prices:

- Asphalt, cement, aggregate, concrete, brick, block, lime: Last—Sept. 6; Next—Oct. 4
- Sewer, water and drain pipe: Last—Sept. 13; Next—Oct. 11
- Lumber, plywood, plyform: Last—Aug. 16; Next—Oct. 18
- Structural steel, rebar, building sheet, piling: Last—Aug. 23; Next—Sept. 27
- Wage rates: Last—Aug. 30; Next—Nov. 29

Lumber, plywood, plyform

Item	Unit	20-city average price $	20-city average % chg yr ago	Atlanta $	Balti-more $	Birming-ham $	Boston $	Chicago $	Cin-cinnati $	Cleve-land $	Dallas $	Denver $	Detroit $
2 x 4", s4s, pine	mbf	454.68	+27.3	– 375.00	+390.00	–413.00	–450.00s	490.00	495.00h	440.00c	–435.00	+509.00	+465.00s
fir	mbf	514.69	+26.9	---	---	+500.00	+650.00s	530.00	595.00	---	---	---	–520.00
common	mbf	463.25	+26.4	– 375.00	+390.00	–413.00	630.00s	490.00	495.00	440.00	–435.00	+509.00	+392.00
2" x 6", s4s, common	mbf	475.10	+25.6	– 350.00f	+385.00p	+400.00p	–450.00s	490.00c	470.00p	750.00c	+450.00p	+491.00h	+390.00s
2" x 8", s4s, common	mbf	485.10	+24.5	– 375.00f	+375.00p	+363.00p	–450.00s	490.00c	470.00p	750.00c	+485.00p	+509.00h	+420.00s
2" x 10", s4s, common	mbf	555.05	+24.0	– 350.00f	+460.00p	+392.00p	700.00s	–490.00h	465.00p	800.00p	–510.00p	+527.00h	+498.00s
4" x 6", s4s, common	mbf	644.50	+27.1	– 600.00	450.00p	450.00p	900.00s	–580.00f	750.00	---	–590.00	–887.00	+660.00p
4" x 12", s4s, common	mbf	665.25	+19.4	---	+600.00p	495.00p	---	–670.00	975.00	---	---	---	–690.00p
Plywood, $\frac{5}{8}$" thick	msf	473.61	+ 0.3	+ 664.00s	+350.00	+384.00p	–450.00	450.00f	565.00	710.00p	–345.00	+517.00	+453.00
Plyform, $\frac{3}{4}$" thick	msf	824.66	+21.2	+1108.00s	640.00	671.00	1070.00	825.00p	975.00	1020.00p	–630.00	–890.00	–820.00
Particleboard, underlayment, $\frac{5}{8}$"	msf	308.18	+10.4	270.00	422.00	250.00	340.31	280.00	165.00	425.00	250.00	+387.00	+325.00
Gypsum board, regular, $\frac{1}{2}$"	msf	128.23	+ 5.0	125.00	150.00	125.00	120.00	110.00	93.00	145.00	100.00	117.00	150.00
$\frac{5}{8}$"	msf	151.22	+ 0.9	160.00	178.00	154.00	160.00	---	93.00	---	125.00	+142.00	---
type-X, $\frac{1}{2}$"	msf	141.42	+ 2.4	125.00	173.00	154.00	155.00	---	113.00	160.00	100.00	+142.00	175.00
$\frac{5}{8}$"	msf	164.95	+ 2.8	160.00	178.00	158.00	160.00	210.00	115.00	170.00	125.00	142.00	180.00
Roofing insulation, unfaced	sf	3.96	+ 5.6	3.75	– 2.60	3.27	4.20	3.20	4.65	4.04	3.60	4.70	3.22
Wall insulation, unfaced	sf	2.58	+ 6.3	2.05	+ 4.20	+ 2.60	2.60	2.00	2.00	2.44	2.60	3.04	1.98
Pipe insulation, fiberglass	sf	5.07	+ 4.4	5.50	+ 4.43	4.24	5.71	---	4.11	---	5.40	5.25	4.27

Item	Unit	Kansas City $	Los Angeles $	Minne-apolis $	New Orleans $	New York $	Phila-delphia $	Pitts-burgh $	St. Louis $	San Francisco $	Seattle $	Canada Montreal C$	Canada Toronto C$
2" x 4", s4s, pine	mbf	---	–474.00	–440.00s	400.00	+581.00p	–570.00s	+480.00	+390.00	–462.00	+380.00h	350.00s	+480.00s
fir	mbf	575.00	–510.00	---	---	+501.00f	–570.00f	550.00	+390.00	–515.00	–285.00	---	---
common	mbf	575.00	–470.00	–440.00c	400.00	+496.00f	570.00f	+480.00	+390.00	–495.00	+380.00	350.00s	+480.00s
2" x 6", s4s, common	mbf	575.00f	–495.00f	–425.00s	390.00p	+496.00h	730.00	+465.00s	+385.00p	–505.00f	+410.00f	350.00p	+480.00s
2" x 8", s4s, common	mbf	575.00f	–522.00f	–430.00s	–368.00p	+498.00h	712.00	+570.00s	+370.00p	–520.00f	+450.00f	510.00p	+510.00s
2" x 10", s4s, common	mbf	625.00f	–560.00f	–550.00f	–395.00p	+804.00h	990.00	+575.00s	380.00p	–575.00f	+455.00f	620.00p	+620.00s
4" x 6", s4s, common	mbf	---	–615.00	900.00	+475.00	+544.00h	650.00	+840.00	+525.00p	–620.00	+565.00	---	---
4" x 12", s4s, common	mbf	980.00	–675.00	---	---	+648.00h	---	430.00	+550.00p	–660.00	–610.00	---	---
Plywood, $\frac{5}{8}$" thick	msf	470.00	–495.00	–515.00	–370.00	+503.00	531.25	+450.00	390.00	–480.00	+380.00	625.00	+695.00
Plyform, $\frac{3}{4}$" thick	msf	920.00	–830.00	–875.00	–617.00	+751.00	656.25	–795.00	895.00	+820.00	+685.00	1340.00	+864.00
Particleboard, underlayment, $\frac{5}{8}$"	msf	330.00	285.00	+385.00	240.00	---	---	321.88	358.00	279.00	+234.00	400.00	348.44
Gypsum board, regular, $\frac{1}{2}$"	msf	117.00	120.00	160.00	100.00	170.00	115.32	145.20	168.00	122.00	112.05	155.00	165.00
$\frac{5}{8}$"	msf	145.00	152.00	---	120.00	170.00	185.94	---	---	149.00	183.20	---	222.40
type-X, $\frac{1}{2}$"	msf	145.00	139.00	---	100.00	105.00	---	171.82	169.00	141.00	136.25	205.00	198.00
$\frac{5}{8}$"	msf	145.00	162.00	185.00	120.00	140.00	234.38	178.35	170.00	159.00	207.25	205.00	198.00
Roofing insulation, unfaced	sf	4.45	3.75	4.05	3.90	4.70	4.67	4.92	4.40	3.75	3.40	5.51	6.00
Wall insulation, unfaced	sf	2.93	2.65	2.50	1.90	3.20	2.49	3.27	2.75	2.65	1.80	3.76	3.50
Pipe insulation, fiberglass	sf	5.32	5.05	5.92	5.55	6.33	6.38	4.63	---	4.75	3.42	6.26	6.94

+ or – denotes price has risen or fallen since previous report. c=spf, d=dougfir, f=fir, h=hemfir, p=pine, s=spruce.

Monthly market quotations by ENR field reports Aug.16, 1993. All prices are spot prices quoted from a single source. Common lumber prices are those quoted for the most popular species in the area. Quotes are delivered prices. Some prices may include taxes or discounts for prompt payment, etc. Product specification may vary, depending on what is most commonly used or most accessible in a city. All quantities are truckloads unless noted. Quotes for Montreal and Toronto are in Canadian dollars and metric units. The above prices are not intended to represent the prevailing or average price in a city but are designed to track price movement from a single source for a given quantity and specification over time.

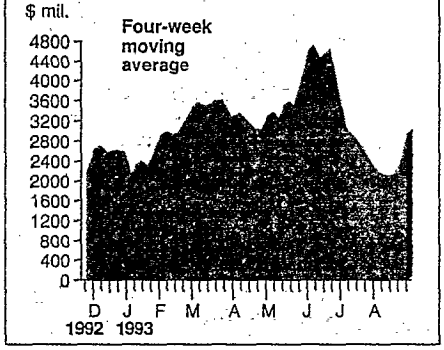
R0013651

Latest Week

COST INDEXES ENR 20 cities 1913=100	Sept. index value	Change from last month %	Change from last year %
Construction Cost	5255.46	+0.5	+ 4.2
Building Cost	3009.17	–0.2	+ 5.3
Common labor (CC)	10654.61	+1.0	+ 2.6
Skilled labor (BC)	4749.46	+0.6	+ 2.4
Materials	1946.30	–1.3	+10.1

Construction contract awards

$ mil.



National totals ENR-reported $ mil.	Week ending Aug. 30	7 mos. cum. 1993	7 mos. cum. % chg. '92-93
CONTRACT AWARDS			
Total construction[1]	2,992.0	87,110.5	– 1
Heavy & highway	1,056.6	34,660.5	+ 6
Water use & control	257.2	9,256.5	– 37
Waterworks	87.4	3,152.2	+ 6
Sewerage	99.7	3,966.6	0
Dams, waterway dev.	70.1	2,137.6	– 9
Transportation	545.4	17,336.2	+ 8
Highways	405.9	11,870.7	+ 11
Bridges & tunnels	102.5	4,069.7	+ 10
Airports, incl. buildings	37.0	1,395.8	– 17
Electric, gas, communic.	42.3	2,939.7	+ 4
Military, space	0.0	7.1	– 79
Other heavy const.	211.7	5,121.1	+ 18
Total nonres. bldgs.	1,665.2	45,982.0	– 5
Manufacturing bldgs.	82.2	3,928.8	– 26
Commercial buildings	730.9	16,963.9	– 4
Offices, banks.	259.8	6,011.8	– 11
Stores, shopping ctrs	258.9	6,232.3	+ 4
Other comml. service	212.2	4,719.8	– 3
Government buildings	72.0	2,109.8	– 43
Administration	58.2	617.2	– 47
Post offices	0.1	66.6	– 77
Prisons	2.4	970.1	– 46
Police, fire	11.3	455.9	+ 2
Educational buildings	374.7	11,266.6	+ 13
Primary	266.5	7,616.8	+ 13
College	74.5	1,445.0	– 2
Laboratories	33.7	2,204.9	+ 28
Medical bldgs.	210.9	5,613.9	– 10
Hospitals	130.0	3,106.6	– 21
Nursing	80.9	2,507.3	+ 9
Other nonresidential	194.4	6,098.8	+ 12
Total multiunit hsg.[2]	270.1	6,468.0	– 9
Apartments	245.7	5,061.1	+ 8
Hotels, motels, dorms	24.4	1,406.9	– 42

Source: ENR-F.W. Dodge Division
[1] *Minimum size: Contract awards, $50,000*
[2] *Excludes 1-2 family houses*

NEW PUBLIC CONSTRUCTION CAPITAL
$ mil.

	Week of Sept. 13	35 weeks cum. Latest figure	35 weeks cum. Annual % chg.
State and municipal	761.7	49,603.7	+ 7
Housing	3.6	1,476.3	– 48
Other bldg. and heavy	758.1	48,127.4	+ 10

Latest Month

CONTRACT AWARDS BY STATE
Cumulative totals in $ mil.

	June	% change from last year	% change from last
CALIFORNIA			
Manufacturing	318.6	+115	– 8
Commercial buildings	2,178.6	+ 79	– 12
Government buildings	171.5	+ 62	– 26
Educational buildings	999.0	+ 74	+ 3
Medical buildings	272.8	+ 96	– 37
Hotels, motels and dormitories	164.3	+227	+ 24
Other nonresidential buildings	129.5	+261	+ 62
NEW YORK			
Manufacturing	79.0	+ 15	– 25
Commercial buildings	959.2	+116	– 6
Government buildings	163.6	+ 50	– 74
Educational buildings	508.8	+ 50	– 7
Medical buildings	436.5	+ 92	+ 41
Hotels, motels and dormitories	45.3	+ 47	– 32
Other nonresidential buildings	60.1	+ 27	– 28

Source: ENR-F.W.Dodge Division

INDUSTRIAL CONTRACT AWARDS
Totals in $ mil.

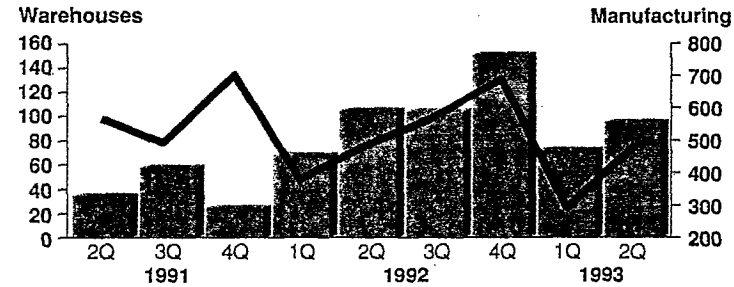
	July 1993	% chg. from last month	% chg. from last year	Cum. 7 mos. 1993	Cum. 7 mos. % chg. '92-93
BY REGION					
Northeast	96.6	+ 30	– 50	449.8	– 33
North Central	159.7	– 8	– 61	946.9	– 47
South Central	365.7	+ 61	– 36	1,765.8	+ 2
West	147.9	+ 25	+ 86	766.4	– 29
BY MARKET					
Total manufacturing buildings	769.9	+ 30	– 39	3,928.8	– 26
Manufacturing plants	603.6	+ 28	– 26	2,944.9	– 29
Aerospace	3.6	– 33	+114	38.9	– 89
Automotive	13.1	– 70	+ 1	256.9	+ 43
Chemical process	175.3	+198	– 61	575.5	– 40
Electrical machinery	20.1	+312	+...	69.3	– 58
Fabricated metal products	6.0	– 37	– 52	48.8	+ 17
Food and beverage	53.3	– 40	+ 92	280.4	– 12
Iron and steel	0.5	– 86	– 90	29.2	+ 64
Machinery, excl. electrical	77.2	+545	+ 71	158.1	+ 26
Nonferrous metals	0.3	– 90	– 93	27.5	– 16
Ordnance & accessories	3.5	– 6	0	15.7	+ 35
Petroleum, incl. products	7.1	+...	+939	109.4	– 78
Printing, publishing, paper	31.5	+ 18	– 12	192.5	– 1
Precision goods	14.6	+ 42	+...	62.4	+ 26
Rubber, plastic goods	9.5	– 74	+194	62.3	– 15
Stone, clay & glass	1.5	– 85	– 50	17.1	– 35
Textile mill products	27.4	+ 88	+ 14	137.7	+ 28
Wood products, furniture	1.7	+308	+...	42.0	– 2
Other (incl. service)	157.5	+ 14	– 17	821.1	– 15
Other manufacturing buildings	166.2	+ 37	– 62	984.0	– 13
Warehouses	139.1	+ 29	+135	669.3	+ 11
Generating plants	20.2	0	– 79	49.8	– 67
Laboratories	7.0	– 48	– 98	264.9	– 31
Gas, electric & communications	159.1	– 86	– 5	2,939.7	+ 4
Powerplants and systems	136.0	– 87	– 4	2,708.1	+ 2
Gas plants, systems, tanks	0.1	– 99	0	15.2	– 50
Communication systems	23.0	– 71	– 35	216.3	+ 54

Source: ENR-F.W. Dodge Division
Minimum size: Contract awards, $50,000; +...=greater than 999%

Trends to Watch

ENR contracts: Warehouses and manufacturing plants

Avg. month per quarter in $ mil.



Source: ENR-F.W. Dodge Division

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A. Type of firm:
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R0013656

St. Lucie County Utility Services Director. This is a management and technical position responsible for planning, organizing, directing, budgeting, and coordinating water and wastewater activities. duties include the coordination of water and wastewater projects and activities with other utilities functions and the public. Minimum qualifications: A Bachelor's degree in Civil or Sanitary Engineering or Business Administration. Ten (10) years of progressive experience, of which at least five (5) years of supervisory experience, including responsibility in the engineering field with part of it in the wastewater and water treatment field. Send resume or apply in person to St. Lucie County Personnel Coordinator, 2300 Virginia Avenue, Ft. Pierce, FL 34982 EOE.

Associate Engineer; 40 hrs./wk.; 8 am-5 pm; $37,334/yr.; Job requires: Master of Science in Civil Engineering or Master of Science in Mechanical Engineering degree, with a major field of study in Structural Engineering. Job also reqs.: 1) thesis or 2 published papers in the field of dynamics of structures; 2) 1 graduate course in finite element methods; 3) 1 grad. crse. in structural analysis; & 4) 1 grad. crse. in structural dynamics. Job duties: Develop finite element models of vehicle structures using finite element softwares such as NASTRAN. Perform analysis of automotive components using finite element analysis software such as DYNA3D and PAMCRASH. Qualified applicants should send resume & verification of reqs. to: 7310 Woodward, Rm. 415, Detroit, MI 48202. Ref. #69493. Employer Paid Ad.

Bridge Design Engineer, Lexington, MA: 40 hrs/wk, 8:00 a.m. - 5:00 p.m.; $38,100 per year. Design computations and preparation of details for structural steel and concrete bridge design including post-tensioned structural steel and post-tensioned segmental concrete bridge design; computer modeling of structural systems; dynamic analysis of bridges and the behavior and design of bridge substructure including soil/structure interaction; layout and analysis of pre-tensioned and post-tensioned systems including temperature and time dependent influences. Develop innovate solutions for structure bridge rehabilitation using post-tensioning and other state-of-the-art procedures. Ph.D. in Civil Engineering/ Structural Engineering req'd. 2 yrs. research experience in high performance cementitious material behavior & its applications to bridge repairs and rehabilitation req'd. Ability to work with all facets of concrete design and detailing; i.e., precast cast in place, post-tensioned, pre-tensioned, and reinforced req'd. Familiarity with the latest AASHTO/ACI Code req'd. Experience in computer analysis programs such as SAP90. ABAQUS. STRUDL, & LPILE req'd. Mail resume to: Dept. of Employment and Training, P.O. Box 8968, Boston, MA 02114. Case No. 30753.

MEXICO STAFFING

Sundtcorp de Mexico, SA. de C.V., a subsidiary of Sundt Corp., plans soon to be performing both construction management and self-performed contract work in Mexico. Candidates are required for the following positions:

PROJECT MANAGER. Minimum of 10 years experience as a Project Manager on commercial building projects having a value of over $20 million. Working knowledge of Primavera scheduling system and B.S. in Civil Engineering required.

PROJECT ENGINEER. Must have at least five years experience as a Project Engineer on multi-million dollar commercial building projects. Good computer skills, strong capability in Primavera scheduling system, and B.S. Civil Engineering required. P.E. credentials a plus.

FIELD SUPERINTENDENTS (4). Requires a minimum of 10 years experience on multi-story commercial building projects as the superintendent-in-charge.

All positions require fluency in English and Spanish (speaking and writing). These job assignment are in Mexico.

Send Resume to: Sundt Corp, Corporate Employment Office
Reference: Mexico
P.O. Box 20766
Phoenix, AZ 85036

SundtCorp

Sundt Corp. is an equal opportunity employer
Arizona contractor Licenses 068012-A and 068013-B-01

Polymer Development Engineer -- 40 hours per week, 8:00 a.m. to 5:00 p.m., $38,500.00 per year. Design, develop and test new plastic compound formulations. Perform research and analyze data. Use machines such as plastic extruders, injection molders, capillary rheometer, fourier transform infrared spectrometer, universal tester and izod impact tester. Supervise three lab technicians and one engineer. Must have Bachelor's degree in Mechanical Engineering or foreign equivalent. Must have two years experience in the job offered or one year and six months as Senior Mechanical Engineer. Must have completed one college level course in each of the following areas: chemical and thermal water treatment methods. industrial ovens and fuel systems, technical thermodynamics and technology of plastics. Must have proof of legal authority to work permanently in the U.S. Send 2 copies of resume to: Illinois Department of Employment Security, 401 S. State St., 3 South, Chicago, IL 60605. Attention: Jean Woodson. Reference #V-IL 10721-W. No calls. An employer paid ad.

Engineer, Growing Construction Equipment Company in Morris County, New Jersey requires structural engineer with 4 to 7 years at similar type of manufacturer. Experience in design and manufacturing as well as hydraulics helpful. Bi-lingual in French/English is a plus. Send resume to: Tramac Corp., 7 Emery Avenue, Randolph, NJ 07869.

Chief Applications Engineer. Oversee the manufacture of butterfly valves and valve actuators which are used to control flow in a wide range of industries such as chemical, pulp and paper, petroleum refining, electric power generation, water treatment, brewing, distilling and food processing, etc.; responsible for technical applications support to other departments, subsidiaries, and distributors; develop new engineered products. 40 hrs/wk. $47,000/yr. Requires Bachelor or equivalent in Mechanical Engineering. Requires 4 years exp. in the job offer or 4 years exp. as a Mechanical Engineer in the butterfly valves industry. Apply at Texas Employment Commission, Houston, Texas or send resume to Texas Employment Commission, TEC Building, Austin, Texas 78771, J.O. #TX6926213. Ad paid for by An Equal Employment Opportunity Employer.

Assistant Director. The Harris County Toll Road Authority, Houston, Texas, is seeking an aggressive, goal oriented, registered professional engineer. Applicant must have a minimum of ten years experience in planning, design, right of way acquisition, construction and maintenance of highway and bridge projects. E.O.E. Resumes should be addressed to: W.D. Harris, Manager of Administrative, 330 Meadowfern, Suite 200, Houston, Texas 77067. Fax No. 713-875-6941. All replies held in strict confidence.

R0013657

CONSTRUCTION ENGINEERING
Nationwide Opportunities for Personnel in Safety, Civil, Mechanical, Electrical and General on Roads, Steel, Municipal, Hazardous, Waste, Process, Power, Commercial, Health Care and Institutional. ***Free and Confidential.***
PERI CORP.
1200 Executive Dr. East #125
Richardson, TX 75081-2227
214/235-3984 FAX 214/437-2017

Connecticut Resources Recovery Authority. CRRA has the following openings in our Engineering department: Senior Engineer (Environmental)- This is a highly responsible engineering position working in solid waste management and recycling. Employee will preform professional civil and environmental engineering work related to permitting, compliance and resource management issues concerning landfills, transfer stations, recycling and waste-to-energy facilities. Involves design of various projects; administration of consulting engineering and construction contracts; and performance of engineering investigations and reports. Position requires experience in landfill design, management or operations, or related work. Qualifications: Master's degree in Civil or Environmental Engineering plus 4 years of progressively responsible experience; or an equivalent combination of work and experience. Must be a Connecticut Certified P.E. Project Engineer- this is a highly responsible professional position working in the management of a resource recovery project. Employee will preform a variety of engineering tasks, including project planning, development, construction management and operations. Work involves complex research and a thorough understanding of power plant operations, construction methods, plans, drawings and specifications. Qualifications: Master's degree in Mechanical Engineering plus 4 years of progressively responsible experience; or an equivalent combination of education and experience. Must possess or be able to obtain a Connecticut P.E. Certification. Experience in the power generation and/or resource recovery fields required. Please respond to: Contract & Personnel Administrator; 179 Allyn Street; Hartford, Connecticut 06103. Deadline: October 8, 1993. CRRA is an Affirmative Action/Equal Opportunity Employer.

General Manager - San Diego Area Wastewater management District (San Diego,CA) Sal. open DOQ. A newly created indep. pub. agency formed to mng. the reg. sewerage syst. of the San Diego metro. area. The pos. is appt. by/rpts. to a 17-mbr. Board: serves 12 jurisd. and 1.7 mil. residents. The budg. exceeds $800,000 with 5 staff. Anticip. this org. will employ about 500 people: the 1st phase of the proj. (10 yrs.) is estim. to be $1.2 bil. Req. BS/BA: pref. Master's. Desire a Reg. Prof. Civil Eng. in CA. Must have sev. yrs. of sr. level admin. and mgmt. exp. in a wstwtr.. water or simular pub. works org. Send resumes by 10/15/93 to Norman Roberts & Associates, Inc.. Attn: norm Roberts. Pres., 1800 Century Park East, #430. Los Angeles, CA 90067-1507 or fax to (310) 552-1113. AA/EEO/ADA.

MECHANICAL SUPERINTENDENT

McCarthy, an ENR Top 35 general contracting and construction management company operating nationwide, is seeking a Mechanical Superintendent. 10 years experience minimum. Must have experience with Mechanical/ Electrical/Plumbing coordination on hospitals or commercial buildings. Must have experience in supervising contractors on above mentioned projects. BSME is required. Must be willing to relocate. Send resume and salary requirements to: Kevin Kuntz; McCarthy; 1341 North Rock Hill Road; St. Louis, MO 63124 EOE/M/F/D/A/V.

McCARTHY

Construction field superintendents for commercial renovation projects throughout the US. Minimum 10 years experience. This is not an office job. Fax resumes to TEAC at (713) 931-6422.

Balfour Beatty America Group, a large int'l contractor, is seeking Business Managers with proven track record in admin of large civil engineering projects. Respons incl project cost rpts, A/P & P/R supervision, cash forecasts, G/L & bank recs, EEO/DBE, P&L analysis. Extensive computer knowledge a must. Excellent salary & benefits. Requires a career minded & flexible individual, willing to relocate. Quals to: P.O. Box 111807, Miami, FL 33111-1807. EOE.

Resident Engineer & Assistant Rsident Engineer. Major water treatment plant Upgrade/Expansion. Gannett Fleming, Inc., a nationwide consulting engineering firm, has two upcoming openings in its Newport News, VA office. Both are key opportunities on a 4-5 year major water treatment plant upgrade/expansion program ($60M) in Norfolk, VA. For either position, must be Registered Professional Engineer with 10-20 years actual field experience on major ($30M+) water and/or wastewater plant construction. Chief Resident Engineer: Responsibilities include general field aspects of this project, including pay estimate review, change order negotiation, client interface and overall construction observation. Must have demonstrated experience on at least two major treatment plant upgrade/expansion projects, directing and managing field staff of minimum five subordinates. Assistant Resident Engineer: Responsibilities include coordinating field staff, coordination with the five project design consultants, special construction observation and related duties as assigned. Background should include similar duties and experience on similar projects in the $20M range. Submit resume (indicating position of interest) to: Gannett Fleming, Inc., P.O. Box 120269, Newport News, VA 23612-0269. EOE, M/F.

Senior Project Manager and Super-intendent The George Hyman Construction Company, a growth-oriented, nationally prominent construction organization has an immediate need for senior Project Managers and Senior Superintendents in its Irvine California office. Candidates must have a minimum of ten years experience in major California Healthcare projects. Background should include planning, monitoring, and supervising on-site construction engineering and administrative activities. Please forward a complete resume and salary history to our office: The George Hyman Construction Co., 9 Executive Circle, Ste. 290, Irvine, CA 92714. An Equal Opportunity Employer.

Structural Steel: Steel fabrication plant in Delaware Valley, 100+ employees is in need of a structural steel Fabrication Estimator, Erection Estimator and a Chief Draftsman. Each must have a minimum of 5 years experience in highrise construction and bridge construction. We offer an excellent salary and benefit package. Send resume and salary history to: P.O. Box 487, Wilmington, DE 19899. EOE.

Florida Dept. of Transportation Professional Engineer III. $1,531.19 - $2,625.99 Biweekly. Position #10072 - Class Code 4663. The Florida Department of Transportation is seeking applicants for the position of Professional Engineer III in the Structures Design Office. Applicants must be registered as a Professional Engineer in the State of Florida or be eligible for registration in Florida in accordance with Florida Statute 471. The candidate must have five or more years experience in bridge design or related structural experience. The position requires good communication skills. Position is in charge of review and approval of consultant produced structural designs and plans for major and complex bridges, A State of Florida Application must be submitted by October 4, 1993 to: Jerry L. Potter; State Structures Design Engineer; Florida Department of Transportation; Mail Station 33; 605 Suwannee Street; Tallahassee, Florida 32399-0450. EOE/AA/VP. If you need an accommodation in order to participate in the application/selection process, please notify the hiring authority in advance.

Mechanical Engineer to use comput-er aided design, included AutoCad, for the engineering of manufacturing facilities and equipment; apply project management software (Time Line) and manufacturing engineering software (Factory Flow) to analyze problems and develop solutions for facility design. Requires Master's in Industrial Engineering. Master's level coursework must include Advanced Computer Graphics, Industrial Operations, and Production Systems/ Computer Integrated Manufacturing (CIM). Must be fluent (read, write and speak) in Mandarin Chinese. 40 hr wk - 9am-5pm. $36,757.40/yr. Send resumes to 7310 Woodward Avenue, Room 415, Detroit, Michigan 48202, Ref. No. 71293. Employer Paid Ad.

R0013658

Environmentally Conscious Manufacturing Engineer

The Industrial Technology Institute (ITI) is a unique inter-disciplinary organization dedicated to improving the competitive position of U.S. manufacturers.

The senior staff member ITI seeks will: lead institute-wide technical and programmatic activities related to environmentally-conscious manufacturing, particularly aimed at smaller durable and plastic manufacturing companies, develop an implement programs of technical assistance, training, information exchange and technology transfer as they pertain to plant-level environmental issues, and participate in strategic and operational planning.

Qualifications: thorough knowledge of manufacturing, particularly a production process-level understanding of environmental issues, including emissions and solid, liquid and hazardous waste reduction. The ideal candidate would also have experience in policy and regulatory aspects of environmentally-conscious manufacturing. A master's degree (or an equivalent combination of education and experience) and a minimum of 10 years of experience in manufacturing, 5 years in the environmental field is required.

ITI offers a challenging environment and an opportunity to have an impact on U.S. manufacturing. Mail your resume, and salary requirements to: HR - #9321 Industrial Technology Institute P.O. Box 1485 Ann Arbor, MI 48106. An EEO/AA Employer M/F/D/V.

CORPORATE DEVELOPMENT DIRECTOR

A highly responsible, quality directed Midwestern Engineering Consulting Firm is seeking a growth oriented person to provide leadership in the company's development.

Do these questions describe you?

- Are you an activator? Do you make things happen?
- Do you think strategically? Can you select and anticipate events which lead to growth and profit?
- Are you a visionary? Can you create images of excellence and growth for an organization?

If so, we want to talk with you. We are a Lincoln, Nebraska based Engineering Consulting Firm founded in 1944. We are searching for a talented individual to take responsibility for the growth efforts of this firm. The ideal candidate will have an engineering or science education background, consulting experience in the design profession and strong persuasive and organizational talents.

We offer:

- Excellent base salary plus performance incentives.
- An established firm focused on quality and growth.
- Equity ownership for the future.
- A chance to join a company with integrity and a mission to serve people.

Call today to investigate this unique and exciting opportunity to work with top management to energize corporate development.

Jim Sorenson
Selection Consultant working with the Company
1-800-793-0450 or 1-800-793-0451
Monday - Friday 8am-5pm CDT

Senior Software Analyst - Plant Design Systems. Responsible for the design, development and implementation of computer graphics software for plant design applications, for use by engineers in advanced CAD/CAM applications. Works under limited supervision. Programs in C or C++ languages in a UNIX operating system environment. Uses CAD system to perform 2D and 3D graphics design. Develops new, modified, enhanced or tailored software, utilizing knowledge of mechanical, structural or chemical engineering. Designs piping and instrumentation software, temperature and control valve software, and other computer software used in plant design applications. Assists others in area of expertise. Must have BS in Mechanical, Structural or Chemical or related engineering field and 2 years of experience in job above or 2 years experience in computer software development. A Master's or higher degree may be substituted for 2 years of experience, if advanced degree work involved computer software development. Requires UNIX or Windows NT operating system, programming in C or C++ languages, knowledge of CAD systems, knowledge of mechanical, structural or chemical engineering or related area. Salary $700 per week, 40 hrs/wk, 7:30am-4:15pm. Resume to M. Thomas, Alabama State Employment Service, P.O. Box 428, Huntsville, AL 35804-0428. Job Order No. AL 4096486. An Affirmative Action/Equal Opportunity Employer.

Construction Search-Presidents, V,P's, Mktg., Proj. Mngrs., Planners & Sched'lers, Estimators, Supers., Highway, Heavy, Marine, Commercial Institutn'l., Indust'l, Utility. Sals. - $35K-$125,000 - Nationwide - Resume to: Construction Search Associates, 52 Temple Pl., 3rd Fl., Boston, MA 02111-617-482-2800 FX 617-482-1346 - No Fee.

Customer Engineer: Perform on-site installation and maintenance of complex semiconductor manufacturing systems, resolve complex system problems, provide technical support and instruct customers on operation and maintenance of system. University training and/or project experience with semiconductor fabricator problems including robotics, vacuum and other systems utilizing a knowledge of semiconductor physics, electron beam lithography, vacuum technology and electronic and/or mechanical debugging techniques and troubleshooting complex electronic problems on multiboard to component level systems. Bachelor's/Equivalent* (*equivalent foreign education) in Physics/Applied Physics. Salary: $2,840/month. Job site/Intv: Portland, OR. Clip this ad and send with resume to Employment Department, Attn: Job Order Number 5550563, 875 Union Street/N.E./Room 201, Salem Oregon 97311.

Heavy/Highway Positions. Search One, 5319 N. MacArthur Blvd, #2062, Irving, TX 75038. (214) 751-0099, Fax (214) 580-8192.

Design Process Engineer. A well-managed Closed Die Forge Plant in Kentucky needs a Design & Process Engineer who would be responsible for deciding the forging process, die design, attending tryouts and solving day to day production and quality problems related with dies and tools. Candidate must have a Master's degree in Mechanical Engineering and minimum 10 years experience in design of dies and tools for closed die forging equipments, out of which 2 years must be in Computer Aided Design/Computer Aided Manufacturing (CAD/CAM), Finite Element Analysis and Computer Numerically Controlled (C.N.C.) Machines. Compensation package would include an Annual salary of $45000 and other benefits like Health Insurance, 401K Plan, Profit Sharing, Earned leave with salary etc. The Position offers a healthy working environment and growth prospects. Send resumes, quoting the Order #354534 to: Peggy Dostal; Department for Employment Services; 600 West Cedar Street; Louisville, Kentucky - 40202-2396. We are an "Equal Opportunity Employer".

Structural Engineer: Expanding precast concrete firm seeks staff structural engineer. Florida Professional Registration (PE) is required. Duties include design/analysis of precast wall panels, field site coordination visits, and manual/computer aided drafting. $3,000.00 per mo. Send resume to 300-A Royal Commerce Rd, Royal Palm Beach, Florida 33411.

R0013659

Structural Engineer needed for new construction, seismic retrofit/repair work and building rehabilitation projects in Guam. Minimum qualifications for this position are 5 years seismic-related structural design experience and professional registration as a Civil or Structural (preferred) Engineer. Strong report writing and client relationship skills a must. Position is located in the Guam office of Winzler & Kelly Consulting Engineers, a multi-discipline engineering firm. Excellent opportunities for advancement. Please send resumes to: Winzler & Kelly. 495 Tesconi Circle, Santa Rosa, CA 95401 - Attn: Bonnie Burrell (707) 523-1010. EOE.

Software (SW) eng. Research/deve. SW tools/products for design/mfr of parking control sys., including elect., mech., control & computer subsys; Operate/ maintain test equip't for hard/SW; Integrate control theory & image processing tech. for parking control & display; Apply modern/class'l control theories & optimization tech. in developing new or modifying existing products; Investigate new languages/deve't tools & generate PERT chart diag. Must have MS in system or mech. eng. Special req. include 2-yr exp. in control sys. as evidenced by 1 publication or degree thesis, 1 grad. course each in optimal digital control, signal & sys. analysis, database sys. design. 40 hrs/wk, $38,500/yr. Send resumes to 7310 Woodward Ave., Rm. 415, Detroit, MI 48202. Ref. #54993. Employer Paid Ad.

Mechanical Engineer I for project management for portable energy products (such as batteries): design & develop new products & production processes to decrease project costs & increase production, utilizing pareto & X-bar, R charts & DPU levels; design products for greater manufacturability & assembly efficiency on UNIX & Sun operating systems; design products on ComputerVision CADD including perform finite element analysis, corrosion/wear analysis & material analysis/selection for optimum strength, utilizing EDX, SEM & Auger; design metal stampings, castings, & composite parts for use in highly stressed mechanical packages; utilize Boothroyd & Dewhurst Methods for design assembly efficiency; design assembly tooling, fixtures for production purposes & manufacturing at global facilities; perform engineering tests & evaluation of complex designs to ensure compliance with functional requirements; analyze production problems & determine & implement appropriate solutions; conduct tests, evaluations & analysis of test results; interpret results into design decisions; complete all design, manufacturing & assembly classifications & drawings. Master's degree in Mechanical Engineering required as well as 6 months experience in job offered or 6 months experience as Graduate Assistant. Must have completed 1 course each in: computer aided manufacturing; failure analysis: elasticity; mechanical engineering design; finite element analysis; materials testing; metallurgical analysis. Experience must have included use of EDX, SEM & Auger in wear analysis & use of UNIX & Sun operating systems. 40 hours, 8:00am to 4:30pm, $42,800 per year. Send resume to Job Service of Florida, 2660 West Oakland Park Boulevard, Fort Lauderdale, Florida 33311-1347, Re: Job Order Number FL-0886228. Employer Paid Ad.

Chief Engineer - Long Beach Water Department (Long Beach, CA) Sal. open DOQ. the Water Dept. serves over 400,000 residents, with a FY93-94 oper. budg. of $61.3 mil. and a 5-yr CIP budg. of $143 mil. the pos rpts. to the Asst. Gen. Mgr. and oversees approx. 25 staff in the Eng. Bureau. Req.a BS in Eng.: prefer an MS in Civil or Env. eng. with 5 yrs. of mgmt. exp. in eng., plng., design, and const. Must be a Reg. Prof. Civil Eng. in CA or able to obtain certif. within 6 mo. Send resumes by 10/15/93 to Norman Roberts & Associates, Inc., Attn: Norm Roberts, Pres., 1800 Century Park East, #430, Los Angeles, CA 90067-1507 or fax to (310) 552-1113. AA/EEO/ADA.

Director of Estimating. Grwth ori- ented, financially stable gen'l contractor lctd. in upper Midwest seeks aggressive, seasoned indiv. This pstn reports to the V.P. of Operations. Good potential for future promotion to upper mgmt for the right person. Qlfctns must include a tech undergraduate degree, ten yrs of similar exp with a major general contracting firm and proven skills in mgmt of people. Prjcts range frm $2.5MM to 30MM frm Michigan West to the Rockies and South to Missouri. Lmtd trvl rqrd. Advncd computer literacy is a must. Comp. sal and bnft pkg. Pls submit resume to P-7277. Our staff is aware of this search.

Positions Wanted

Sales Opportunity Wanted. Results oriented professional with proven history of excellence is looking for commission sales opportunity in Chicago and No. Central area. Reply to PW-7287, ENR

Construction Manager - CE International and Domestic experience on large and small projects; Fluent Portuguese, working Spanish. Short term or long term assignment desired. PW-7278, ENR.

Planner/Scheduler/Cost Control Engr. Over 15 yrs exper. with leading engr/constrn companies. desires perm or contract posn. Travel no problem. Call Khaliq 203-254-2466.

Ph.D. in Nuclr. Engr., B.Sc. Engrg. Physics with excellent computer and analytical skills seeks position in safety analysis, PRA, or design call Joseph at (602) 888-4637.

CEO/Gen Mgr seeks responsible position with an aggressive construction company. 30 yrs exp in proj 10k to 18 both domestic and foreign. Please call 907-345-4864, ask for Jerry.

International Construction Manager w/15 yrs. exp. in Middle East, Africa, Southwest & Southeast Asia. BSCE & TQM'd. USAID/USCOE contracting expr'd. Heavy concrete/PEMB specialty. Self starter in adverse conditions. Seek short/long term. Call Jim: (812)379-4451 or 372-0012.

Employment Services

Overseas Craftsman's Association - Est. 1946. The networking association for overseas workers. A nonprofit membership association. (714) 827-5800.

Work overseas. Read the Fischer Report & receive free link up with employers worldwide through Manlink, the world's only direct access manpower data base. 40 yrs. exp. For free copy & details: Group Fischer, PO Box 9348, Newport Beach, CA 92658 (714) 759-3374. Fax (714) 760-1792.

Educational Services

Free! 40-page booklet about HOW TO PASS E-I-T, P.E., and L.S. Exams. Professional Publications, Inc, Dept. 75 1250 Fifth Avenue, Belmont, CA 94002. (415) 593-9119.

Prepare for fundamental and PE exams at home comprehensive notes, problem solving methods, examples and solutions. PERC Inc., Box 123, Northport, NY 11768. (516) 424-8682.

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(212) 512-2422

R0013660

Official Proposals

New York City Transit Authority Notice of Solicitation

Contract #A-35724-1,2,3,4.

Bid Opening: Monday, October 18, 1993 at 2 PM local time.

Title: Rehabilitation of Canal Street Complex.

A site tour has been scheduled on September 21, 1993, at 10:00 A.M., at Canal Street Station, Lexington Avenue Line, South bound mezzanine Token Booth R-214. There will be a Pre-bid Conference Scheduled on September 22, 1993, 10:00 A.M., at 386 Park Avenue South, Room 308, New York, N.Y. Prospective bidders who desire to attend shall notify the Procurement Specialist no later than noon of the day prior to the scheduled event.

Procurement Specialist Yasmin M. Thomas
(718) 694-4111

Sealed bids will be received by the NYCTA at 130 Livingston Street, Brooklyn, New York 11201 at the Bid Solicitation Counter until the bid opening time and date. Bids will be publicly opened and read in Room 139 at said location. Bidders will be fully responsible for the delivery of their bids in a timely manner. Reliance upon the U.S. Mail or other carriers is at the bidders risk. Late bids will not be considered.

Bid solicitation documents may be obtained at the Solicitation Counter at the aforementioned address from 9:00 AM to 3:30 PM Mon-Fri except holidays. Requests can be made in writing, in person but not by telephone. There is a non-refundable charge of $75.00 for each set of documents.

Please be advised that all of the funding anticipated for this contract has not been secured. However, it is the intent of the Transit Authority to have necessary funds in place prior to award. Should funds not become available in a timely manner, bidders are hereby advised that this solicitation may be withdrawn.

"Locker Facility Addition" for William Paterson College 300 Pompton Road Wayne, New Jersey 07470 Job #A0272.00 Notice to Bidders

Notice is hereby given that sealed proposals will be received by The William Paterson College of New Jersey for "Locker Facility Addition," located in Wayne, New Jersey, completed and in accordance with bid documents, plans, specifications covering the work in connection therewith and incidental thereto.

Sealed bids for "Locker Facility Addition" will be received at the College of the Office of the Administration and Finance in the President's Conference Room located in Morrison Hall off Pompton Road at Entry #2, Wayne, New Jersey until 2:00 P.M. on October 5, 1993. A mandatory pre-bid meeting will be held in Morrison Hall at 10 A.M. on September 21, 1993. All prospective bidders must attend this meeting.

No bids shall be received by mail, facsimile transmission or overnight delivery service.

Bid Documents for the proposed work are on file at the College at the above office and at the Office of the Director of Facilities located in the College's Maintenance Building.

Bid documents can be obtained at the Office of The RBA Group, 1 Evergreen Place, P.O. Box 1927, Morristown, NJ 07962-1927, between the hours of 8:00 A.M. and 5:00 P.M., Monday through Thursday. Requests for mailing of contract documents will not be accepted. Deposit fees will be $50 per set and shall be refunded to only those bidders who return the bid documents in good condition within two weeks of the bid opening.

Bids must be made on the proposal forms furnished with the bid documents and must be enclosed in a sealed envelope. The bid envelope should be marked on the outside with the project #A0272.00 and titled: "Locker Facility Addition."

Bidders must be prequalified under N.J.S.A. 52:35 and must submit security as provided in the Instructions to Bidders. No bidder may withdraw his bid for 60 calendar days after the opening. The College may reject any and all bids.

Bidders are required to comply with the requirements of P.L. 1975, C. 127, N.J.S.A. 40A:11-1 et. seq. New Jersey Law Against Discrimination.

Peter S. Spiridon, V.P.
Office of Administration and Finance
William Paterson College

New York City Transit Authority Notice of Solicitation

Contract #C-33467

Bid Opening: October 12, 1993 at 2:00 PM local time.

Synopsis: Construction of RTO Facilities at Westchester & Mosholu Yards (IRT), "A" Division Borough of The Bronx.

A site tour will be held on Sept. 23, 1993 9:00 AM at the Westchester Yard, Signal Tower at Westchester Ave & Water Place in The Bronx. A Pre Bid Conference will be held on Sept. 23, 1993 1:00 PM at Site Visit Place.

Sealed bids will be received by the NYCTA at 130 Livingston St., B'klyn, N.Y. 11201 at the Bid Solicitation Counter, Room 160, until the bid opening time and date. Bids will be publicly opened and read in Room 139 at 130 Livingston St., B'klyn, as specified above.

Bid documents may be obtained at the Bid Solicitation Counter, Room 160, New York City Transit Authority, 130 Livingston St., B'klyn, from 9:00 A.M. to 3:30 P.M. Mon.-Fri. excl. holidays. Requests can be made in writing, in person but not by telephone. Each request must be accompanied by a check or money order for $75.00 (Non refundable) for each set of specifications and drawings. Cash or personal checks are not accepted.

Minority and women-owned Business Enterprises are given full opportunity to submit bids and receive or participate in contract awards. Discrimination on the basis of race, religion, color, sex or national origin is prohibited. Compliance with all applicable Affirmative Action, Equal Opportunity, and Minority and women-owned Business Enterprise conditions is required. A full description of these and all other provisions is included in the bid documents.

Bidders will be fully responsible for the delivery of their bids in a timely manner. Reliance upon the U.S. Mail or other carriers is at the bidder's risk. Late bids will not be accepted.

It is anticipated that funds for this work will be provided in part (20%) by the MTA and in part (80%) by the U.S. Govt. Federal Transit Administration.

Please be advised that all of the funding anticipated for this contract has not been secured. However, it is the intent of the Transit Authority to have necessary funds in place prior to award. Should funds not become available in a timely manner, bidders are hereby advised that this solicitation may be withdrawn.

Request for Proposals The Port Authority of New York and New Jersey

Sealed proposals for the following contracts will be received by the Chief Engineer, Room 72S, One World Trade Center, New York, N.Y. 10048, until 2:30 p.m. on the date indicated and will then be opened and read in Room 72E. Contract documents may be seen in Suite 5147 – 51st Floor and each set of contract documents for the subject contract may be obtained upon receipt of a non-refundable payment specified below. Only company checks or money orders payable to the order of the Port Authority of New York and New Jersey will be accepted. If checks or money orders for documents are mailed, they should be addressed to The Port Authority of New York and New Jersey, One World Trade Center, Contract Desk – Suite 5147, New York, N.Y. 10048. For availability of contract documents, call 212-435-7420. Questions by prospective bidders concerning any one of the contracts should be directed only to the person whose name and phone number is listed for the contract in question.

Contract EWR-574A – Newark International Airport – Rehabilitation of Taxiways I, O and U. Bids Due Thursday, October 14, 1993. Price per set of contract documents is $25.00. For questions about this contract, call Arnold Silverberg at 201-216-2499.

Contract LGA-110.113 – La Guardia Airport – Parking Garage Overpass. Bids Due Thursday, October 14, 1993. Price per set of contract documents is $25.00. For questions about this contract, call S. Park at 212-435-8686 or 201-961-6600 Extension 8686.

Contract PN-110.064 – Port Newark – Facility Sign. Bids Due Thursday, October 14, 1993. Price per set of contract documents is $25.00. For questions about this contract, call Joseph Iantuono at 212-435-8672 or 201-961-6600 Extension 8672.

Contract WTC-955.221 – The World Trade Center – Access Doors for Physically Challenged. Bids Due Thursday, October 14, 1993. Price per set of contract documents is $25.00. For questions about this contract, call Tim Dacey at 212-435-8657 or 201-961-6600 Extension 8657.

Addendum to Request for Qualifications Construction Support Services for Los Vaqueros Project

This addendum to the Contra Costa Water District's "Request for Qualification (RFQ) - Construction Management Services for Los Vaqueros Project" (ENR Sept. 13, 1993) gives notice to interested parties that the deadline for submittal of letters of interest has been extended from September 15, 1993 to 4:00 p.m. September 27, 1993. RFQ packages will be mailed upon receipt of letters of interest and Statements of Qualifications will be due by the revised date noted in the RFQ.

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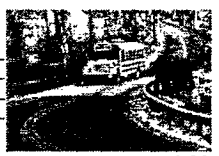
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Official Proposals

New York City Transit Authority Notice of Solicitation

Contract #E-31259. Bid Opening: Wednesday, October 20, 1993 at 2:00 PM local time.

Synopsis: Rehabilitation of Five Pan Plants, Rutgers Street Tunnel "F" Line, "B" Division (IND), Boroughs of Manhattan and Brooklyn.

Prospective bidders are advised that a tour of inspection of the job sites will be held on Oct. 1, 1993 at 9:00 A.M. at the Token Booth N-530, York St. Station, "F" Line, Borough of Brooklyn. A Pre-bid Conference will be held on Oct. 5, 1993 at 10:00 A.M. in the 9th Floor Conference Room at 10 Columbus Circle, Borough of Manhattan. Prospective bidders who desire to attend shall notify the Procurement Specialist, Marsha Korotyk at (718) 694-4097. Prospective bidders are advised that this solicitation contains a new Master Legal, revising its standard Terms and Conditions with a view towards a more equitable sharing of risks and liberalizing other items. Prospective bidders should bear in mind that the revised contract will give rise to different assumptions used in costing the project especially with respect to contingencies and risks.

Sealed bids will be received by the NYCTA at 130 Livingston St, B'klyn, N.Y. 11201 at the Bid Solicitation Counter, Room 135, until the bid opening time and date. Bids will be publicly opened and read in Room 135 at said location.

Bidders will be fully responsible for the delivery of their bids in a timely manner. Reliance upon the U.S. Mail or other carriers is at the bidder's risk. Late bids will not be considered.

Bid documents may be obtained at the Solicitation Counter at the aforementioned address from 9:00 AM to 3:30 PM Mon-Fri except holidays. Requests can be made in writing, in person but not by telephone. Each request must be accompanied by a company or bank check for the following amount: $75.00 for each set of specifications and the associated drawings. Cash and personal checks are no longer accepted. This fee is non-refundable.

Disadvantaged Business Enterprises are given full opportunity to submit bids and receive or participate in contract awards. Discrimination on the basis of race, religion, color, sex or national origin is prohibited. Compliance with all applicable Affirmative Action, Equal Opportunity, and Disadvantaged Business Enterprise conditions is required. A full description of these and all other provisions is included in the bid documents.

Funds for this work are provided in part by the Metropolitan Transportation Authority and in part by the United States Government, Federal Transit Administration. Please be advised that all of the funding anticipated for this contract has not been secured. However, it is the intent of the Transit Authority to have necessary funds in place prior to award. Should funds not become available in a timely manner, bidders are hereby advised that this solicitation may be withdrawn.

California Department of Water Resources Division of Design and Construction Civil Design Branch Chemical Grouting Consultant Request for Qualifications

The Department requires the services of a consultant to advise design staff in the preparation of contract plans and specification to grout hydraulic piezometer tubing and concrete joints in earth and concrete dams owned by the Department. The consultant will also advise staff during the performance of the subject contract. Consultant must have extensive knowledge and experience in chemical grouting and possess current knowledge of applicable State and Federal environmental regulations.

Copies of the Request for Qualifications may be requested from the Department of Water Resources, Division of Design and Construction, Civil Design and Construction, Civil Design Branch, Room 533-6, Post Office 942836, Sacramento, California 94236-0001, Attention: Les Harder, (916) 653-8055, Responses must be submitted no later than October 20, 1993 at 10:00 a.m.

City of New York Department of Environmental Protection Bureau of Water Supply and Wastewater Collection

Notice to Engineering Consultant firms to submit a Statement of Qualifications for Engineering Services.

The New York City Department of Environmental Protection, Bureau of Water Supply and Wastewater Collection hereby invites Engineering Consultant firms to submit a Statement of Qualifications to perform resident engineering inspection services for the construction of sewage treatment plants located in the Catskill and Delaware Watersheds.

The estimated costs for the construction contracts are in the range of $10,000,000 to $20,000,000. The Department intends to award 5 separate Resident Engineering Inspection contracts each having a period of performance of 24 to 30 months.

Interested Engineering Consultants, who wish to be considered for these projects, are invited to submit Federal Standard Forms 254 and 255, and a New York City Vendex Questionnaire. These submittals will be used to formulate a Pre-qualified list of candidates.

The completed forms (10 copies of each Federal Form and 1 copy of the Vendex Form) must be received no later than 4:00 p.m. on October 20 1993 by:

Joseph W. Iannuzzi, P.E.
Acting Chief, Planning and Programs
Department of Environmental Protection
Bureau of Water Supply & Wastewater Collection
59-17 Junction Boulevard, 3rd Fl.
Corona, New York 11368

Copies of the Vendex Questionnaire may be obtained at the above address from 10:00 A.M. to 4:00 P.M., Monday-Friday, except holidays. Requests may be made in writing, in person or by telephone. Telephone requests should be made to Ms. Ingrid Weseman at (718) 595-5472.

The services to be provided under each contract shall include, but not be limited to:

1. Resident Engineering Inspection of the construction of one or more sewage treatment plants which will include advanced state-of-the-art treatment processes. There will be multiple construction contracts as required by the Wick's Law.
2. Evaluation of contract changes and the preparation of change orders.
3. Checking of record drawings.
4. Preparation of O & M manuals.

A minimum of 8 randomly selected firms from the pre-qualified list shall be asked to submit a technical and separate cost proposal for each contract based on a detailed scope of work prepared by the Bureau. It is anticipated that the five contracts will be awarded within a 24 month period beginning in 1994.

The contracts to be awarded under this Request-for-Qualifications are expected to be funded 100% by the City of New York. The Federal Standard Forms requested are to facilitate the establishment of a Pre-qualified List only.

Final selection for the contracts shall be based on a combination of the best Technical and Cost Proposals.

The Contracts will be subject to the utilization requirements for participation of certified Minority and Women Business Enterprises.

The City of New York's Department of Environmental Protection is not responsible for costs incurred in the preparation of any documents relative to this advertisement.

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R0013663

Contractors need clear direction on fall protection requirements

Some regional administrators of the Occupational Safety and Health Administration are grabbing the bull by the horns and addressing what they feel is a very serious safety problem in fall protection requirements for the construction industry.

They believe that the current construction standard protection thresholds of 25 ft for exterior work and 30 ft for interior work are too generous and are enforcing more strict limits based on the general duty imposed on employers to provide a safe work place (see p. 6). We don't disagree with the good intentions, but the agency must spell out a uniform national policy after soliciting input from the industry and then enforce it nationwide.

Its regional offices are enforcing thresholds far below the national standard—6, 8 and 10 ft, depending on the type of work and the region. OSHA's internal study showing that 60% of deaths from falls occur from less than 30 ft indicates that there are some real hazards that should be dealt with effectively. The agency should develop a new standard that protects workers from falls, even if they are from less than 10 ft. Such limits have long been kicked around, but politics and the glacial standard-making process have prevented adoption.

The confusion must be dealt with. Constitutional due process requires regulators to give clear direction before penalties can be imposed.

Despite protests to the contrary from some quarters, the industry continues to need a strong federal safety program enforced vigorously. Contractors could provide fall protection voluntarily to their workers when they are engaged in hazardous activities no matter what the height, but many choose to let the government make those decisions for them.

Basinwide is the way to go

Government officials and consulting firms finally seem to be getting a handle on managing overall watershed pollution problems, only 21 years after that approach was encouraged by federal legislation. It certainly is about time; there are some 900 river basins with serious water quality degradation.

Efforts to eliminate point sources have been quite successful. But pollution snoops have long known that amorphous nonpoint sources can be more damaging. Now they are finding ways to identify them and develop realistic, coordinated abatement strategies (see p. 38).

The new approaches should make our water pollution control programs far more efficient and contribute substantially to quality of life. Cleaning up the lower reaches of a river is to some extent a cosmetic exercise if vast amounts of pollutants from agriculture, stormwater runoff and other less obvious sources continue to pour into the watershed's tributaries.

Building in a longer highway life

Travelers returning from a trip to Europe usually bring back memories of good food, and perhaps something from a duty-free shop. But some U.S. highway engineers returned from a tour with something extra—realization that are better ways to build roads.

One member of the visiting group, Michael Cuddy, who is chief engineer of the New York State Dept. of Transportation, is putting the European technique to work on two highway projects. One with a concrete pavement in Corning (see p. 53) and another having an asphalt pavement in Saranac Lake. For not very much extra capital cost the state is getting roadways with a design life of 50 years, two and a half times longer than that to which we are accustomed.

The investment appears to be highly worthwhile. We now know that long-life roadway construction works in other countries, so it's time we caught up and paved the way for better use of our own highway funds.

Peace promotes business, and that can solidify peace

The historic agreement signed last week between Israel and the Palestine Liberation Organization already has launched proposals for construction projects costing billions of dollars. We expect that momentum will accelerate, and it will contribute to stabilizing the region.

The ink literally was not dry on the agreement when plans started to erupt for major projects in what will be PLO-administered areas (see p. 7). As confidence in the peace process transforms euphoria into reality, firm developments should take form in the previously Israeli-occupied territories. And with tensions in the region lessening, that may even spill over to impoverished parts of neighboring countries.

The Mideast has been a tinderbox for 45 years. Terrorism has flourished in areas of abject poverty. Bringing in jobs and promoting prosperity will help provide barren ground for terrorist groups. Construction can make the peace permanent. Our industry can build something worth living for.

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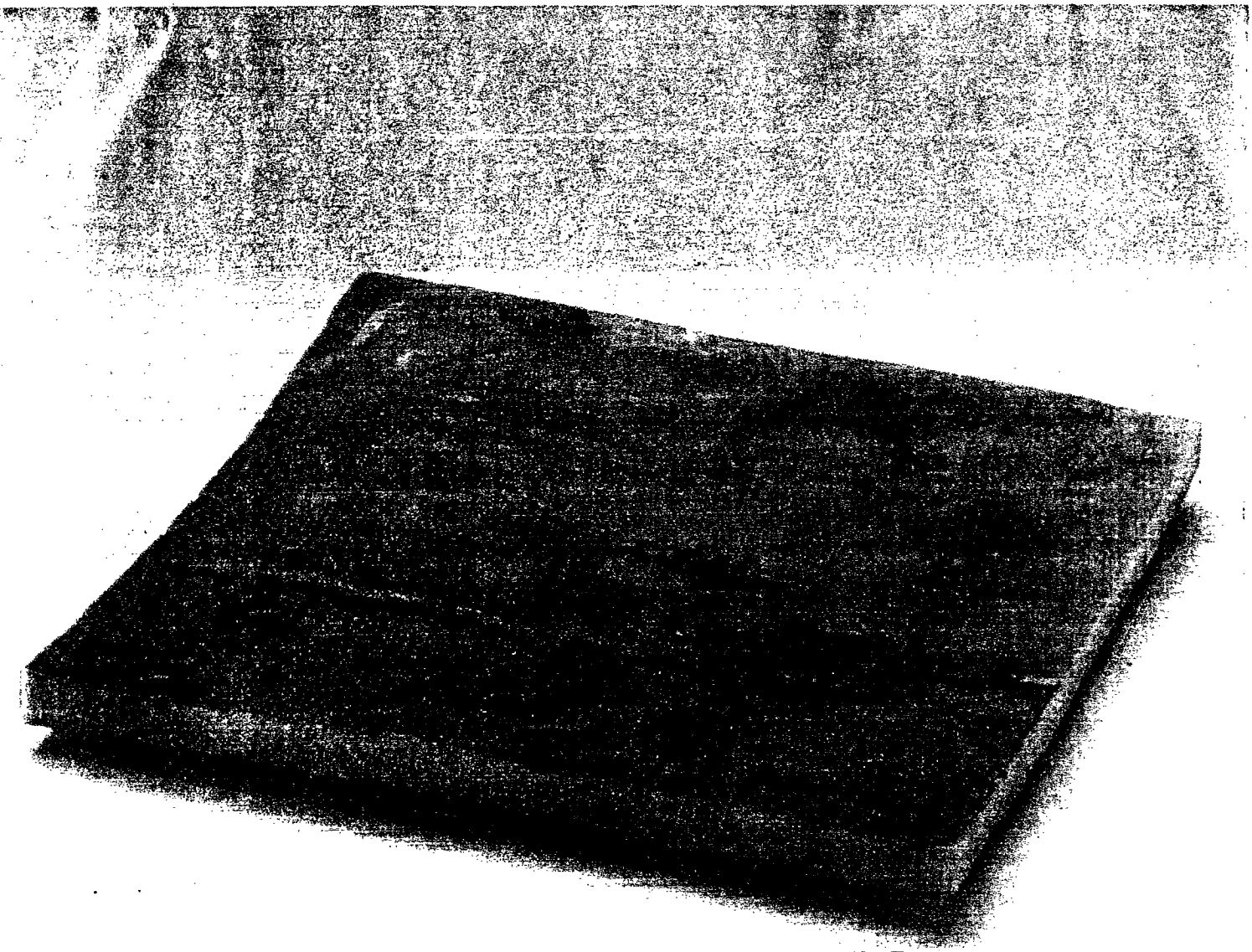

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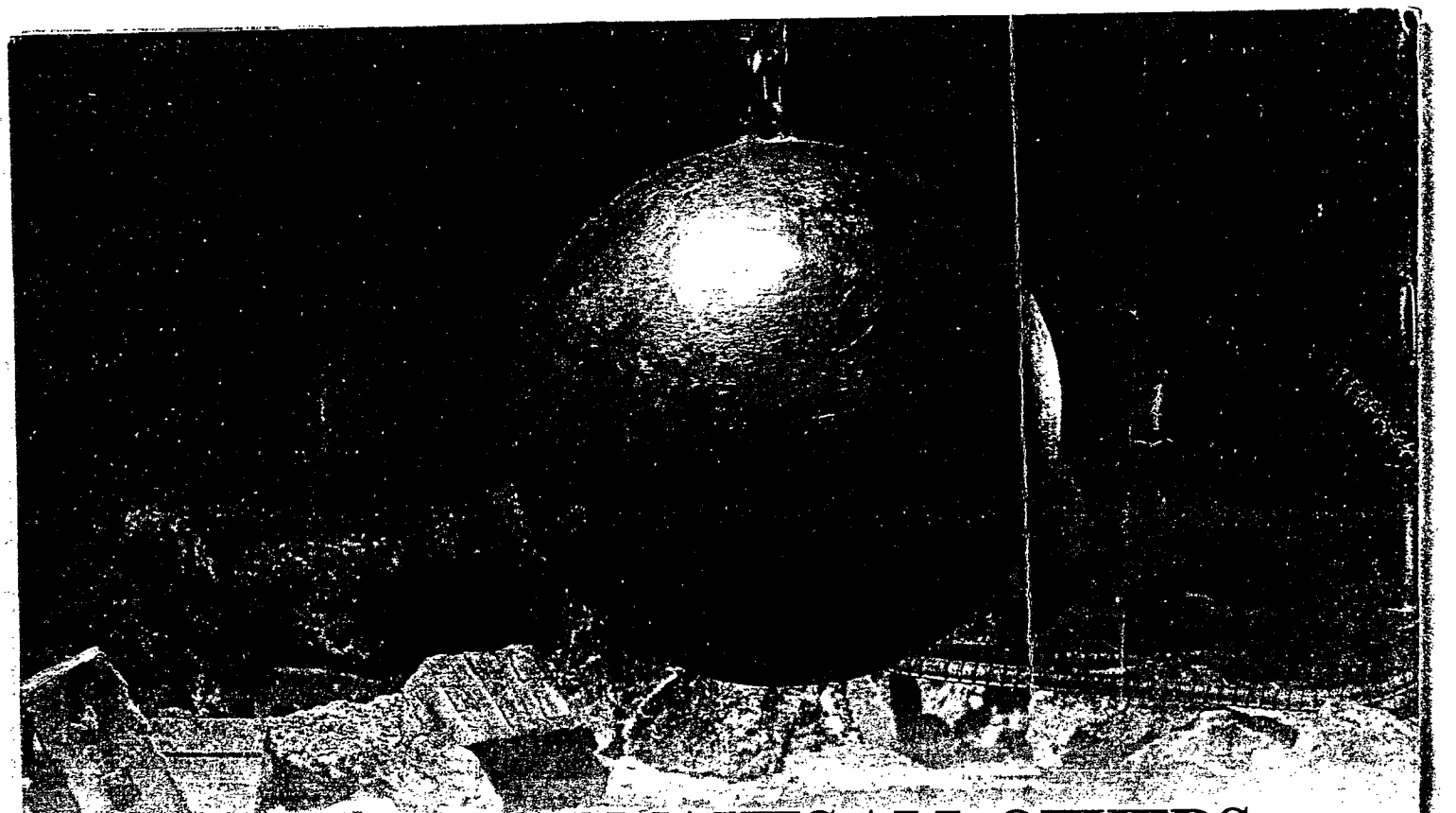

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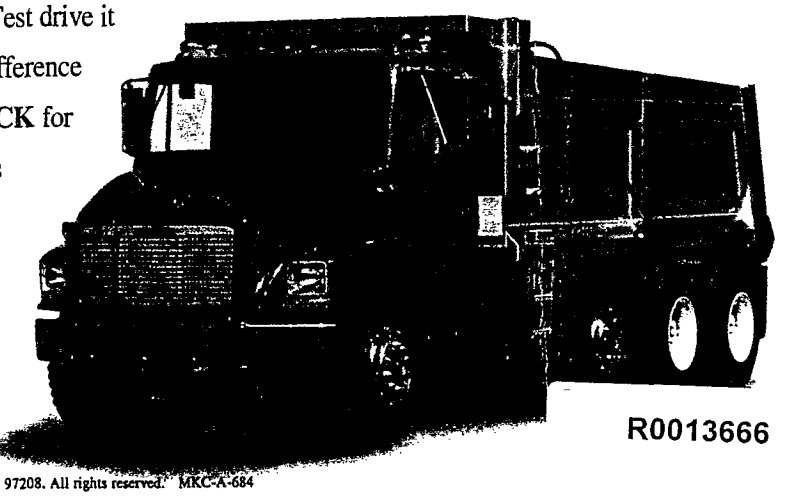

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Philip E. Gerwert, Manager, Plant Environment-Compliance Consistency Section, General Motors Environmental and Energy Staff, Detroit, Michigan, is the President-Elect of the Water Environment Federation. *More on page 14.*

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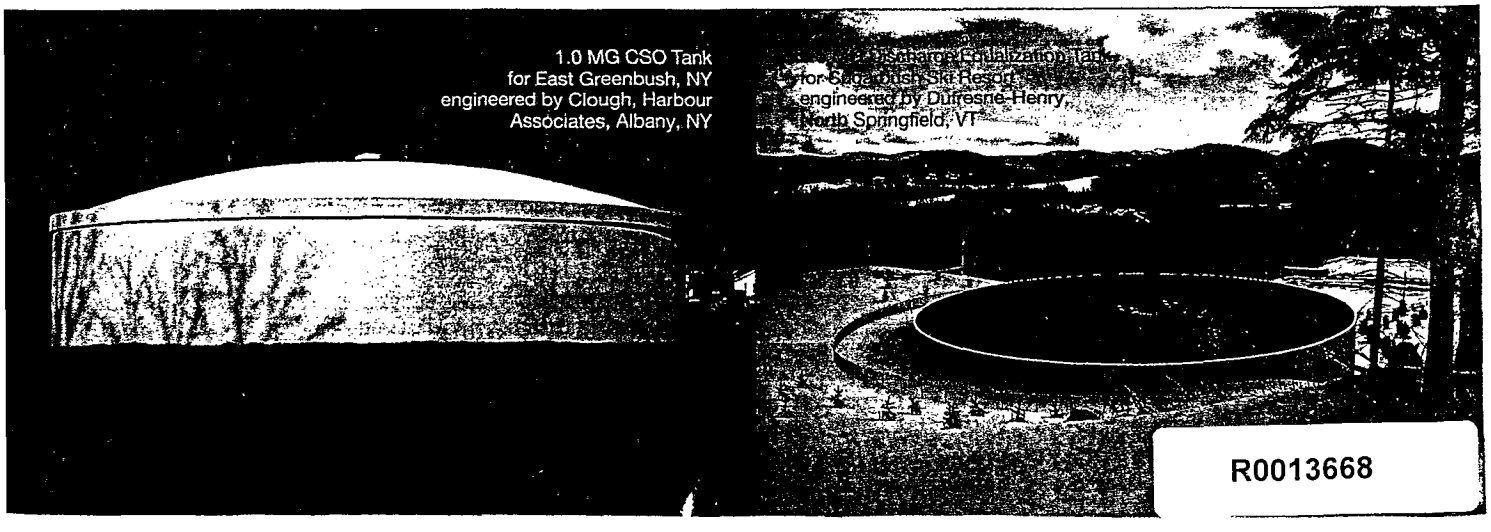

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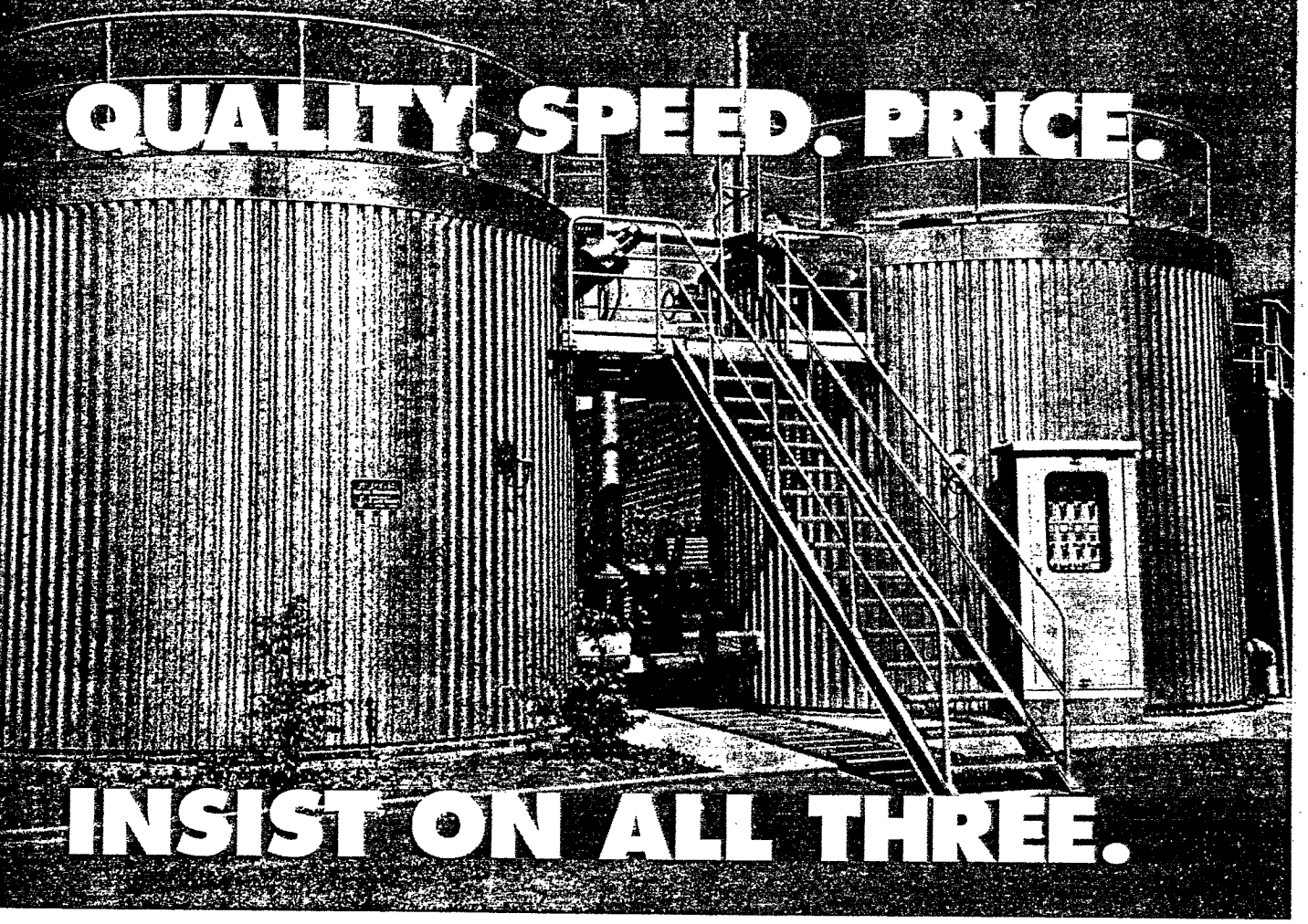

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Water Mark.



Mark Weidman, Vice President and General Manager of Wheelabrator Clean Water's Thermal Operations Group, fishes in the Hudson River, downstream from WTI's Poughkeepsie EOS wastewater treatment facility and upstream from our New York Organic Fertilizer Company project in the Bronx, designed to turn two-thirds of New York City's sludge into an environmentally safe agricultural product.

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When Mark Weidman talks about water, you sense his urgency. An avid outdoorsman, he fears that unchecked growth and development threaten our finite water supply. As one of Wheelabrator Technologies' Clean Water Systems managers, he's also relieved to be able to recover some of that water. "We work in many areas. One is simply the purification of wastewater. We clean it so it can be returned to nature. In another, we convert wastewater biosolids into organic, pathogen-free pellets that are used as fertilizer and to restore damaged land. I consider it recycling in its purest form. Our pelletizing operations are not only a reliable, cost-effective way to help manage and recycle wastewater byproducts, but produce a marketable product as well. For my children to enjoy the kind of environment I had as a child, communities must manage waste effectively and organizations such as ours must continue to find better solutions. We're not going to change the world overnight. But anything we can do here today contributes to global solutions for tomorrow."

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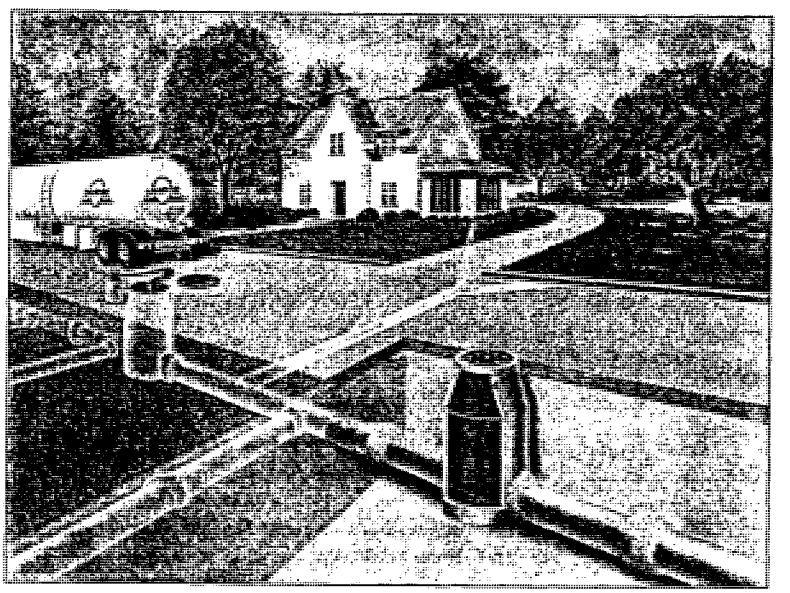

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editorial viewpoint

Harrassment, Diversity, And Challenge

EARLIER this year, much national publicity was given to a claim of sexual harrassment made by a county public works employee—a male employee—against his female supervisor. Some women probably thought, "So what! We deal with it all the time. It's only *news* because a man's experienced it!" Some men may have felt vindicated: "See! Women can be just as guilty as men of crossing the line." Whatever the merits of the particular case, most of us, male and female, have witnessed or experienced incidents of discrimination, harrassment, glass ceilings, etc. The unfortunate fact is that they exist in every work environment and public works is no exception.

The field of public works is populated by many women and minorities of distinction and achievement. Many of our articles are authored by women and minorities. In the past year, PUBLIC WORKS has featured more women and members of minorities on its covers than in any previous year. And although we are proud of that fact, we admit it's not because we specifically set out to put women and minorities on the cover, but rather because women and minorities are, more than ever before, achieving positions of prominence in the public works field.

Which makes it all the more unfortunate that the harrassment issue has to rear its ugly head. Awareness and education are needed to alert us all to avoid situations that make others uncomfortable. It may be an idealistic goal, but if we treat our co-workers—superiors, peers, and subordinates—with consideration, respect, and understanding, provide opportunities for excellence and achievement, and recognize that diversity equals strength, harrassment will cease to be a divisive issue in the workplace.

Chicago Embraces 'Streetwise' Parking Meters

CHICAGO is replacing old mechanical parking meters in its business district with new high-tech models. Good news for the city, but maybe not so good news for parkers. As reported in the *Chicago Tribune*, the city expects to save substantially on maintenance costs and repairs, reduce vandalism damage, and increase revenues. The new digital meters have no moving parts, feature a one-piece iron casing, and are accurate down to the second.

Parkers, however, may not appreciate some of these improvements. Previously, parkers had been given an extra three to five minutes of parking time to compensate for any inaccuracy on the part of the old meters. Also, to raise the parking rates per minute on the old meters meant taking each one apart and installing new parts, discouraging the raising of rates. Now, the parking rate per minute on the new meters can be raised immediately using an infrared light to reprogram the unit.

The new VIP 95 meters are supplied by Duncan Industries, Harrison, Arkansas.

Good News for Rural Communities

RURAL communities in the future will be better able to stay on top of municipal solid waste management practices and issues, thanks to a grant awarded to the Solid Waste Association of North America (SWANA). The "Solid Waste Management Grant" was awarded to SWANA in cooperation with the National Association of Development Organizations, Research Foundation (NADORF) through the U.S. Department of Agriculture, Rural Development Administration. The grant funds will allow SWANA and NADORF to develop guidebooks and provide training geared to the needs of rural America.

The SWANA and NADORF guidebooks will focus on Integrated Solid Waste Management Systems, Decision Making in the Public Sector, Managing Financial Resources, and Regional Approaches to Municipal Solid Waste Management. They will be sent to 5000 rural solid waste management professionals during spring 1994.

The five workshops will be offered between May 1994 and July 1994 in South Carolina, Maine, Kansas, Mississippi, and Oregon. For more information, contact Lori Swain at SWANA 301-585-2898.

New Suburban Fund-Raiser—Golf

AN informative article in *Crain's Chicago Business* tells us that golf is now a "lucrative business venture" for local suburban park districts. Responding to the public's increased interest in the sport and to the need to preserve open space, municipalities are considering operating golf courses to generate revenue for local budgets.

In the Chicago area, the Hoffman Estates Park District, which acquired its golf course for $4 million in 1989, expects to earn $300,000 in profits on revenues of $1.7 million this year. After debt payments, the net income will be $70,000. In ten years, after the district has paid off its debt, net proceeds from the golf course are projected to reach $750,000.

The article admits that profits are not assured at municipally run courses—capital costs and substantial maintenance requirements must be considered. However, most municipally run courses are exempt from property taxes, allowing them to charge lower acccess fees than privately run courses.

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washington report

William F. Reynolds
Washington Correspondent

PRESIDENT Clinton's Omnibus Budget Reconciliation Act of 1993 was signed into law August 10, with October 1 this year as the date the federal excise tax on gasoline and most other transportation fuels will be increased by 4.3 cents per gallon. The legislation eked its way through the House by a vote of 218-216 and through the Senate by 51-50. Vice President Al Gore broke the tie.

The legislation was designed to reconcile the existing revenue and spending law with deficit-reduction targets set by the congressional budget resolution in March, which in turn, was designed to lower the projected growth in the deficit by $496 billion over the next five years. The 1990 Budget Reconciliation Act was intended to achieve $482 billion in savings over the following five years, but Congress failed to achieve much of that goal.

The new hike in the gasoline tax raises the federal tax by 30 percent to 18.4 cents per gallon. The tax on automotive diesel fuel will move to 24.4 cents per gallon. Since the increase also applies to marine fuels, diesel fuel used by inland waterway vessels will rise from 17 cents to 21.3 cents per gallon. Aviation fuel use by commercial airlines is exempt from the increase for two years, however, private aircraft and corporate jets will be subject to the increase beginning October 1.

Gasoline substitutes and additives also are affected under the new law. These substitutes and additives would include compressed natural gas, liquid propane, alcohol fuels (ethanol and methanol) and their octane-enhancing derivatives.

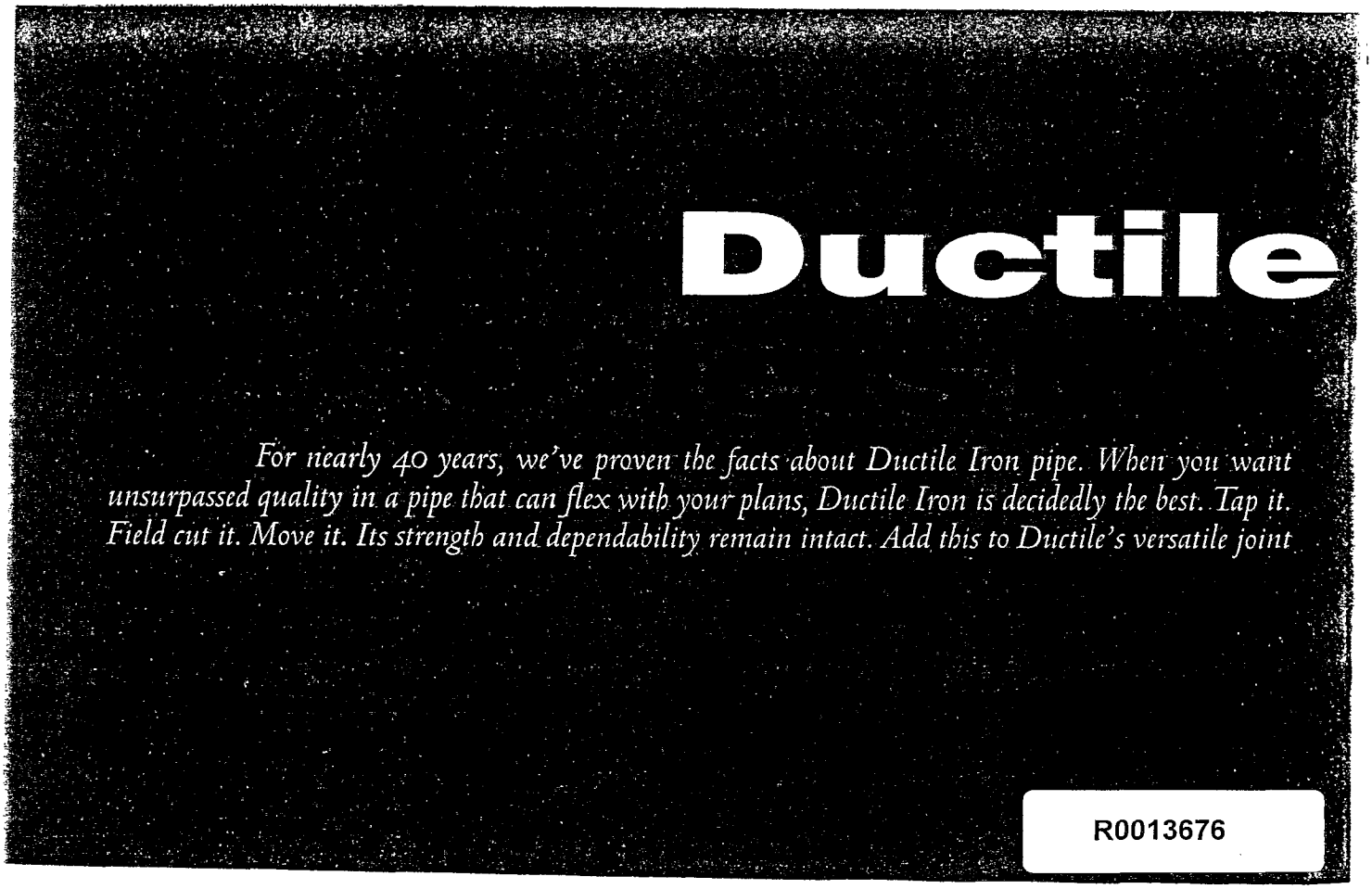
About $23.2 billion in revenues is expected to be generated from the fuel tax increases over the next five years, with about 70 percent of that total coming from gasoline increases. The Administration claims all those funds are earmarked for deficit reduction. President Clinton's original Btu tax was expected to raise about $72 billion over five years. It was dumped in favor of the gasoline tax increase.

Arguments for the gasoline tax hike noted that the average American family driving about 12,850 miles a year, at 20 miles per gallon, would only pay an extra $28 a year under the new law. But arguments against the increase pointed out that the average American household pays about $204 a year in federal motor fuel taxes, and the 30 percent increase, amounting to $62 a year, would move the total outlay for taxes to $266 a year. In some states, like Wyoming, with long range driving, the increase could jack tax outlays to well over $300 a year.

Other tax provisions relating to the existing tax on transportation fuels include:

1) extension of some of the existing federal gasoline tax, 2.5 cents per gallon, which was set to expire in 1995. Extension through 1998 means it will raise $7.82 billion, which is not earmarked for deficit reduction.

2) The tax will be collected on diesel fuel at terminal storage facilities, and no longer



from the wholesaler, a move designed to reduce evasion of payment of the fuel tax. Over five years, the increased revenue from the change is expected to top $1 billion.

3) The passive-income tax credit on certain income derived from foreign shipping and from oil and gas extracted overseas would be removed, and additional revenues of $2.5 billion over five years are anticipated.

4) Eliminating the exemption for recreational boats from the existing 20.1 cents per gallon diesel fuel tax is seen bringing in an additional $148 million over five years. Recreational boats would also be subject to the 4.3 cents per gallon increase.

Congress is expected to place the reauthorization of the Clean Water Act on a fast track this month. In the Senate there have been seven hearings on the measure, and the Senate Environment subcommittee is planning to have it reported out to the full committee, headed by Senator Max Baucus, Montana, early this month. Senator Baucus has often said he will give it highest priority and wants to see it cleared for Senate floor action this session.

An additional seven hearings were held by the House Public Works subcommittee on water resources, headed by Representative Douglas Applegate, Ohio. The House Public Works Committee has not introduced its draft of the reauthorization legislation, but work on clearing it for House floor debate is seen matching the pact set by the Senate panels.

Major motivation for passage of the reauthorization is the federal fund assistance to states and localities for construction of wastewater treatment plants and other water pollution control projects. The Environmental Protection Agency claims it will need more than $100 billion for pollution control projects if it is to comply with existing Clean Water Act requirements.

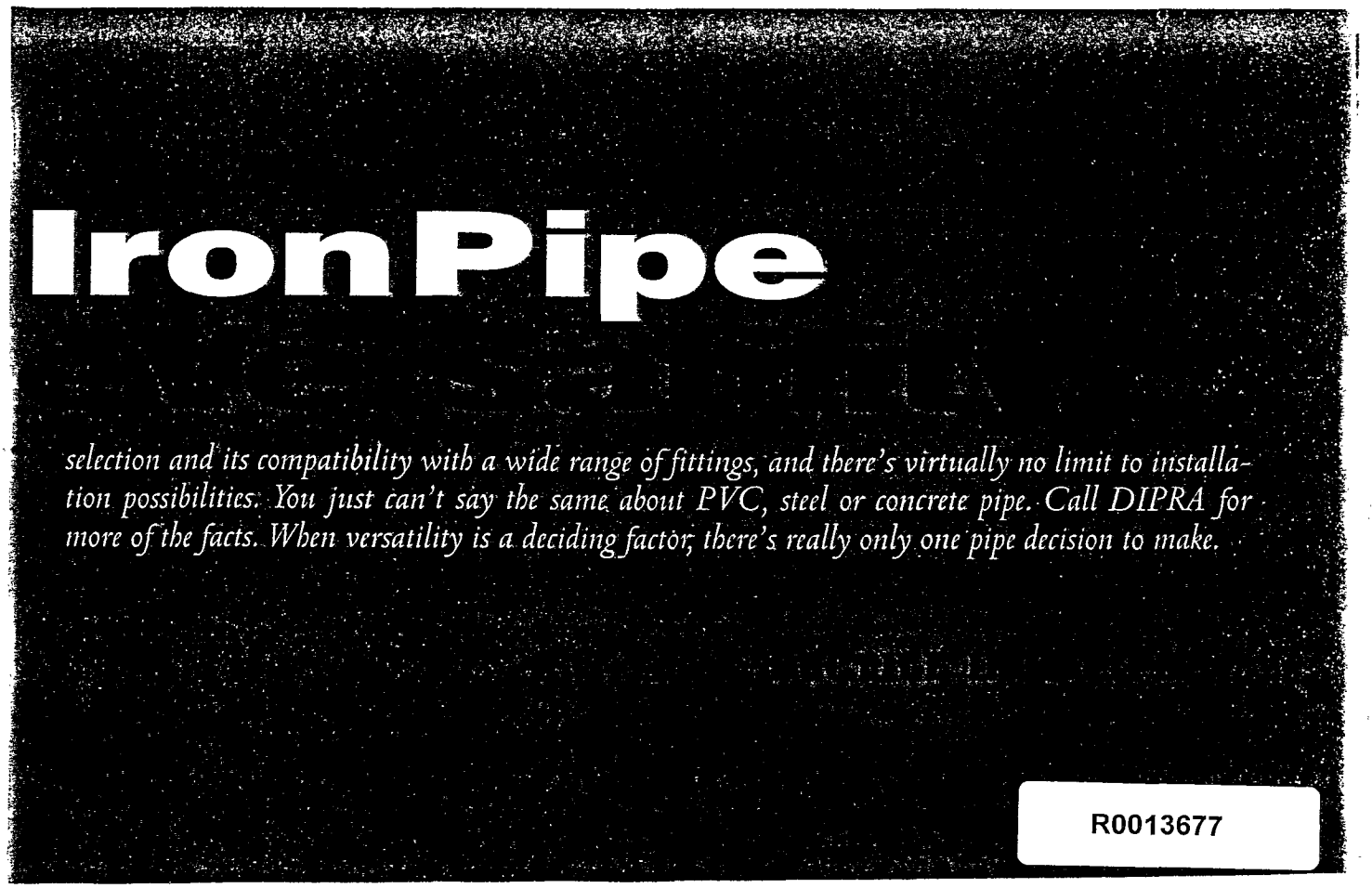
The Senate's Baucus-Chafee bill would authorize $2.5 billion a year for the state revolving loan funds, starting in fiscal 1995. Grants to the funds would be authorized to go up by $500 million every year until FY 2000, but increases would be contingent on the federal government meeting certain deficit-reduction targets.

Champions for federal aid cheer the Senate bill's proposals, but the problem is there might be a big chunk of the revolving loan funds cut in FY 1994. The House passed a spending bill for EPA in June, to provide $1.25 billion for revolving loan funds next year, a big drop from the former $2 billion a year for the program. President Clinton wanted to take $845 million from the $2 billion slated for the program, and use it for supplemental spending to aid the economy, but the president's bill died in April. That defeat left the EPA with $1.2 billion for wastewater treatment program in FY 1994.

Two House committees have still not solved their differences over what should be done on drinking water legislation. The House Energy Committee, chaired by Representative John Dingell, Michigan, has offered a bill that would authorize $3.6 billion over four years to establish a new revolving loan program under the EPA that would help states keep contaminants out of drinking water. It was adopted by the committee in April. Outbreaks of intestinal disease from drinking water in several locations prompted fast action for the legislation.

The same day the Energy Committee approved its bill, Public Works Committee Chairman Norman Mineta, California, introduced a similar bill, and his full panel approved the bill the next day. It would authorize $2.6 billion over three years to set up a new program, but it would use the revolving loan fund structure already in place under the Clean Water Act to distribute the money to states.

The two panels have to compromise on jurisdictional authority; the Energy Committee does have jurisdiction over the Safe Drinking Water Act. However, the Public Works Committee, Chairman Mineta claims, has jurisdiction over the legislation because it deals with construction of water supply facilities. When a compromise has been reached, the legislation will move along.



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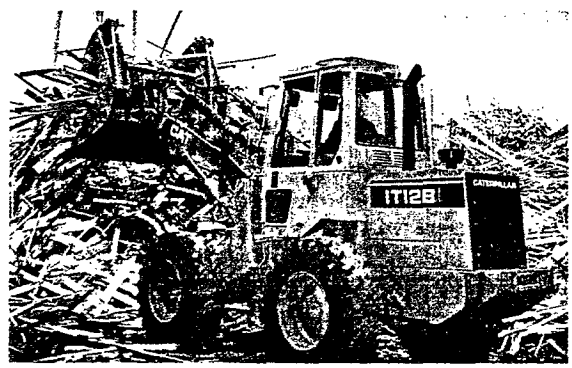

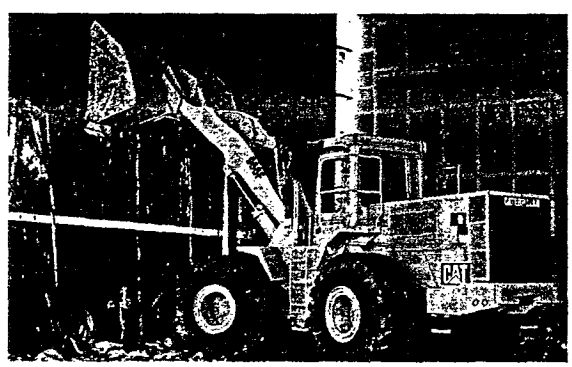

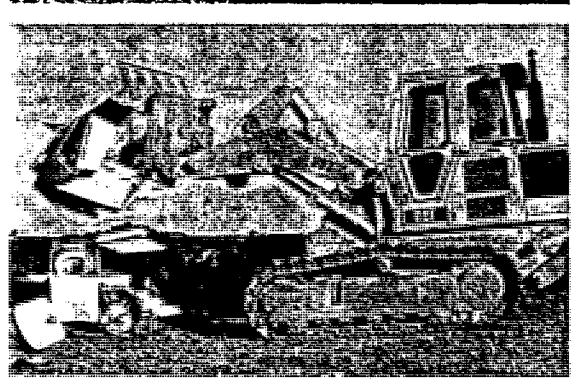

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about our cover

Philip E. Gerwert, the President-Elect of the Water Environment Federation, is the Manager, Plant Environment-Compliance Consistency Section, General Motors Environmental and Energy Staff, Detroit, Michigan. He is responsible for coordination and oversight of compliance consistency programs at the company's manufacturing plants worldwide. For the three years before this assignment in 1992, his responsibilities included coordination, oversight, and regulatory interface of both solid and hazardous waste control programs worldwide and Superfund activities. In addition, his experience includes managing the Industrial Waste Activity, GM Environmental Activities Staff, with responsibilities for developing and coordinating solid and hazardous waste control programs worldwide. Other duties of that position included complying with the requirements of the Toxic Substances Control Act and the Department of Transportation Hazardous Materials Transportation Act conformance programs as well as the regulatory interface in these areas.

He was appointed Manager, Water Pollution Control, GM Environmental Activities Staff with responsibility for coordinating water pollution control programs worldwide. He began his career with the firm in 1958, with various assignments in production supervision, manufacturing process research and development, work standards and methods, advanced product planning, and environmental engineering at various plant locations.

Mr. Gerwert is a graduate of the University of Missouri-Rolla with a Bachelor of Science degree in Chemical Engineering. He attended the Pennsylvania State University Executive Management Program.

His professional affiliations include the Water Environment Federation of which he will become president at the organization's 66th annual conference in October. He has worked extensively for the WEF on both the local and national levels. He has served on the Executive Committee, the Board of Control as a Director-at-Large, the International Committee, and the Long Range Planning Committee. He is a past chairman of the Industrial Waste Committee and a member of the Government Affairs Committee. He is also a member of the Michigan Water Pollution Control Association, Air and Waste Management Association, New York Academy of Sciences, and American Water Works Association.

Mr. Gerwert also served on environmental quality committees of the Business Roundtable, Motor Vehicle Manufacturers Association, the Southeast Michigan Council of Governments, and the Michigan Chamber of Commerce Environmental Quality Committee. He was a member of the National Academy of Engineering Roundtable on Engineering Contributions to the Clean Water Act and the National Science Foundation Inter-Agency Task Group to develop regulations for pollution control in Antarctica.

Mr. Gerwert received the WEF Arthur Sidney Bedell Award in 1989 and is listed in *Who's Who in the Midwest* and *Who's Who Worldwide.*

Mr. Gerwert and his wife Pat reside in Rochester, Michigan and have a married daughter, Vicki, who is a civil engineer. He has been active in the local Kiwanis Club for 19 years, serving as President in 1983. Mr. Gerwert and his wife enjoy golf, cross-country skiing, and bridge.

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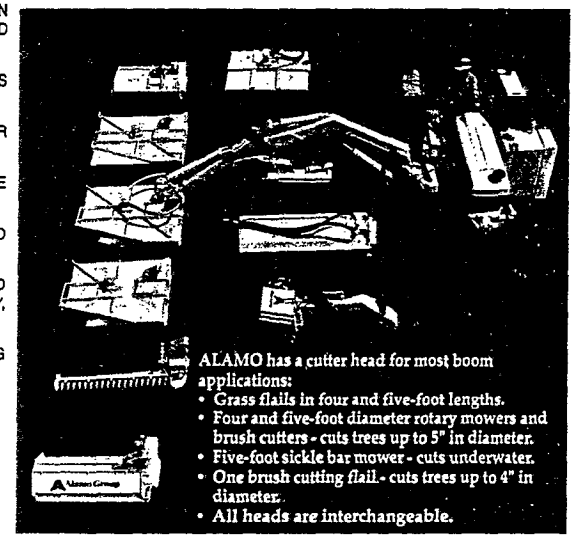

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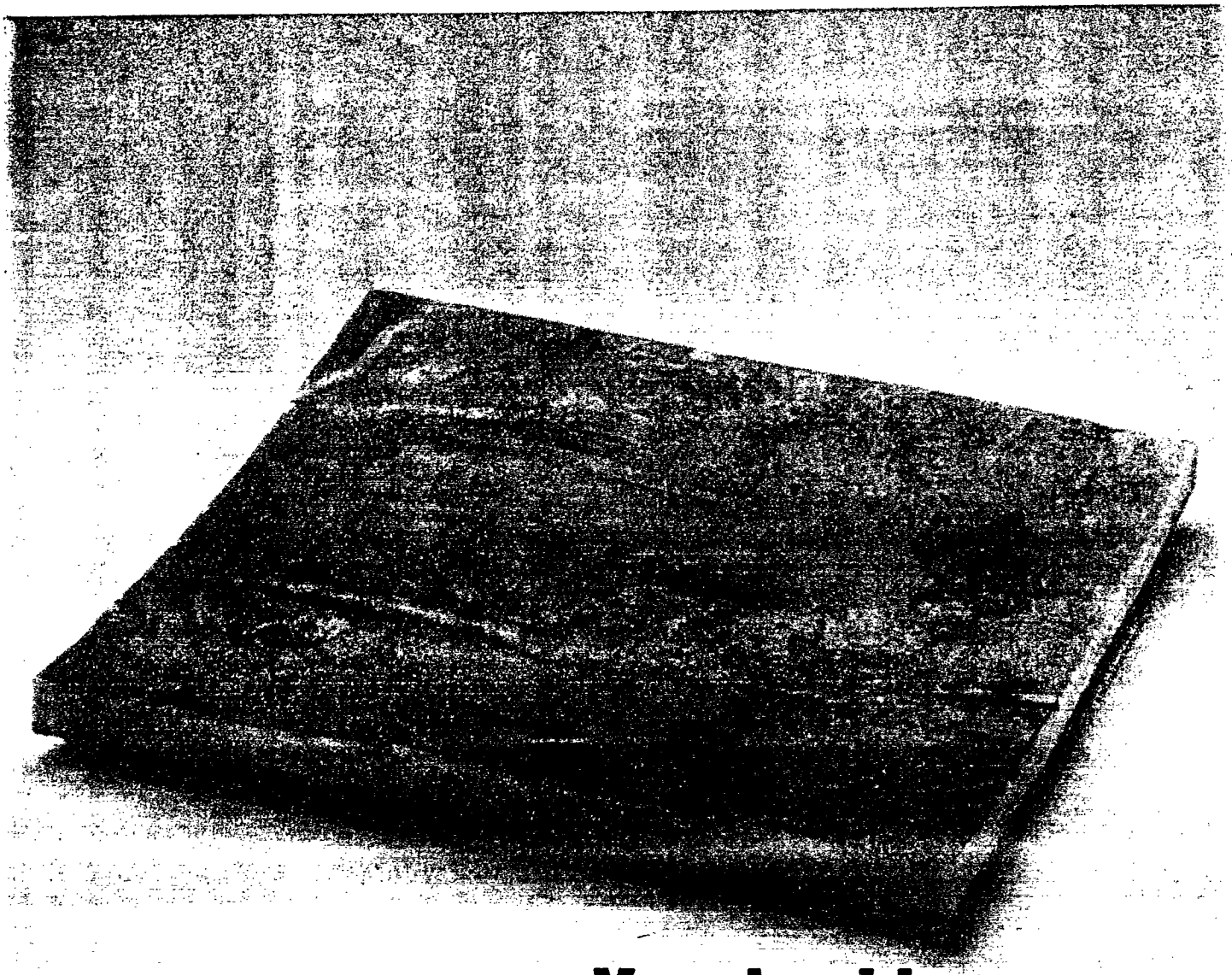

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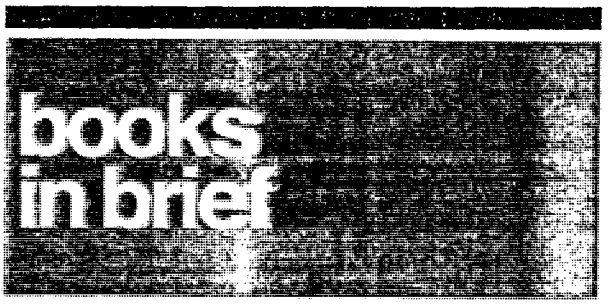

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The fourth edition of the "blue book" is not only an indispensable handbook to inspection procedures, but gives an overview of the entire public works process. Main areas of the book cover general information; construction materials and materials control procedures; methods and inspection procedures; and preview, final inspection, and acceptance. The numerous and numbered subsections help locate particular information. There are suggestions on what to look for on specific projects, questions to consider, the proper equipment and techniques to be used, and other useful hints. There is information on the type and extent of records to be kept, sample forms, estimating, scheduling, grades marks, job site accidents, and so forth. The appendixes contain drawings, diagrams, sample records, and tables. A recommended guide for inspectors, designers, engineers, contractors, architects, consultants, and others involved in construction on the local, state, or federal level.

A GUIDE TO UNDERSTANDING LAND SURVEYS

Stephen V. Estopinal; 226 pages; $49.95; John Wiley & Sons, Inc. 1 Wiley Drive, Somerset, NJ 08875-1272, (908) 469-4400.

The second edition of this book features new drawings, updated information, and expanded explanations based on the reaction of readers from the first edition. Areas covered include real property, geometry, defining north, projection systems, measurement fundamentals, land record systems, boundaries, survey plats, legal descriptions, and deed descriptions. Useful as a basic reference, it is especially useful for those who are not surveyors, but whose work involves land surveying in some form (engineers, attorneys, site developers, and so forth). There are several useful appendixes including a section on the minimum requirements of the American Land Title Association and American Congress on Surveying & Mapping.

MILLER ON MANAGING

William H. Miller; 175 pages; $19.95 members, $24.95 nonmembers, catalog no. 10056; American Water Works Association, 6666 West Quincy Avenue, Denver, CO 80235; tel-1-800-926-7337, fax-(303) 795-1440.

Subtitled, *Straight talk on the ups and downs, do's and don'ts of managing a water utility,* this publication delivers just that—basic, practical advice. Replete with anecdotal stories and based on the author's 20 years at a large water utility (including 12 years as the head manager), it covers communication (with employees, the public, the managing board), the differing perceptions of managers and employees, mission statements, training, considering the future, regulations, and much more. Although based on a career at a water utility, the axioms and experienced-based knowledge found in this book are applicable to all management situations.

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LANDMARK AMERICAN BRIDGES

Eric DeLony; 152 pages; $40.00; American Society of Civil Engineers, Publications Department, 345 East 47th Street, New York, NY 10017-2398.

Part of the "Historic American Engineering Record," this book shows the evolution of design, transportation, and engineering in American bridge building. With over 150 illustrations, it gives an interesting look at the types of innovation and ingenuity that occurred when a river or valley had to be crossed.

THE DESIGN OF WATER-RETAINING STRUCTURES

Ian Batty and Roger Westbrook; 202 pages; $89.95; John Wiley & Sons, Inc. 1 Wiley Drive, Somerset, NJ 08875-1272, (908) 469-4400.

Applicable for water and wastewater structures, this book covers basic design parameters and provides design data on cantilevered walls, rectangular and circular tanks, prestressed concrete circular tanks, flat slab roofs, columns, and conical tanks. There is a sample analysis of a ground-supported structure and information on computer programs. It has numerous illustrations, diagrams, tables, and sample calculations.

CLIMATIC BUILDING DESIGN: ENERGY-EFFICIENT BUILDING PRINCIPLES AND PRACTICE

Donald Watson and Kenneth Labs; 288 pages; $29.95; McGraw-Hill Book Company, 11 West 19th Street. New York, NY 10011, 1-800-2-MCGRAW.

An intensive look at how design greatly affects a structure's ability to provide a suitable living environment and how to do so cost-effectively. Information is provided on minimizing and maximizing solar gain, strategies of climate control, heat flow, ventilation, and so forth. There are hundreds of drawings and diagrams as well as tables, charts, photographs, and other ancillary information. There is an extensive reference list and information on useful computer programs.

HYDRAULICS FIELD MANUAL

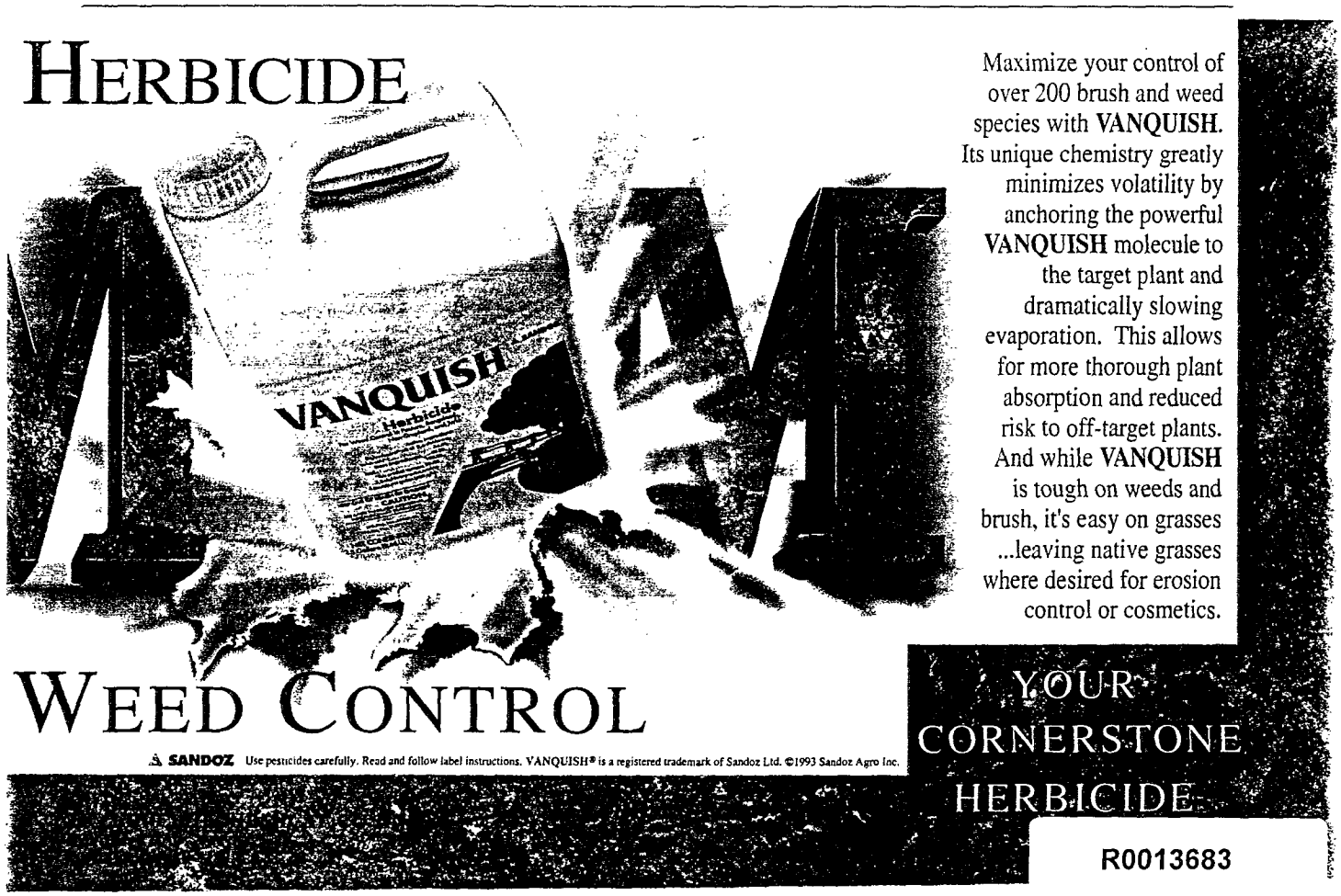
Robert O. Parmley, ed.; 334 pages; $42.40; McGraw-Hill Book Company, 11 West 19th Street, New York, NY 10011, 1-800-2-MCGRAW.

This book is designed to be a source of "quick" information in the field where a wide range of problems may be encountered. To aid in that task there are numerous charts, tables, diagrams, nomographs, drawings, and other illustrations. Main topics cover groundwater; pumps; weirs, flumes, and orifices; pipe flow; culverts and storm water; storage and fire protection; and estimating flows in the field. A supplemental section provides information on miscellaneous items as unit conversions, pipe curvature, infiltration rates, and much more.

Other Titles of Interest...

STATE ADMINISTRATIVE OFFICIALS CLASSIFIED BY FUNCTION; 331 pages; $30.00, order number D-003-91; Order Department, The Council of State Governments, P.O. Box 11910, Iron Works Pike, Lexington, KY 40578; tel-(800) 800-1910, fax-(606) 231-1858. Because job titles vary from state to state, this listing by function makes it much easier to find the right person; names, addresses, and telephone numbers of state officials in 147 areas.

DICTIONARY OF WATER AND WASTEWATER TREATMENT TRADEMARKS AND BRAND NAMES; Tom Pankratz; 139 pages; $39.95; Lewis Publishers, Inc., 2000 Corporate Blvd., N.W., Boca Raton, FL 33431. Arranged in alphabetical order with over 1,100 listings and cross-referenced; with current, obsolete, and dormant product names.



reviews of catalogs

Catalogs reviewed in this section have been selected for their helpful engineering and product information. New listings are designated by a star (☆). To order the catalogs you want just circle the numbers on the reply card and fill in your name, title, and address. This free Readers Service is restricted to persons actively engaged in public works.

Versatile Lifts Mean Better Servicing ☆

51. Literature describes parallelogram indoor/outdoor aboveground lifts that install easily and allow unrestricted access to the vehicle undercarriage. Standard safety features include automatic lock system, emergency stop bars, and an electronic logic control panel. Advantage Lift Systems, Inc., San Diego, CA.

Aerial Photography/ Photogrammetry Services ☆

52. This full-service company performs photogrammetric mapping, aerial photography, GIS services, and conventional and GPS surveying. Aerial Data Service, Inc., Tulsa, OK.

Rubberized Asphalt Kettle ☆

55. Literature features the Model KERA-130H diesel fueled rubberized asphalt kettle for crack sealing. Its Heated Hose System delivers heated fluid material to the application point through a heated discharge line that will maintain sealant temperatures, even during periods of non-use. Aeroil Products Co., Inc., South Hackensack, NJ.

Economy Lighting for Heavy Duty Trucks ☆

56. Catalog offers the full line of American-made strobe and halogen lights, rotating beacons, and warning lights. Shatter-resistant Lexan® lenses come in all five safety colors. Austin Electronics, a Div. of Whelen Engineering Co., Chester, CT.

All-Purpose Truck Covers ☆

60. Company offers an automatic cover for a roll-off truck that covers all height and length containers, and a dump truck cover powered by electricity, hydraulics, or hand crank. B & B Equpt. Sales Co., Inc., Miami, FL.

Suspension for Smoother Rides ☆

61. Product sheet describes the Chalmers 800 rubber spring tandem truck suspension—no leaf springs or air bags to replace. Soft ride increases mileage and stability and cuts maintenance needs. Chalmers Suspensions Int'l. Ltd., Brampton, Ontario, Canada.

Curvimeters & Precision Timing Instruments ☆

62. Catalog presents curvimeters for measuring distances in various scales, including the Comcurve-5 digital model, and stopwatches/time study watches. M. Ducommun Co., Inc., Warwick, NY.

Post-Emergence Vegetation Management ☆

511. Brochure outlines the chemistry and benefits of Vanquish® herbicide, provides problem vegetation information, and charts variations of tank mix options for broadleaf weed and brush control. Sandoz Agro, Inc., Des Plaines, IL.

Utility Castings, Hydrants, & Valves ☆

64. Catalog offers manhole frames and covers, catch basins, trench grating, tree grates, fire hydrants, gate valves, and much more, and includes flow capacity. East Jordan Iron Works, East Jordan, MI.

Tapping & Linestopping Equipment ☆

67. Perform pipe repairs without system shutdown—this company sells standard tapping and linestopping machines for 3/4- through 16-in. pipe diameters and performs contract services for 3/4- through 48-in. diameters. Hydra-Stop, Inc., Blue Island, IL.

Specialty Vehicles And Equipment ☆

68. Literature explains the custom design services this company offers for specialized multi-purpose and specific task vehicles, even with on-board power source. Masterack, Atlanta, GA.

Control Fueling Automatically ☆

71. Literature presents the RFC-2000™ automated fuel management system, which records vehicle ID, fuel dispensed, odometer reading, date, and time, unattended, and without cards, keys, or keypads. Tank Tech Corp., Congers, NY.

Measurement Gauges for Roadway Applications ☆

72. Electronic gauges to measure density, moisture, and asphalt content include the Model 4545 continuous density gauge to update compaction results while rolling and the Model 3241-C asphalt content gauge to measure asphalt cement content of pavement mixes. Troxler, Research Triangle Park, NC.

Clean Clogged Valve Boxes ☆

73. Literature highlights valve box cleanout systems to remove debris in minutes—including mud, rocks, water, clay, glass, etc. E.H. Wachs Co., Wheeling, IL.

Recycling: A Systems Approach ☆

76. Recycle America® programs focus on the three areas critical to program success: collection, processing, and marketing. Waste Management, Inc., Oak Brook, IL.

Large Document Copiers ☆

78. Literature introduces the model 516M mid-volume plain paper copier, which makes copies from any drawing and copies 36 in. wide by any length. Blu-Ray, Essex, CT.

Barrier System for On/Off Road Applications ☆

87. Literature covers this company's lightweight plastic channelizing device that can be water ballasted for positive protection in work zones, for flood protection, and against soil erosion. Yodock Barrier Systems, Bloomsburg, PA.

Replacement Blades ☆

99. Company offers replacement blades for snow plows, graders, dozers, loaders, and scrapers—available in high treated through hardened, high carbon, carbide edged, and surface hardened styles. Valley Blades Ltd., Waterloo, Ontario, Canada.

Eliminate Grease, Odor In Lift Stations ☆

209. Brochure presents Lineze™, an all-natural product of the citrus industry that floats on top of the wet well and prevents normal lift station odors from leaving the wet well, while also liquefying grease. Earth Chemical, Inc., Parrish, FL.

902 Pages of Safety Supplies ☆

211. Voluminous 1994 catalog displays thousands of personal, environmental, and industrial safety supplies, with an expanded section of ergonomics products. Lab Safety Supply, Janesville, WI.

Storm Alert/ Warning Service ☆

212. Company provides road and highway departments with accurate, timely storm warnings. DVM Weather Service, Florida, NY.

Solve Surface Seal Problems ☆

213. Literature describes how this durable, watertight fiberglass surface bonds to concrete or steel and seals swimming pools, fountains, tanks, zoos, aquariums, etc. Fibre Tech, Inc., Largo, FL.

Guide to Stormwater Runoff Monitoring ☆

217. New guide answers questions about the EPA monitoring guidelines, provides application information, and features product specifications on integrated monitoring systems. Isco, Inc., Environmental Div., Lincoln, NE.

Using PVC for Trenchless Pipeline Reconstruction ☆

223. Literature presents NuPipe, made from corrosion- and abrasion-resistant PVC. It is pre-manufactured in continuous folded lengths for long, jointless pipe runs and expands to its round shape during installation. NuPipe, Inc., a Subs. of Insituform Technologies, Inc., Memphis, TN.

Match the Truck To the Job ☆

224. Brochure (233-05919) profiles the Model FE and four-wheel drive PG439 line of Class 3, diesel-powered, light-duty trucks with tight-turning radius and tilt-forward cab for easy maintenance. Mitsubishi Fuso Truck of America, Inc., Bridgeport, NJ.

Prevent Pavement & Sidewalk Buckling ☆

225. Literature describes the Biobarrier® root control system, a geotextile fabric with controlled-release nodules containing trifluralin to control tree root encroachment. Reemay, Inc., Old Hickory, TN.

Reliable Wastewater Odor Control ☆

226. Brochure (Form B-60) explains how Odor-Master Systems control odors by chemically changing, not masking odorous compounds in contaminated air. The compact systems include scrubber tower, fan, brine tank, eletrolytic cells, rectifier, motor control center, and automatic control system. Pepcon Systems, Inc., Henderson, NV.

New Bucket Couplers ☆

227. Illustrated info sheet introduces the Remote Hydraulic Quick Coupler, the Quick Change JAW®, and the Piggy Back Swinger for coupler versatility. Wain-Roy,® Inc., Hubbardston, MA.

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It's hard to find the answers to those questions before delivery. After all, the promises a salesman makes, are just that.

All too often, unexpected problems increase operating and maintenance costs beyond tolerable limits. Problems that simply do not exist with MITSUBISHI FUSO trucks.

What to expect after you buy or lease a MITSUBISHI FUSO truck.

1. Expect your MITSUBISHI FUSO truck to perform reliably. Without problems. MFTA and your MFTA dealer will work their hardest to make certain it does. Our warranty isn't just a piece of paper with disclaimers in barely legible type. It helps protect your investment.

2. Fully expect your MFTA dealer to do what's necessary to make certain your truck is an asset and not a liability. The common things most dealers do. And, the uncommon things few dealers do. While many dealerships offer a wide smile and a hearty handshake as you drive away—but forget you 5 minutes later—expect your MFTA dealer to remember your name and business whenever you call. Expect your MFTA dealer to act like a true "partner."

3. Expect your MFTA dealer to know how to keep your MITSUBISHI FUSO truck on the road. Working. We require every MFTA dealer to put sales, maintenance, and repair people through MITSUBISHI FUSO comprehensive training programs that have yet to be matched by anyone else in the industry. As a result, you

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"My Mitsubishi Fuso trucks have saved me over 50% on my fuel cost, and even more in repair bills. They just don't break down. I appreciate a company that can engineer a truck that's exactly right for my business. Believe me, that's something no one else has done."

Richard Fulmer–AKCA, The Pavement Marking Company



"My Mitsubishi Fuso FH has 140,000 miles on it and neither the brakes nor clutch have had to be replaced. That savings alone in repair and down time cost, inspired me to buy another FH."

Terry Chapman–Chapman's Wrecker Service



"The complete dedication from my dealer for quick response is critical to my business, and our Mitsubishi Fuso FM trucks solve equipment problems traditional in my industry."

Mike Statt–Resurface Inc.

R0013686



"My 1987 FE has over 300,000 miles on it and it's never been taken apart."

Richard Brendle–Brendles Transfer



"Before I started in business two and a half years ago, I researched the truck situation thoroughly. I think I visited every truck dealership in New England and compared everything before I settled on Mitsubishi Fuso. My decision was based on the fact that the truck line offered more and had the best features."

Isaac Edry–Isaac's Moving and Storage



"After 107,000 miles, we've only added fuel, tires, and filters to keep our Mitsubishi Fuso FH running, and it gets the best fuel economy of any truck in our fleet."

Scott Hoover–Roaring Spring Bottling

can expect your truck to be in the hands of highly-trained, highly-skilled, dedicated people whose sole mission is to keep your truck profitable.

4. Expect replacement parts and component assemblies to be immediately available. Although parts availability may be a legitimate concern with other trucks it is not a concern with MITSUBISHI FUSO trucks. MFTA routinely fills all dealer parts orders within 48 hours. And, our parts fill rate remains consistent at 99% or above.

5. Expect your MITSUBISHI FUSO truck to perform durably, reliably, and economically for a long time. When you're ready to sell, or trade it in, remember that MITSUBISHI FUSO truck resale values have been traditionally high.*

What all this means, is that buying or leasing a MITSUBISHI FUSO Light/Medium™ or Medium Duty truck, is an extremely sound investment. One that also includes the best service, parts, and "value" for the life of the truck. From a company and dealers who know the difference between just "selling" and "superior customer service."

That is why the level of customer service you get, separates MITSUBISHI FUSO trucks and dealers from the rest of the crowd. And why MITSUBISHI FUSO trucks will provide an exceptional return for your investment, and profits for your business.

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R0013688

Stop Pump Sealing Problems ☆

228. Literature describes S.B.S. stuffing box sealant and other mechanical seals, gaskets, O-rings, and lubricant products. Sterling Plastic & Rubber Products, Inc., South Amboy, NJ.

Pinpoint Leaks in Valves & Valve Systems ☆

231. Product sheet covers the AccuTrak™ Model VPX and Model VPX-WR (water resistant) ultrasonic leak detectors. Each kit includes detector/headset, sound generator, wave guide, horn restrictor, case, and charge adaptors. Superior Signal Co., Inc., Spotswood, NJ.

Valves for Hydraulic Power Control ☆

88. Literature presents mobile hydraulic control valves, integrated circuits, cartridge valves, electronic programmable controllers, and feedback devices. Gresen/Dana, Minneapolis, MN.

Suspension System for Demanding Refuse Operations ☆

89. Literature explains how the new maintenance free RS system's transverse rods reduce bushing wear and eliminate system maintenance. Hendrickson Suspension, Woodridge, IL.

Versatile Leaf Disposal Unit ☆

90. Product data features the Hi-Way AutumnMate 720, which handles wet and dry leaves with a brush, roller, conveyor, auger, and impeller/blower system. Highway Equpt. Co., Cedar Rapids, IA.

Comply With the OSHA Confined Space Rule ☆

600. Literature kit on respiratory equipment and gas detection instruments is designed to help employers meet the requirements of the new OSHA Confined Space Rule. Scott Aviation, A Figgie Int'l. Co., Lancaster, NY.

Boats for Debris Removal ☆

92. Company supplies boats for oil skimming, trash and debris removal, and aquatic plant harvesting. Hydraulic Boat Co., Inc., Port Byron, NY.

Advanced Cart Lifting Technology ☆

93. This company's rotary TuckAway cart lifter installs and stores compactly and lifts carts high and steep for complete dumping. Perkins Mfg. Co., Chicago, IL.

Permanent Asphalt Repair ☆

95. The 4TCR asphalt recycler and storage unit recycles new or old asphalt; the TR-48 heats asphalt in place with no burning or oxidation. Poweray Infrared Corp., Claremont, NH.

Pipe Joining System ☆

243. Literature explains the Victaulic system of joning pipe with only two bolts, making sludge clean-out, maintenance, expansion, etc. easier. Victaulic Co. of America, Easton, PA.

A Market for Waste Plastics ☆

613. Literature introduces Envirowood™, a synthetic lumber substitute made of 100 percent recycled plastic. The company is looking for sources of material and encourages communities with collection programs to investigate a mutually beneficial relationship. Envirowood, Mt. Prospect, IL.

Datalogging Open Channel Flow Measurement ☆

586. Product Data Sheet (US/275) features the MSPLOG data logging system, able to log daily totalized flow accumulated up to 32 days, plus a 2000 point flow measurement logging. The data storage rotates to provide continuous information. Magne-Sonics, Houston, TX.

Submersible Pumps ☆

244. Literature covers the wide range of horsepower, capacity, and heads offered in this company's line of submersible pumps. Flygt Corp., Norwalk, CT.

CCTV Sewer Inspection System ☆

245. The Port-A-Pac is a versatile CCTV system for both remote and mainline inspection. Available in four configurations. Cyclops Electronics, Inc., Boerne, TX.

Municipal Truck Leasing ☆

96. For information on the municipal leasing program for Ford vehicles, contact Southside Sales, Chicago, IL.

Plastic Covers Contain Odors & Vapor ☆

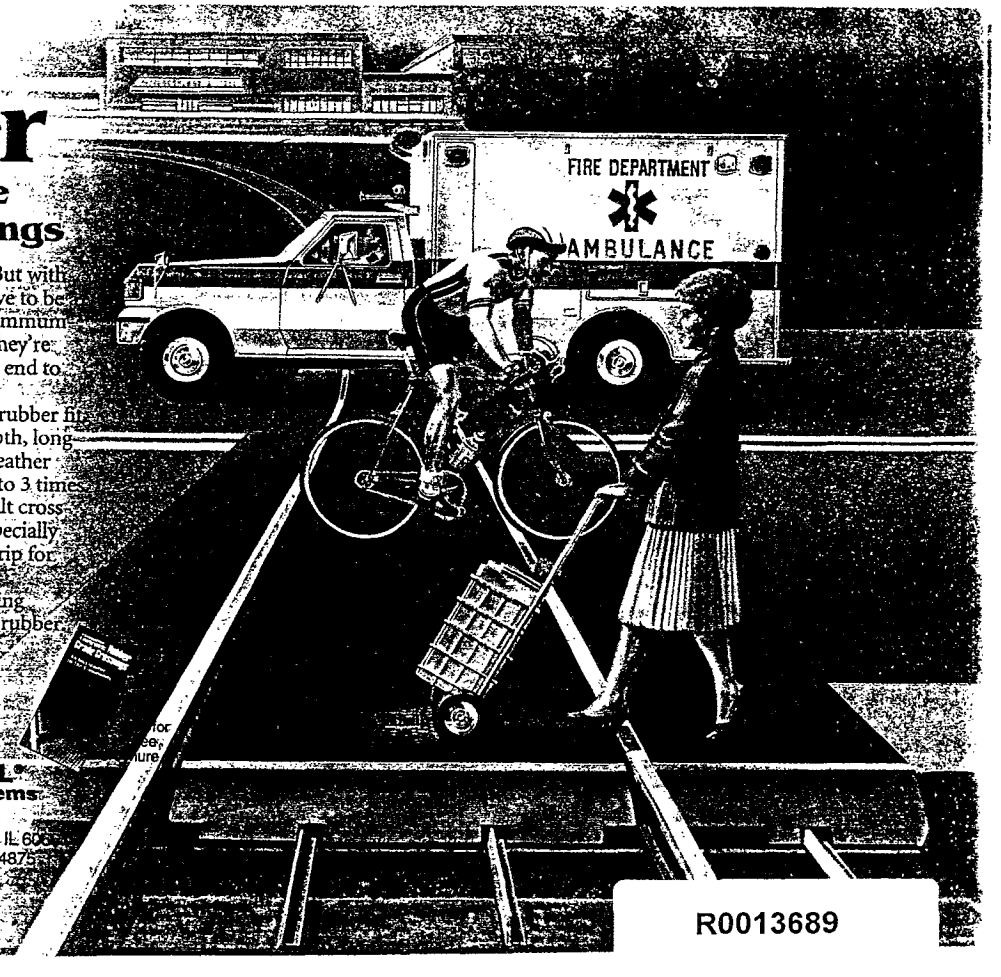
237. Fiberglass reinforced plastic covers are designed and manufactured for maximum strength at minimum weight, efficient on-site assembly, corrosion resistance, and minimal moisture collection points. SynTechnics Inc., Paducah, KY.

Alternative Hydraulics/ Hydrology Software ☆

238. Literature announces new releases to the STORM SEWERS and SANITARY SEWERS modules, operating inside AutoCAD®, for sewer analysis and/or design. Eagle Point, Dubuque, IA.

Tackifier Boosts Bonding Power ☆

404. Literature presents Silva-Tack™ concentrated formula tackifier to boost the bonding power of mulch, resulting in a web-like network of interlocking fibers that hold seed, fertilizer, and soil in place; stabilize soil and sand; and control dust. Weyerhaeuser, Engineered Fiber Products, Snoqualmie, WA.



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Gentle Weed Control ☆

240. Technical guide tells how Surflan™ herbicide can stop over 50 weeds and grasses, protecting over 175 ornamentals. DowElanco, Indianapolis, IN.

Aerator for Wastewater Treatment ☆

493. Brochure details the TORNADO surface aspirating aerator. Design improvements include the replaceable seal module, which simplifies initial assembly and eases routine service inspections. AEROMIX Systems, Inc., Minneapolis, MN.

Towable Sewer Flushing Machine ☆

498. Product sheet (Bulletin 3030) covers the Model HV2060TR/L Hy-Velocity Sewer Flushing Machine, designed with high-pressure triplex pump and dual axle design for easy towing and positioning. Sreco Flexible®, Lima, OH.

Two-Function Rear Loader ☆

499. Specification sheet (PMRDG100-930501) introduces the RDG100 Load Liner II Series dual chamber rear loader to handle separated refuse collection and recycling. Pak-Mor®, San Antonio, TX.

New Microbiology Catalog ☆

502. A 48-page "Microbiology—Systems for Analysis" catalog (Lit. #3986) contains current information on testing for coliforms and other bacteria in water and wastewater and describes incubators and equipment, ready-to-use media, presterilized apparatus and labware, and much more. Hach Co., Loveland, CO.

Air Purifying Respirators ☆

503. Color brochure details the disposable Series 86--the low-maintenance air purifying respirator, the reusable Blue 2000 half-mask, and the full facepiece unit. Survivair®, Santa Ana, CA.

Effective Sludge Treatment ☆

241. Literature details the Kruger/Fuchs Autothermal Thermophillac Aerobic Digestion (ATAD) process for sludge treatment, which features a sludge holding time of six days. I. Kruger Inc., Cary, NC.

Diaphragm Valves for Fluid Handling Systems ☆

479. Literature (Bulletin 530) introduces the new Series 530 plastic diaphragm valves with high flow capability, new sizes, double shaft seal, and true union end connections. AquaMatic®, Inc., Rockford, IL.

Engineering Handbook for Bearing Users ☆

480. New 364-page handbook contains bearing specifications, engineering data, and rating life calculations for MRC bearings. A 20-page table provides data on vibration frequencies of widely used bearings. MRC Bearing Services, King of Prussia, PA.

New Tool Carriers— More Than Wheel Loaders ☆

489. Brochure (Form No. CE014053) presents the 621B and 721B XT Extra tool carriers with excellent engine efficiency, superior hydraulic capacities, maximum loader productivity, quick change tool capability, and a wide variety of application specific tools available. J I Case, Racine, WI.

Extending a Driver's Field of Vision ☆

492. Brochure explains how the Safety Vision SV55 Camera System helps drivers safely perform hazardous tasks such as backing up, making wide turns, and changing lanes. The United Group, Inc., Bannockburn, IL.

Plastic Products for Testing & Storage ☆

963. Catalog includes bottles, laboratory supplies, tubing and fittings, shipping supplies, etc. Consolidated Plastics Co., Inc., Twinsburg, OH.

Horizontal Pumping System ☆

424. Brochure covers a low-maintenance, cost-effective alternative for split casing and positive displacement pumps—a multistage centrifugal pump horizontally skid mounted for surface pumping applications. Reda, A Cameo Int'l. Inc. Co., Bartlesville, OK.

Scanning from Aerial Photos ☆

426. Literature (M-002-0390) discusses the VX3000 Image Scanner™, providing accurate, high resolution images from aerial photos for geographical surface modeling or landbase information capture and management. Vexcel Imaging Corp., Boulder, CO.

Spiral Technology for Dewatering Products ☆

786. Color brochure describes a new eight-product line of liquid/solid separation products based on spiral technology, including an all-in-one in-channel fine screening, conveying, and dewatering system, septage receiving system, dewatering press, grit separator, and more. Hycor Corp., Lake Bluff, IL.

Confined Space Entry Monitor ☆

789. Specification sheet (TR0293) details the Triple Plus multifunctional portable gas detector that simultaneously monitors up to four gases. The unit can be configured to provide instantaneous alarms, time weighted averages, or peak hold values. CEA Instruments, Inc., Emerson, NJ.

Handheld Meter Reading ☆

862. Brochure tells how the Route Management System (RMS) provides hardware and software to reduce data collection costs by improving accuracy, eliminating redundant data entry, and interfacing between field units and office PC. Radix Corp., Salt Lake City, UT.



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Gene Amlin, P.E., HNTB-Indianapolis

HNTB environmental engineers are committed to providing hands-on, personal service. We consider this approach critical to helping our clients meet the operational, financial and regulatory challenges that they face daily. This dedication to service, combined with technical expertise, is the hallmark of HNTB environmental engineering.

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The all new Hiwind™ series vacuum sweeper from Elgin is more than a new product, it's a new concept in street sweeping productivity. With high dump capability, an extra-wide sweeping path and state of the art electronic controls, the Hiwind provides versatility and efficiency never before available in a full sized vacuum sweeper.

World's Widest Vacuum Sweeping Path. The Hiwind features two independently suspended vacuum nozzles that focus extraordinary cleaning power on the widest vacuum path you'll find–a full 60". A unique Hi-Flow™ design lets each nozzle adapt to changing surface contours for optimum cleaning efficiency. 42" side brooms extend the cleaning path to 10 feet and provide plenty of digging power to break-up heavy, compacted debris.

Lifts A 4½ Ton Payload 11½ Feet. Variable high dump capability lets you lift and empty the Hiwind's 6 cu. yd. hopper directly into a dump truck and quickly return to sweeping. Hiwind is the first full sized vacuum sweeper that gives you the option of unloading at ground level, 11½ feet, or any height in between.

Automated Sweeping Controls. Elgin's revolutionary new INTELLA-TOUCH II™ electronic control system lets operators handle all sweep system functions, including hopper dump, without leaving the cab. A unique "memory" function remembers all sweep settings for fast, easy conversion from transport to sweeping mode. Built-in self-diagnostics help service technicians check out the operating system and components in seconds. These innovative features and more make the Hiwind the most productive vacuum sweeper to hit the streets in years.

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Tunnel & Underpass Lighting ☆

626. Illustrated brochure (Form TSLC 8-91) discusses tunnel and underpass lighting—the luminaires and lighting control systems available for correct, safe illumination of enclosed areas. Thomas/Schreder Lighting, Milan, IL.

Weight Data Management System ☆

630. Fold-out brochure details the Model 9000 Weight Data Management System, designed to quickly and efficiently collect data, display it graphically, and generate reports and tickets for documenting weighing transactions. Interface Logic Systems Inc., Weighing Div., Columbus, OH.

Durable & Corrosion-Resistant Hydraulic Cylinders ☆

634. Literature (DKPF104) presents the 120- and 180-Series Hydro-Max™ hydraulic cylinders with nickel-chrome plated hardened rods to extend seal life and improve corrosion resistance. John Deere Harvester Works, Moline, IL.

Versatile Waste Processing Unit ☆

779. Literature introduces "The Beast," a combination chipper/hammermill/hog with a 5-ft wide by 15-ft long feed conveyor to handle logs, brush, stumps, concrete blocks, demolition waste, etc. with knives, swinging hammers, and fixed hammers. Bandit Industries, Inc., Remus, MI.

Protection for Manhole Workers ☆

703. Literature discusses the new AMH Series of lightweight aluminum manhole shields for worker protection while setting or repairing manholes. The shields surround the manhole pit and provide an unobstructed inner span for excavating and placing the manhole. Griswold Machine & Engineering, Union City, MI.

Hydraulic Rough Terrain Cranes ☆

699. Product sheet (#SE/38/8030) covers the RTC Series of hydraulic rough terrain cranes with capacities from 25 to 30 tons. The exclusive Confined Area Lift Capacities system allows work in confined job areas where full outrigger extension is not possible. Link-Belt Construction Equpt. Co., Lexington, KY.

Combustible & Toxic Gas Detector ☆

704. Information sheet covers the LEAKATOR™ 10 battery-powered, hand-held, gas detection instrument, complete with carrying case, installed and tested gas sensor, flexible probe, earphone, and manual. Bacharach Inc., Pittsburgh, PA.

Video on Choosing Metal Detectors ☆

707. Free video kit includes, "Choosing the Right Metal Detector," an updated guide to various models that sense out ferrous and non-ferrous metals in conveyed materials. Eriez Magnetics, Metal Detector Div., Erie, PA.

128-Page Lighting Specification Manual ☆

811. Updated guide (SAG-100) allows users to evaluate various lighting options including fluorescent, compact fluorescent, high intensity discharge, incandescent, and halogen. It provides detailed information on the National Energy Policy Act of 1992 and the EPA Green Lights Program. Philips Lighting Co., Somerset, NJ.

CAD for Windows ☆

644. Literature explains MicroGDS 3.1, a Windows NT compatible CAD software program. It directly interfaces with the workstation-based Graphic Data System, a comprehensive GIS, CAD/CAE system. Electronic Data Systems Corp., Maryland Heights, MO.

Maintenance Lift for Utility Vehicles ☆

438. Product sheet features the Uni-Lift Model 390 maintenance repair lift for accessibility to the underside of riding mowers, grounds maintenance tractors, etc. G & H Products, Div. of Riburn Industries, Inc., St. Paris, OH.

Electronic Control Unit ☆

440. Specification sheet (20-685) describes the Motionpac™ Controller, a single board, microprocessor-based unit to control bucket tilt, vibratory frequency, skid steer steering, mower reel speed, and more. Apitech, A Unit of Applied Power Inc., Butler, WI.

Odor Control for Compost Piles ☆

851. Literature describes the Windrow-Mate™ Odor Control System, an as-needed, air-operated chemical spray system, developed to control the odors associated with mechanical blending or turning of compost windrows and piles. NuTech Environmental Corp., Denver, CO.

Water & Wastewater Chemical Feed Equipment ☆

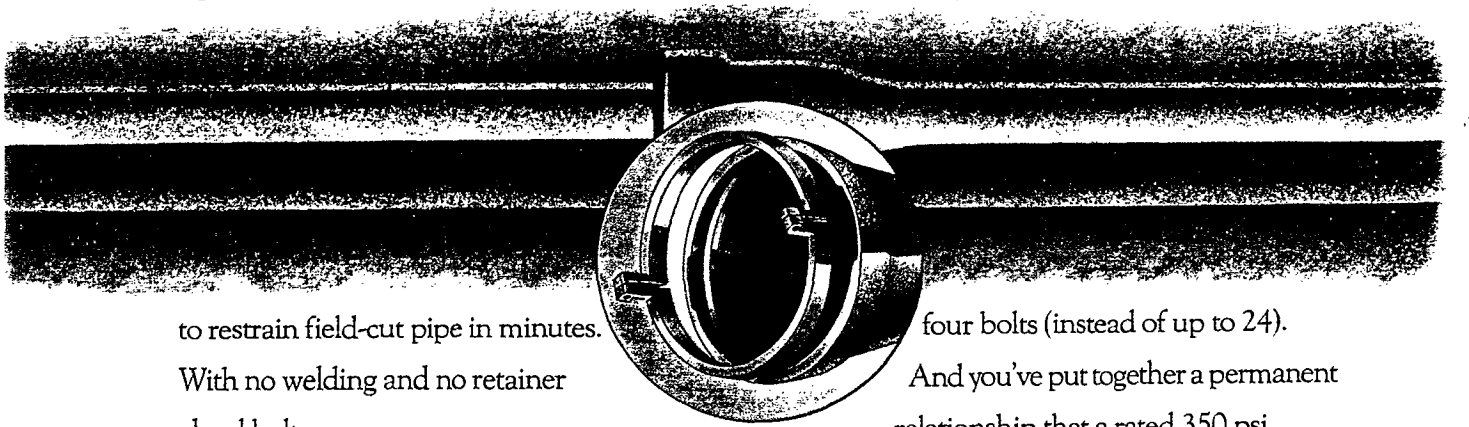
856. Product portfolio showcases the company's complete line: disinfection equipment, metering pumps, dry chemical feeders and systems for water and wastewater treatment applications, and flow measurement equipment. Wallace & Tiernan, Inc., Belleville, NJ.

Precision Surveying System ☆

750. Brochure describes the Geodetic Surveyor™ Series 4000 precision surveying system with advanced 6th Observable™ technology. It uses the GPSurvey software operating in the Windows™ environment. Trimble Navigation, Survey & Mapping Div., Sunnyvale, CA.

The TR FLEX GRIPPER® Ring works hand-in-hand with our TR FLEX® Pipe and Fittings the TR FLEX GRIPPER Ring, and then the field-cut spigot end. Now just tighten two to

ONCE YOU PUT ON THE RING, IT'S FOREVER.



to restrain field-cut pipe in minutes. four bolts (instead of up to 24).
With no welding and no retainer And you've put together a permanent
gland bolts. relationship that a rated 350 psi
It's a simple ritual: A TYTON® (for 4"-24"; 250 psi for 30" and 36") can
Gasket goes into the bell socket, then never put asunder.

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R0013692

Jean La Duc is careful about which herbicides she recommends for maintaining 4,000 acres of parks.

After all, she not only works in them...she plays in them.

"I write or assist in writing all recommendations for chemicals used by the City of San Jose Department of Recreation, Parks and Community Services. And I have no second thoughts about taking my son here to play.

"People entering our parks have to trust us and the type of product we pick. We select Roundup® because we appreciate its favorable environmental traits, the fact that it dries quickly and has no residual activity in the soil.

"As professionals, we want to leave the environment in a better condition than we found it. That's easy when you select the right material for the job."

Ask for your FREE brochure telling how Roundup combines ecology and economy.
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Roundup
Herbicide by Monsanto

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Salt/Sand Storage Lockers ☆

711. Product sheet details the new heavy-duty, 1000-lb capacity storage lockers, molded from industrial strength polyethylene and designed to safely store sand and salt year round. Go Plastics Inc., Waterloo, Ontario, Canada.

Storage for Standing Gas Cylinders ☆

855. Brochure features the Safe-T-Rack™ and Safe-T-Wall™ storage and containment systems for compressed gas cylinders. Safe-T-Rack Systems, Inc., Rocklin, CA.

Modernize Treatment Facilities ☆

622. Brochure (WWT-1.0) tells how this company's adjustable frequency AC drives and control systems can modernize fresh water pumping systems and wastewater treatment plants. Allen-Bradley Co., A Rockwell Int'l. Co., Milwaukee, WI.

Level the Load ☆

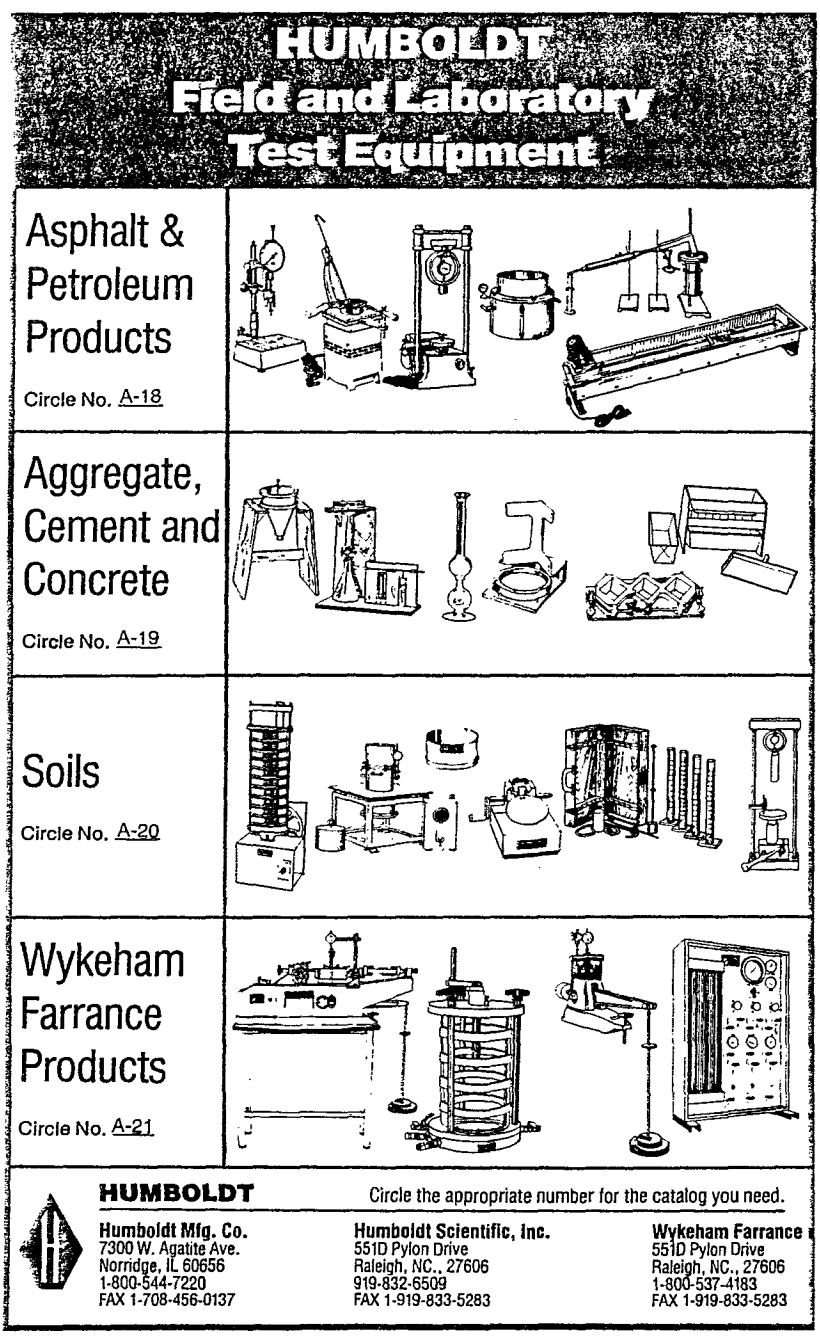
857. Brochure presents Add-On Air Springs to provide up to 5000 lb of load leveling support and improve ride, handling, stability, safety, steering, and comfort. Installed with no cutting or welding. Air Lift Co., Lansing, MI.

Erosion Control Mat ☆

858. New 8-page brochure discusses properties and performance of SuperGro® erosion control product, easily installed to provide quick vegetative establishment. Phillips Fibers Corp., Greenville, SC.

Water Analysis Products Reference Guide ☆

860. Catalog offers products for pH and electrode measurement, water testing, measuring dissolved oxygen, chemical testing, plus sections on technical applications, EPA methods, and technical literature. ATI Russell, Boston, MA.



SAFETY EQUIPMENT

Microprocessor-Based Gas Detector

153. Data sheet covers the OMNI-4000 gas detector that simultaneously detects up to four gases and is appropriate for use in confined spaces with diverse atmospheric hazards. It features interchangeable precalibrated toxic "smart block" sensors. Enmet Corp., Ann Arbor, MI.

Rear Vision Systems Promote Safety

370. New brochure (KG/6712/1-93) depicts rear vision system applications and presents the benefits and features of the TK-6712 camera, with 2.04 mm F/2.1 lens for panoramic view, and 6-in. monitor. KG Rear Vision, Arlington Heights, IL.

Tanks for Handling Hazardous Liquids

810. Brochure describes fully draining tanks that handle regulated and non-regulated chemicals. Available in 75- and 110-gal sizes. Poly Processing Co., Monroe, LA.

PAVEMENT REPAIR

Field & Laboratory Test Equipment

839. Catalogs offer testing equipment for asphalt and petroleum products, aggregate, cement and concrete, soils, and more. Humboldt Mfg. Co., Norridge, IL.

Rubber Grade Crossing Systems

942. Fold-out brochure promotes the advantages of Hi-Rail® interlocking tongue and groove pad rubber grade crossing systems for smooth grade crossing upgrades and water-tight design. Kraiburg® Corp., Chicago, IL.

Year-Round Patcher Versatility

185. Catalog introduces the UniBelt patcher with a 24-in. wide hot belt conveyor. It tackles pothole patching and utility cuts, and spreads salt, sand, or chippings. PB Loader Mfg. Co., Fresno, CA.

Road Marking Systems & Signage

854. Catalog offers extensive selection of regulatory signs, construction and warning signs, street name signs, hardware, etc. Super Precision Design, Inc., Fairfield, NJ.

SOLID WASTE COLLECTION & DISPOSAL

Rugged Truck Loaders

23. Literature describes this line of trailer-mounted and self-contained trailer dump model truck loaders with 3/4-in. impeller blades, 1/2-in. housing at wear point, and spring loaded boom. Giant-Vac Mfg., Inc., South Windham, CT.

Convert Waste Wood To Usable Products

485. The Series II "Tub Type Grinder" processes yard waste and leaves into mulch for landscaping or composting at a rate of over 15 tons per hour. The 12-ft diameter tub accepts 6-in. diameter limbs in any lengths, and up to 12-in. diameter limbs cut to 4-ft lengths. Fuel Harvesters Equpt., Grass Valley, CA.

Versatile Yard Waste Collector

522. Product bulletin (T/S-8/92) presents the TARCO® "Shuttle" Model TS-4 yard waste collector with front compartment for hand and bag loading, rear compartment for vacuum and brush chipper loading, and removable center panel for full capacity leaf collection. Tarrant Mfg. Co., Inc., Saratoga Springs, NY.

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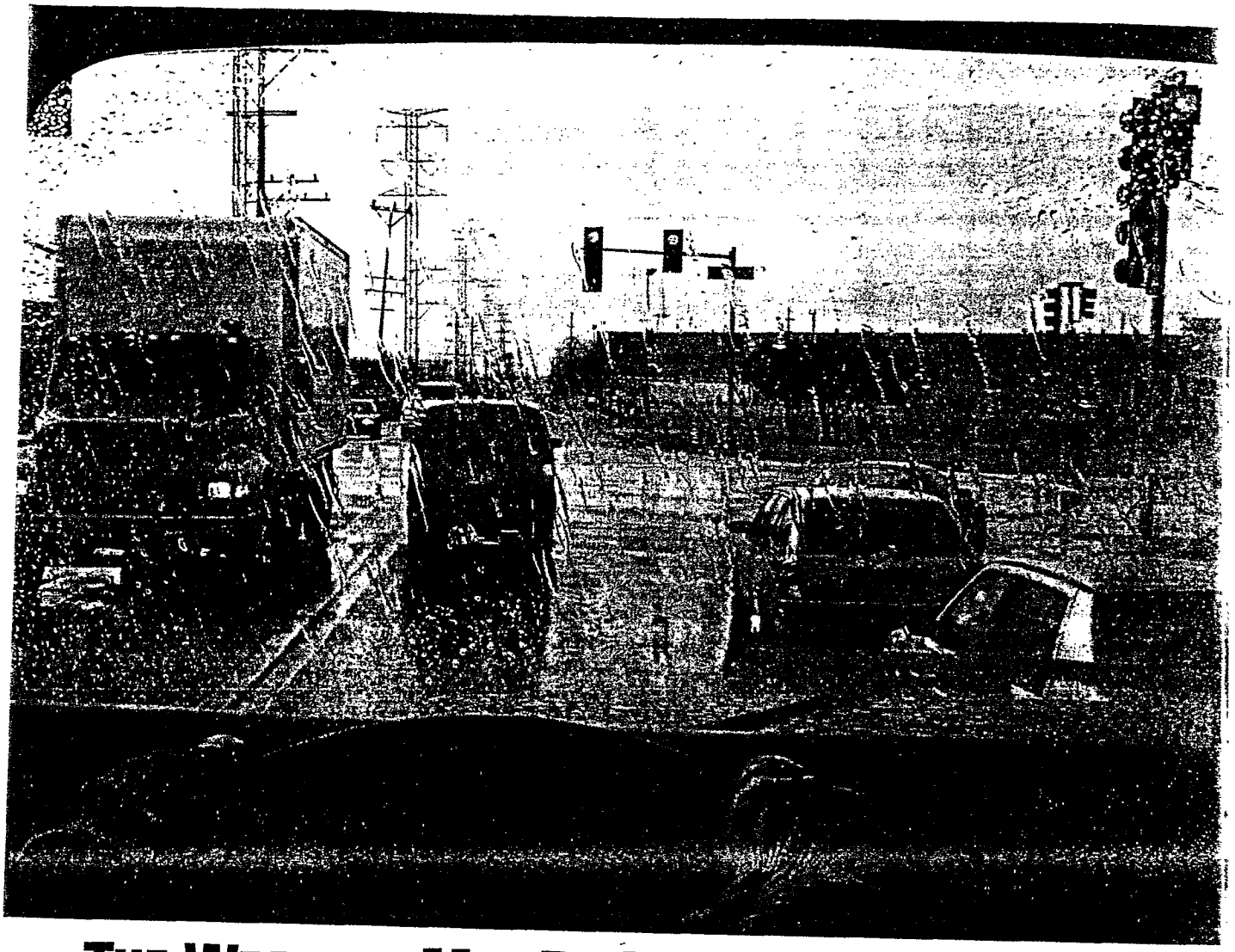

THE WEATHER MAY BE OUT OF YOUR CONTROL, BUT AN INTERNATIONAL TRUCK WON'T BE.

International® is the first to offer 4-wheel anti-lock brakes on all medium duty trucks. Which means superior control and stopping power in all kinds of weather.





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4-wheel ABS brakes are one more reason why International is the No. 1 selling line of medium and heavy duty trucks.

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Federal Compliance Guide

342. Free guide gives rules for hazardous material storage and brochure describes this company's lockers, buildings, drums, etc. for cost-effective storage. Haz-Mat Containment Corp., Inc., Walnut Creek, CA.

STREET SANITATION

Street Sweeping & Stormwater

369. Valuable "What You Should Know" brochure (P/N 0705186) promotes understanding of the new stormwater provisions of the Clean Water Act and how they may impact street sweeping practices. Helpful list provides contacts for area EPA offices. Elgin Sweeper Co., Elgin, IL.

CONSULTING SERVICES

Environmentally Sound Solutions

345. Literature covers the options this company offers for material-handling: composting, landspreading, bioremediation, or landfilling. BFI®, Industrial Waste Services™, Houston, TX.

Drinking Water Technologies For the '90s

758. Brochure provides an overview of this consultant's engineering expertise and experience in the development, treatment, and delivery of safe drinking water supplies. Camp Dresser & McKee Inc., Cambridge, MA.

Environmental Engineering Services

871. Company helps clients meet their operational, financial, and regulatory challenges. HNTB Corp., Indianapolis, IN.

Stormwater Management Services

36. Literature packet presents this firm's comprehensive stormwater services, including master planning, combined sewer overflow studies, separate stormwater system permitting, water quality monitoring/modeling, utilities management, facilities design, and public education. Camp Dresser & McKee Inc., Cambridge, MA.

Water & Wastewater Management Services

197. Brochure describes and illustrates this company's water and wastewater services, including: contract operation and maintenance of treatment plants, plant evaluations and start-ups, operations training, sewer collection and water distribution system maintenance, and operations and maintenance manuals. Professional Services Group, Inc., Houston, TX.

Consider Environmental Quality

676. Literature tells how this company can bring a balanced approach to solid waste, air, and water pollution problems. Wheelabrator Technologies Inc., Hampton, NH.

Public Works Services

340. This company offers a complete scope of public works services, from vehicle maintenance to sanitation to meter reading/billing, and more. OMI, Operations Management Int'l., Inc., Kingwood, TX.

COMPUTERS & SOFTWARE

Enhanced Software Upgrades CAD Productivity

902. Brochure (100553) tells how AutoCAD® Release 12 delivers enhanced command options, more easily accessed pull-down menus, new dialogue boxes, faster zoom and pan operations—174 new features and changes. Autodesk Inc., Sausalito, CA.

BRIDGES

Pre-Engineered Modular Bridge System

373. Brochure describes the Mabey Universal Panel Bridge system with clear spans to 318 ft for one, two, or three lanes of AASHTO traffic loading. Mabey Bridge, Inc., Baltimore, MD.

ROADSIDE & PARK MAINTENANCE

Herbicide Combines Ecology & Economy

812. Brochure presents Roundup® herbicide, appropriate for use in municipal park areas because it dries quickly and has no residual activity in the soil. Monsanto Co., St. Louis, MO.

Mowing & Brush Cutting Equipment

846. Brochure (Form No. FL-1291-LG) covers flail, rotary, and sickle bar mowers, both mechanical and hydraulic. Numerous in-use photos demonstrate applications. The Alamo Group, Seguin, TX.

Disc Chippers for Brush & Tree Cleanup

815. Literature lists feature for the complete line of disc style, hydraulic feed system chippers for both brush and whole trees. Bandit Industries, Inc., Remus, MI.

Pruning Tool for Safe Tree Trimming

869. Specification package highlights the lightweight Model D Power Pruner, powered by a 24cc, two-cycle gasoline engine. Technic Tool Corp., Lewiston, ID.

Not All Water And Wastewater Tanks Are The Same. The Columbian Difference Is...

COLUMBIAN COATING All interior and exterior components are coated in the factory creating a durable surface which fights corrosion. Our internal coating, "Trico-Bond 478" is completely covered with 2 coats of epoxy. For extra corrosion resistance we use "Z Bond 493" which is Columbian's exclusive coating for exteriors rich in zinc-based primer followed by 2 layers of thermally-cured epoxy, and a final layer of urethane which is electrostatically-applied.

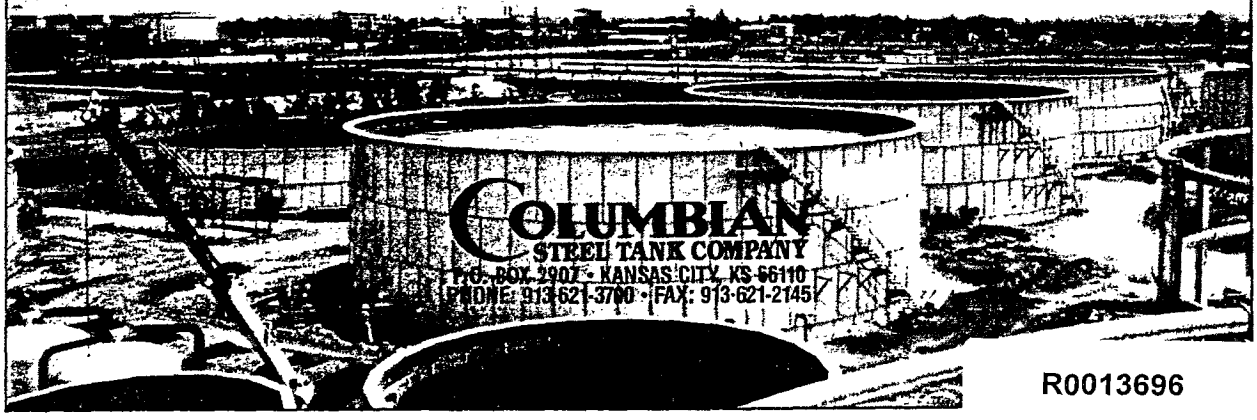
COLUMBIAN DURABILITY Coatings are carefully applied on exteriors and interiors for complete coating to assure the longevity of the tank. Columbian tanks don't leak. GUARANTEED.

COLUMBIAN SAVINGS All tank components are shipped unassembled in compact kits, allowing economical shipping to any part of the world. You do not need skilled welders. Storage and handling are easy.

COLUMBIAN VERSATILITY Columbian tanks are easy to repair, enlarge or move, because they are made of pre-engineered components which are precision-designed, fabricated and packaged for shipment.

COLUMBIAN EXPERIENCE Since 1918 Columbian has served the liquid storage needs of thousands of clients. Columbian is the intelligent alternative over welded tanks because they last longer and are less expensive.

WHAT A DIFFERENCE! Call or write for FREE INFORMATION.



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This CDM stormwater team really applied itself for Tulsa, Oklahoma.



CDM project engineers prepared an NPDES Part 1 permit application for the city of Tulsa that was one of the first in the region to earn approval. Backed by technical and regulatory expertise, CDM worked closely with the city and the regulatory agency throughout the project to meet all NPDES requirements. Using our own software, CDM developed a state-of-the-art database and computerized map of the city's stormwater system, contributing to a comprehensive—and comprehensible—document. This permit application added to Tulsa's reputation as a leader in stormwater management. And to ours. When it comes to stormwater management, CDM gets it done.

For more information on CDM's stormwater management services nationwide, call 904 281-0170.

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Stormwater Management: CDM Gets it Done.

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R0013697

WINTER MAINTENANCE

Storing Salt In-The-Round

906. Fold-out brochure explains the benefits of storing salt in spherically designed domes. Domes are designed with a 12 in. thick concrete retaining wall and a base wall from 6 to 12 ft high. A capacity chart relates tonnage to size. Bulk Storage Inc., Crete, IL.

LIQUID CONTAINMENT

Tank Design & Construction Process Summarized

496. Literature package (690) highlights wire wound prestressed concrete tanks for water storage, wastewater treatment, etc. Schematic drawings and photos explain each phase of the construction process. Preload Inc., Garden City, NY.

Creative Water Storage Solutions

693. Literature tells how this company helps solve specific water storage needs with prestressed concrete tanks. DYK Prestressed Tanks, El Cajon, CA.

Replace Conventional Septic Leachfields

754. Literature presents Infiltrator™ chambers for septic leachfields. The lightweight units require no gravel and are easily installed and inspected. Infiltrator Systems, Inc., Old Saybrook, CT.

How to Calculate Tank Painting Costs

993. This simple chart allows the user to calculate painting costs of steel tanks and how those costs are affected by rates of inflation. The chart is available from Natgun Corp., Wakefield, MA.

PIPELINE MAINTENANCE

Combination Cleaning/ Vacuuming Machines

80. New brochure shows the complete range of B-Series combo/vac units for municipal use, including the B3 (3.5 cu yd) and the B20 (20 cu yd). Aquatech, Inc., Cleveland, OH.

Underground Utility Locating

325. Brochure details the Vac-N-Dig system, a diesel-powered air compressor and a high powered vacuum that uses a jet of compressed air to break up dirt and the vacuum to remove the loosened material. The air stream uncovers buried utilities without damage. VACMASTERS of Denver, Inc., Arvada, CO.

A Pipe Replacement Breakthrough

434. Literature gives specifications, physical properties, and requirements for the XPANDIT® trenchless pipe replacement system, capable of upsizing. The installation process is quiet, non-destructive, and eliminates impact shock damage to adjacent utilities. Miller Pipeline Corp., Products & Services Div., Indianapolis, IN.

Combination Jetting/ Vacuum Truck

680. Product sheet describes the Vactor®2103 mid-size combination jetting and vacuum truck for heavy-duty cleaning of sewers and catch basins, providing 0 to 35 gpm and pressures from 0 to 3000 psi. Peabody Myers, Streator, IL.

Engineering Design Guide For Trenchless Pipeline Systems

59. New guide contains information and design data to assist engineers in using cured-in-place technology for trenchless pipeline reconstruction in specific design situations. It includes formulas and values based on tests and extensive field experience. Insituform Technologies, Inc., Memphis, TN.

Correct Inflow/ Infiltration Problems

37. No-dig technology uses a flooding system without liners, socks, or pipe inserts that may reduce flow. Sanipor North America, Cornelius, NC.

Speed Up Pipe & Cable Locations

759. The RD 333 Sonde Trace System saves time locating and tracing metallic and non-metallic drains and sewer systems and can be used with horizontal boring machines or pigs. Radiodetection Corp., Mahwah, NJ.

PIPE, VALVES & FITTINGS

Full Line of Valves for Public Works Applications

453. Company manufactures pressure reducing, altitude, relief, surge control, back pressure sustaining, pump control, and hydraulic valves and strainers for water and wastewater applications. Ross Valve Mfg. Co., Inc., Troy, NY.

Ductile Iron Pipe For Municipalities

684. Ductile iron pipe provides strength, corrosion resistance, and conservative design (ANSI/AWWA C150/A21.50). For complete information, contact American Ductile Iron Pipe, A Div. of American Cast Iron Pipe Co., Birmingham, AL.

New Ideas in Ductile Pipe & Fittings

715. The TR FLEX® Restrained Joint System delivers positive joint restraint with no bolts, rods, clamps, or thrust blocks. In unstable soil, use the TR Teleflex™ Flexible Expansion Assembly. For information on how the components of this system fit together, contact U.S. Pipe & Foundry Co., Birmingham, AL.

UNIBELT MAKES PATCHING A HOLE LOT EASIER

When it comes to pothole patching, Unibelt is the solution. Easy to operate and maintain, fully equipped so you can tackle patching jobs with just one machine. Unibelt features a belt conveyor that moves asphalt out of the container as you need it for continuous operation—it won't clog like auger patchers do. Plus, Unibelt is better insulated than other patchers, so asphalt stays hot, all day and night, even during winter months. Its radiant heater and adjustable thermostat range of



100° to 300° keeps hot asphalt hot and heats cold mix. Insulated container doors guard against heat loss and keep asphalt protected and useable. The LPG heat tube system eliminates hot oil leaks, potential fires and uses one third the BTU's required with hot oil systems—so you save operating costs. Take a serious look at the Unibelt Patcher... available in truck mounted, dump body slip-in and trailer models. It's easy, just call 800-350-8521, we'll cover the details.

PB LOADER
CORPORATION

3275 E. Central P.O. Box 341 Fresno, CA 93708 800-350-8521 FAX 209-268-0734

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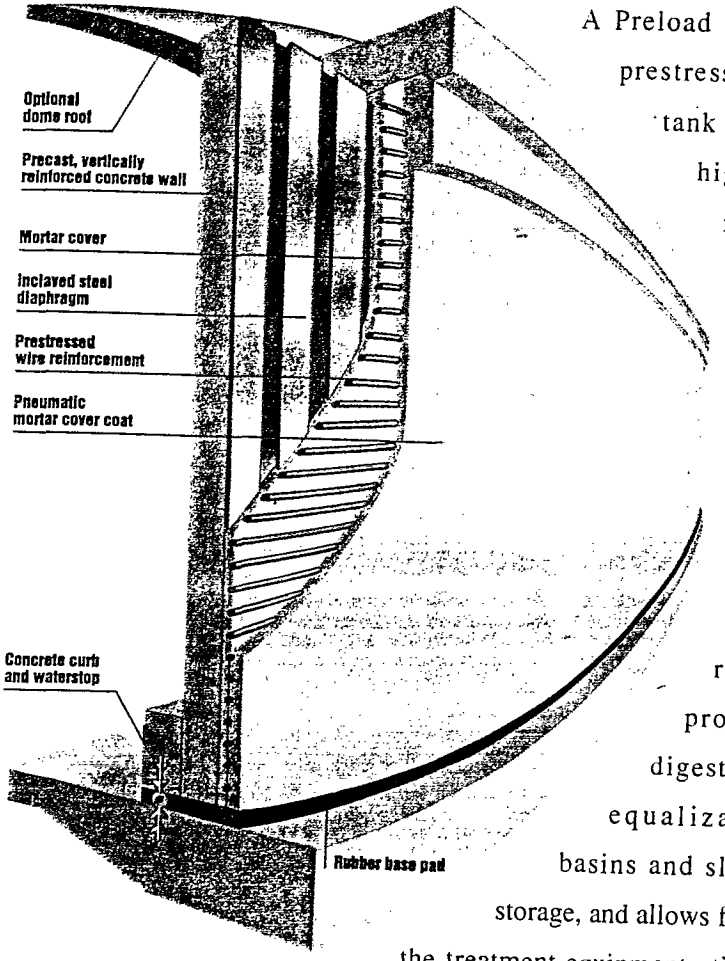
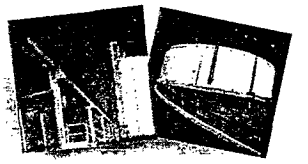
WRAP UP YOUR WASTEWATER STORAGE





A Preload wire wound, prestressed concrete tank gives you the highest quality, most versatile solution for wastewater treatment storage. ■ The precast wall, with inclaved steel diaphragm, is *wrapped* in layers of high-strength wire and shotcrete covercoat, providing virtually maintenance-free service. ■ Whether covered or open-top, above ground or buried, our tanks can satisfy any function or site requirement. The versatile design is proven to be superior for anaerobic digesters, aeration tanks, clarifiers, flow equalization basins and sludge storage, and allows for all the treatment equipment utilized within. ■ Call for more information on Preload's 60 years of design and construction experience in storage technology: **800-645-3195** (in New York 516-222-0550), Dallas, Texas Office: 214-385-0550. Preload Inc., 839 Stewart Avenue, Garden City, New York 11530.



PRELOAD

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R0013699

WATER TREATMENT

Filter Sand & Gravel

107. All-color literature includes the company history along with specifications for supplying materials for all water filtering needs. Northern Gravel Co., Muscatine, IA.

The Bicarbonate Method For Corrosion Control

690. Literature explains how raising pH and alkalinity can virtually eliminate corrosivity of surface water, lowering lead levels in drinking water. Church & Dwight Co., Inc., Chemicals Div., Princeton, NJ.

WASTEWATER TREATMENT

Sludge Recycling & Land Application

649. Informative brochure on treated sludge supplies answers to questions on nutrient value, advantages and disadvantages, regulation, application, odor, etc., with helpful charts. Bio Gro Systems, Inc., Annapolis, MD.

68-Page Used Equipment Catalog

783. This company buys and sells centrifuges and filters of all manufacturers. Aaron Equpt. Co., Bensenville, IL.

Aluminum Pipe Railings & Ladders

823. Literature describes this company's ready-to-install, quality engineered aluminum pipe railings and ladders, available in specification finishes. Sterling Factories, Inc., Erie, PA.

Chlorination/Dechlorination Systems

612. The Sanuril® Chlorinator is a complete, one-piece system to treat wastewater from any sewage treatment plant without requiring controls, power pumps, instruments, or additional equipment by using Sanuril 115 chemical tablets. D-Chlor™ System dechlorinates wastewater using similar controlled release tablets. EES Corp., an ELTECH Systems Co., Sugar Land, TX.

VEHICLES & ACCESSORIES

Good-Looking Line of Work-Hungry Trucks

425. Brochure details the full line of International® trucks—the 4000, 4000LP, and 7000 Series medium trucks, the 2000 and 5000 Series sever service trucks, plus the network of supportive parts distribution centers. Navistar Int'l. Transportation Corp., Chicago, IL.

CONSTRUCTION & MAINTENANCE EQUIPMENT

Multi-Purpose Maintenance Machine

299. Literature features the versatile Model 1200 (116 hp) and Model 300 (177 hp). Attachments include: compost auger, grapple fork, bucket, broom, angle dozer, snow blower, and more. Brown Bear Corp., Corning, IA.

Analyze Equipment Costs

643. Booklet explains how "life cycle costing" helps determine the true cost of equipment, taking into account operating, maintenance, and repair costs. Caterpillar Inc., Peoria, IL.

Backhoe, Grader, & Loader Attachments

576. Product literature packet covers fork lift attachments, asphalt cutters, backhoe mounted air hammer, bucket mounted ripper, sheepsfoot compactor, quick-attach sweeper, loader-mounted snow plows, and more. Guest Industries, Inc., Torrington, CT.

Equipment Financing Options

852. Literature (DKD1357, DKE5362) presents alternative financing programs for public agencies interested in construction equipment—short-term rental contracts, annual renewable governmental lease, municipal lease-purchase, the Life Cycle Bid, and the BEST BID™ program. John Deere, Moline, IL.

CONSTRUCTION & MAINTENANCE MATERIALS

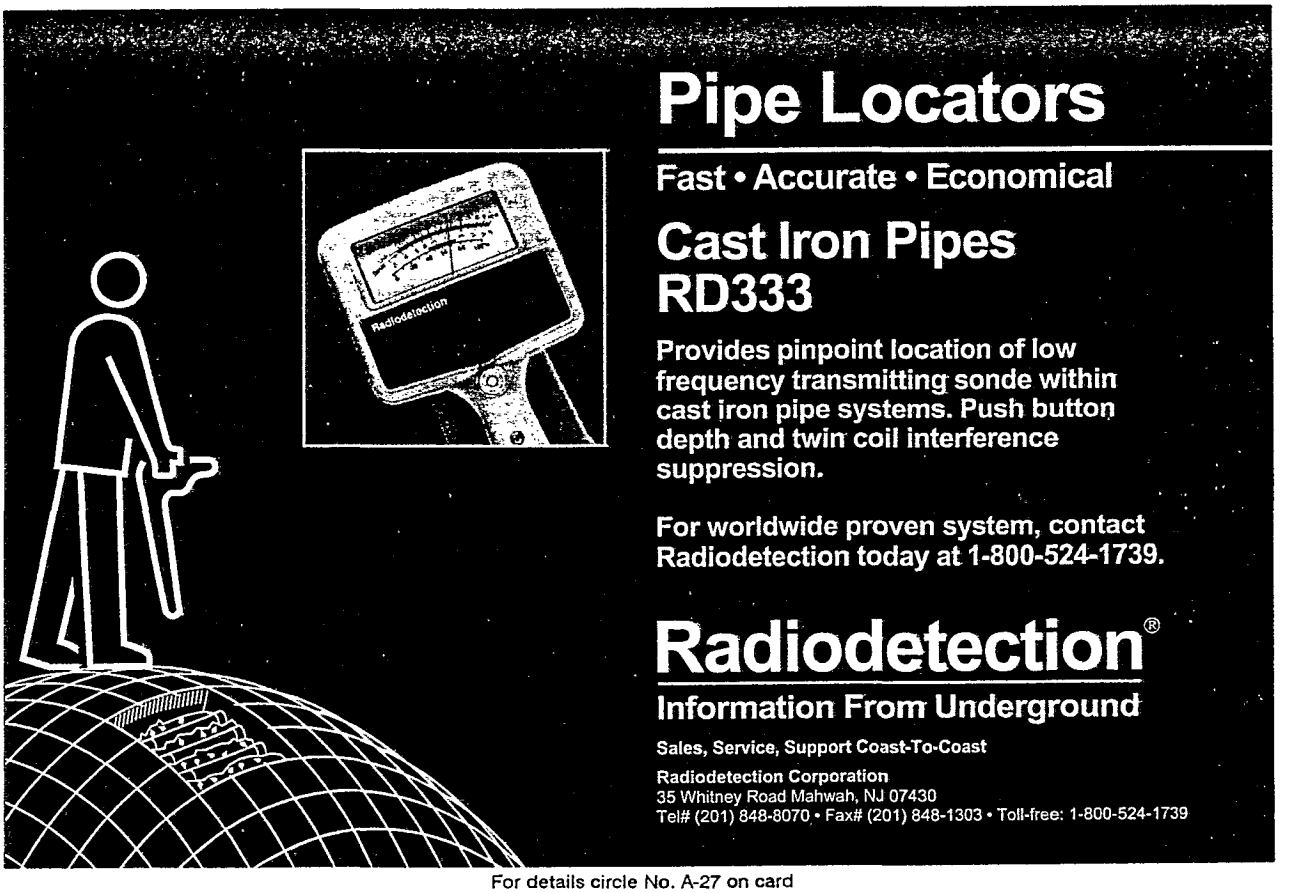
How to Use Cement, Grout, & Mortar

798. Product reference guide covers RapidSet® cement, grout, mortar, and concrete. An easy-to-read chart gives technical data on compressive strength, flexural strength, and bond strength for each product. CTS Cement Mfg. Co., El Toro, CA.

SOIL STABILIZATION & EROSION CONTROL

Geotextiles for Drainage And Stabilization

85. Brochure (TRV-2000) covers HBC 100 percent polyester needlepunched nonwoven geotextiles, which can reduce soil migration and mixing, reduce localized shear failure, provide high permeability and permittivity, and reduce unwanted soil piping. Contech Construction Products Inc., Middletown, OH.



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R0013701

RETIRE BEFORE THE PIPE YOU SPECIFY DOES.

Pipe that takes early retirement could force you to do the same. That's why our attention to quality borders on the obsessive. Each length of American Ductile Iron® Pipe is hydrostatically tested and consistently exceeds AWWA standards. Each pipe is designed to have a high tolerance for stress so you don't have to. Water hammer, expansive soil and construction abuses are simply no match for ductile iron. So specify pipe that's going to be around a long time. From a company that's been around for nearly a century.

AMERICAN DUCTILE IRON PIPE

A Division of American Cast Iron Pipe Company

P.O. Box 2727, Birmingham, AL 35202, 205-325-7813, FAX 205-325-8047.

District Sales Offices in Atlanta, Birmingham, Chicago, Dallas, Kansas City, Minneapolis, New York, Orlando, Pittsburgh, and Sacramento. Depot stock locations in Birmingham, Dallas, Kansas City, Minneapolis, and Pompano Beach.

NSF

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the solid waste forum

Prepared by
Abraham Michaels, P.E.
Consulting Engineer

Recycling

It isn't often that a FORUM discussion subject is repeated two months in a row, but recycling is such a popular issue these days, a repeat seems in order. Last month we described Germany's plan to use "disassembly plants" to permit auto manufacturers to recycle car parts, i.e. old fenders melted down and used to produce new fenders, a procedure that is described as a "circulatory economy." The September 1992 *National Geographic* contains a discussion on the subject in the "Earth Almanac" section. As noted, about 75 percent of the total weight of automobiles is metal that has been "...recycled for decades," and the remaining 25 percent, called "fluff" ends up in landfills. Plastics are expected to constitute half of the fluff soon, and the industry is attempting to reduce the types of plastics used to simplify the task of recycling. According to the *National Geographic* article, there is "A crucial goal: finding markets for the coded plastic parts. 'This will complete the recycling loop,' says William Steinkuller of the Automotive Dismantlers & Recycling Association."

We recently received a news release from R. Frazier, Inc., of Salem, Virginia, which describes a recycling operation that appears to fit the "circulatory economy" definition. The release reports: "During 1992, R. Frazier processed 30 million pounds of electronic scrap and returned millions to clients such as IBM, AT&T, State Farm Insurance, General Electric, and BellSouth."

It is not clear whether the millions returned are dollars or pounds, but the release claims: "R. Frazier's recycling capabilities are 97 percent revitalization of assets, with less than 3 percent being diverted to landfills. R. Frazier's goal is 100 percent. To accomplish this, the company is participating in future equipment designs that will facilitate the total recyclability of newly manufactured equipment."

The release reports on a recent Carnegie-Mellon University study which predicts that 150 million used computers will have been discarded by the year 2005. "If measured, these old computers would fill a one-acre hole 3.5 miles deep with plastics, metals, and leaking batteries. Furthermore, it's a disturbing fact that old mainframe computers are being discarded at the rate of 10 million a year."

Randy Frazier approaches the recycling of computers by engaging in a "partnership" with the business that discards computers and either resells the discards to third world countries or dismantles the discards for reuse or recycling. Most of the components are expected to have many years of useful life left at the time of the initial discard.

"Frazier has developed world-wide markets for marketing the materials. Frazier's European market center opened in Dumfries, Scotland in April, a mirror-image of its Roanoke Valley operation. There is also a branch in China, a branch in Mexico, and two new locations planned for 1993."

Although the rapid growth of the computer industry may be an important factor in the apparent recyclability of computers, the aggressive pursuit of new markets for old equipment by recyclers like R. Frazier, Inc., may keep them out of the waste stream.

As for waste from more mundane sources, over a year ago an article about the New York City recycling program entitled "Recycling Minus the Myths" by John Schall of the Tellus Institute appeared in the *New York Times*. The article discussed the city's proposed solid waste management plan and addressed the issues of recycling cost, public participation, marketing of recyclables, and its "competition" with incineration. According to Mr. Schall, although costly, the proposed New York plan is cost-effective, and a uniform, properly designed recycling collection program coupled with a public education campaign and volunteer recycling coordinators should result in 65 to 80 percent public participation.

As for markets for recyclables: "Recycling makes economic and environmental sense. A study released in June by the Tellus Institute, a nonprofit research organization in Boston, reports that most industries have found using recycled materials technologically feasible, and that this has reduced toxic pollutant, green-house gases, and ozone-depleting emissions. According to the American Paper Institute, paper mills using recycled materials were five times more profitable last year than those using virgin fiber."

Regarding incineration, John Schall optimistically estimates that 50 percent to 65 percent of New York's municipal and commercial MSW would be recycled, which still would leave 9,800 to 14,000 tpd of MSW available for disposal. Recognizing the limited landfill space available in the metropolitan area, incineration, particularly if used for energy generation, would still make economic and environmental sense.

How successful New York City has been in implementing its new solid waste plan was briefly described in the August 1993 PUBLIC WORKS Magazine. The issue pictures Sanitation Commissioner Emily Lloyd on the cover standing next to a two compartment recycling collection truck, two curbside recycling storage containers, a blue bag, and two packages of wrapped paper. The "About Our Cover" write-up describes the status of the plan as follows: "The plan calls for city-wide recycling by September 1993, which will serve approximately 3 million households in 59 districts. In June, 13 community board districts in Brooklyn joined the recycling program and in September recycling will start borough-wide in Queens. By 1995, curbside collection will be expanded from eight to 26 materials. Over the past year, curbside collection of recyclable materials has increased by 37 percent city-wide and the overall percentage of material recycled has risen by 40 percent."

The write-up states that the recycling program is on schedule and by the year 2000, the city expects to recycle 42 percent of its MSW.

We received a copy of a report entitled "Integrated Environmental and Economic Policy Necessary in Argentina and Brazil" prepared by Frank J. Sudol, Manager, Division of Engineering, Newark, New Jersey, which was prepared for the U.S. Information Services. As the title indicates, Mr. Sudol, who actually visited nine cities in Argentina and Brazil to obtain first hand information, studied the impact of the economies of the two countries on the environment, including solid waste management. His findings revealed that, although disposal practices were well below standards experienced in this country due primarily to the poor state of their economies, in the two countries studied, recycling was an important practice in all of the cities visited. As reported:

"Poverty is driving the poor to pick through trash to recover marketable recyclables. These individuals, called

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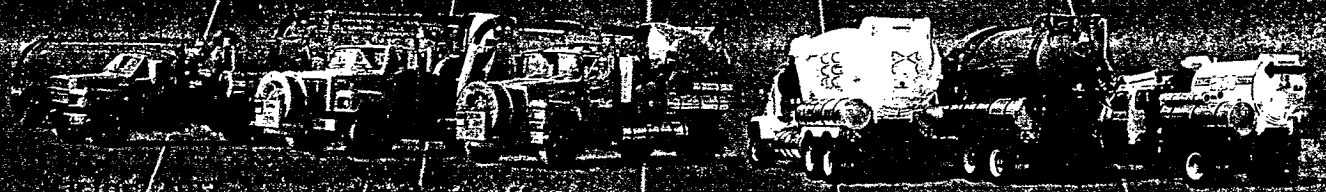

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"catadores," recover materials such as metal, paper, and cardboard. The materials are collected in large wagons that are manually pushed and/or pulled. The materials are brought to market in exchange for cruzeiros (at the time this article was written, $1.00 U.S. was equivalent to approximately 40,000 cruzeiros), though this changes daily because of the high rate of inflation."

Frank Sudol reported that catadores also pick recyclables at the dump, and: "City officials in Porto Alegre have effectively organized many of the pickers by providing them with a level work-site near the landfill to sort though selectively collected trash, rather than allowing the catadores to pick at the active landfill dump area. This minimizes, to some extent, the risk of exposure to equipment which otherwise might injure or kill the pickers. This strategy also minimizes injury in climbing over mountains of trash, which in the past was responsible for causing numerous injuries due to tripping and infectious cuts from sharp objects."

Regular FORUM readers may recall reading of similar recycling descriptions in earlier columns. For the benefit of those of you who are new to solid waste management, scavenging at landfills (dumps) and from curb set-outs was fairly common practice in this country as recently as the 1960s. It wouldn't surprise me to learn that there are still signs up in some of our landfills warning that "Dump picking is prohibited."

Mr. Sudol advises that he discussed the value of landfill methane with some of the municipal officials he visited, and apparently they were unaware of this potential. This is surprising since over five years ago I reported in the FORUM that the COMLURB people in Rio De Janeiro took me to see the methane gas extraction and treatment facility at their Caju landfill. They then brought in a couple of trucks that were powered by the treated methane, filled their tanks, and sent them on their way.

The gas experience notwithstanding, Frank Sudol's assertion that the state of the economy has a significant impact on the environment generally and solid waste management particularly is valid in Latin America as well as North America. I wonder what the economic and environmental impacts would be if mixed recyclables from North America would be shipped to Latin America for sorting and reuse?

Finally, FORUM participant George Bergtholdt sent me an article from the January 12, 1993 *Wall Street Journal* headlined: "A New Market for Paper Shredders May Be Opening Up In Switzerland." The article discusses a new Zurich city ordinance that requires residents to sort their MSW for separated collection or pay higher collection fees. The program is described in the following:

"Now, homemakers here will have to put garbage in 'designer' bags marketed by the city, in sizes easily identified by abstract patterns in pink, yellow, blue, or red. Inspectors will track down people who don't use the spiffy new sacks and hit them with fines."

The article describes the "search and seizure" method used by the city, and the mixed public reaction to the new rule. What the Swiss are doing is not unlike some curbside separation techniques currently in use in this country. We learned one reaction to the extensive curbside separation set-outs from the comic strip Shoe several months ago, now let's hear what you readers think.

Incinerator Residue

Over a year ago, April 1992, we told you of the ASME/U.S. Bureau of Mines Investigative Program on Vitrification of Combustion Ash/Residue, and, thanks again to Herb Hollander who keeps us up to date on the status of this important program, we are pleased to tell you that a findings report of the project has been prepared and distributed to a select number of knowledgeable professionals for peer review. "The final results will not be made public until the peer review comments have been assimilated...and the



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report reviewed and finally approved by ASME, BuMines, NYSERDA, and EPRI."

The importance of further reducing the quantity of waste that ultimately is landfilled by converting residue to a useful product is indicated by the wide interest in the project described in Herb's letter: "This collaborative program provided the opportunity for modest contributions from many leveraged into a substantial investigative program which eventually included $1 million in funds and $250,000 in voluntary services."

Herb included a status report of the project which lists 15 government agencies and professional associations and 22 corporate sponsors from the U.S., Canada, France, and Norway. The report, which was prepared by Hollander, Plumley, and DeCesare, describes areas of study in the report abstract as follows: "This discussion covers some of the concerns which have prompted vitrification, the environmental implications, derived products, their potential uses, and the scope and expectations of the recently completed furnace operations of the $1.2 million ASME/BuMines Investigative Program conceived to demonstrate the effective vitrification of combustion residues from several diverse sources."

Of interest to readers is the environmental findings reported which reveal that the vitrified residue tested well below the EP-Tox standards for all metals. Even the cadmium, which in the ash residue condition tested above the EP-Tox limit, was well below in the Vitreous and Metal Products conditions.

The Hollander, et al, report concludes with the following note: "The objectives of this investigative program were to demonstrate on a commercial scale the technical, operational, and environmental feasibility of utilizing electrotechnology to consecutively vitrify combustor ash/residues from multiple sources to produce new, dense, benign materials having potential uses...in lieu of burial and potential future liability."

All indications from the Hollander letter and report are that the test process used to convert incinerator residue by vitrification to a useful product is successful. The reference in the final note that the demonstration is "...on a commercial scale..." alerts one to the need to introduce the cost factor into the project. Although cost, other than the program cost, is not mentioned in the interim report or letter, Herb advises that: "There are some 23 vitrification facilities of one type or another in operation or under construction in Japan. With their very limited land resources they have an urgent need for volume reduction and beneficial use."

He also notes that there is a vitrification facility in the U.S. that processes sewage sludge to vitrified ash and "...there are several industrial and hazardous waste facilities, and coal burning power plants that do."

Herb Hollander, his associates, and the ASME should be congratulated for having shepherded this important project from conception to the present state of near successful conclusion. This gives us the opportunity to remind you that the ASME Solid Waste Processing Division is again seeking graduate and undergraduate candidates for their annual scholarship awards. The 1994 awards consist of three awards for graduate study totaling $9,000 and two awards for undergraduates totalling $5,000. If you are or know someone who may be interested in learning more about these scholarships, contact Junius Stephenson, P.E., 38 Sunset Road, Demarest, NJ 07627, or call (201) 767-1998.

We offer the rest of you the opportunity to participate in the educational experience which is the "Solid Waste Forum." The FORUM is yours to use to seek advise to help solve your problems or tell others of ideas or experiences you have had which may help them to solve their solid waste management problems. All you have to do is tell us about it by writing to me c/o PUBLIC WORKS Magazine or to Abraham Michaels, P.E., 872 Main Street, Osterville, MA 02655. If you want to talk about it, the telephone number is (508) 428-9282.

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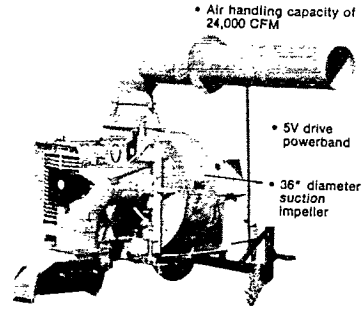

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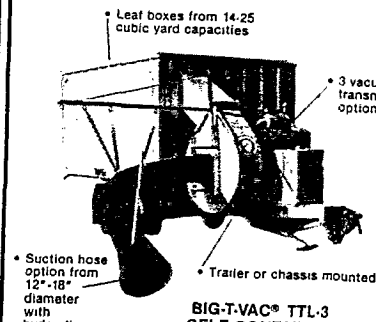

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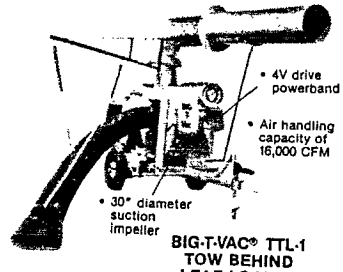

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The How-To of Stormwater Sampling—Not Just a Drop in the Bucket

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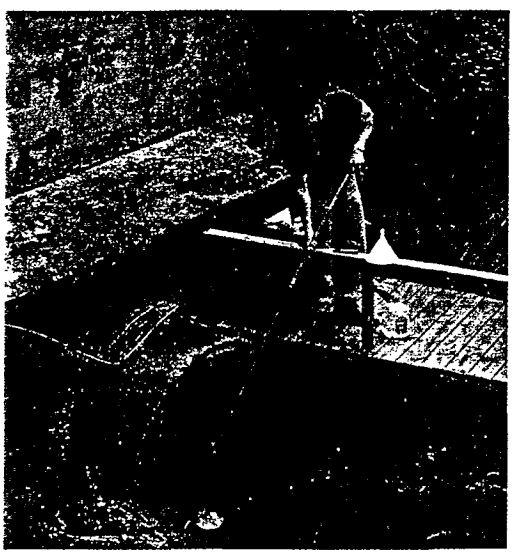
Winston-Salem, North Carolina

STORMWATER SAMPLING is probably one of the more interesting aspects of the relatively new pollution regulations. Whether that aspect remains interesting or becomes a frantic and frustrating experience depends a lot on how the sampling program is conducted.

The promulgation of EPA's National Pollutant Discharge Elimination System (NPDES) stormwater quality regulations triggered collecting stormwater samples nationwide. That explains the "why." The practical aspect—the necessity for hands-on work—requires the "how to" knowledge. Catching storms is like winning football games—it takes the proper equipment, a good playing field, a committed team, and a lot of luck. Even with everything in the right place at the right time, a "representative storm" may not occur. When the storm does happen, equipment preparation, personnel readiness, sampling techniques during the storm event, safety precautions, and sample handling and preservation are the prerequisites for a winning team. The sampling program conducted for the city of Winston-Salem, North Carolina, illustrates one possible "winning" strategy.

■ **SAMPLING platforms were built to be safe, accessible, and comfortable.**



Before deciding on specific details of the Winston-Salem sampling program, there were certain items to be addressed. The preferred sampling technique, personnel availability, and laboratory flexibility were all interdependent topics necessary to determine the sampling program's general direction. A "kickoff" meeting involving city officials and HDR representatives finalized the initial sampling program strategy. Flexibility to fine tune and refine the sampling work was recognized as a key to project success.

Sampling Technique. North Carolina regulations require that a grab sample be taken within the first 30 minutes of runoff for a representative storm event. In addition, the state allows time-based composite sample collection during the first 3 hours of runoff in lieu of flow-based composites. This composite sample could be collected by an automatic sampler; however, since volatile pollutants were parameters in the grab sample, these had to be collected manually and sealed immediately. Choosing either all manual or a combination of manual and automatic was an economic decision. Could it be cost-effective to leave sampling crews on site for an additional three hours to complete sampling and thereby avoid acquiring automatic samplers? The availability of sampling personnel and necessary laboratory services determined the answer.

Personnel Availability. A search began to find qualified personnel who would be available and willing to spend the summer "chasing" storms. Using city employees was investigated first and sign-up sheets were passed through the inspections and surveying departments. These were groups typically made up of engineering technicians whose normal duties were interrupted during rain events anyway. The response was excellent and arrangements were made to make the city staff volunteers available for sampling duty. The city agreed to excuse them from normal duties when necessary and the field crews would work under the direction of the consultant's on-site coordinators. Having the personnel available left open the first option, all manual collection.

Laboratory Flexibility. Due to the short holding time of the bacteriological pollutants, part of the grab sample had to be analyzed almost immediately. A nearby accredited laboratory was found that was willing to perform analysis at any time of the day with a 24-hour notice before the sampling event. This allowed the flexibility to collect a sample at any time.

Outline of the Program. In this instance, the first option, all manual collection, became the clear choice. Combining city personnel and an accredited laboratory allowed the Winston-Salem sampling program to be full-time and ongoing, capable of collecting samples at any site. Project costs would be minimized by using city staff and direct contract arrangements.

Like the Scouts—Being Prepared

Seven sampling locations across the city were chosen during part I of the permit application and approved by the state. The state prepared a list of pollutants to test for and also designated the limits of what would be considered a "representative storm event" for North Carolina. With the ground rules confirmed, preparation for sample collection began.

Equipment. To document specific storm events, semi-permanent recording rain gauges were placed at five of the sites and precipitation at all seven sites was calculated using the Thiessen Polygon Method. (This is a graphical technique to account for nonuniform distribution of recording stations within the drainage basin as each gauge is assumed to only measure the precipitation in the area around it.) Flow meters were installed in the discharge pipes at each site and then programmed and calibrated using a laptop computer. These rain gauges and flow meters were kept in continuous operation and routinely maintained; rain gauge data sheets had to be changed weekly and flow meter batteries had to be replaced every three to four weeks.

To facilitate sample collection at the seven sites, custom fabricated plywood boxes were constructed and outfitted with locks. Each box contained a plastic storage container (purchased at a local department store) for storing sample bottles and other useful items. These "utility packs" included:

Umbrella
480-ml plastic beaker
Flashlight
Funnel
Stopwatch/Clock
Gloves
Clipboard with laminated log sheet and grease pen
Collection bucket with handle
Telescoping pole with hook (paint roller handle assembly minus the roller)

Styrofoam blocks were cut out of packing materials and holes were drilled into them to match the diameter of the smaller

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sampling containers (those used for volatile organic chemicals [VOCs] and fecal coliform/fecal streptococcus [bacteriological] samples). This kept the smaller glass vials from sliding around and getting broken.

Sampling Stations. Before sampling started, some work had to be done to the sampling sites to make them safe, accessible, and somewhat comfortable (three hours of sitting in the pouring rain is bad enough). Each site was visited, pictures were taken, and sketches were developed by the consultant for building platforms, steps with landings, handrails, and even temporary gravel paths and roads. The sketches were forwarded to a city construction foreman and building materials were acquired. Right-of-entry permission was obtained for sites located on private property. Once the facilities were constructed, the sites were closely inspected (during a rain storm, if possible) to ensure safe conditions during the inclement weather. It was important not to cut any corners in this area. The cost of an accident could have far exceeded the cost to build these stations properly.

Communications. Realizing communication would be the key for successful mobilization and sampling, portable phones rugged enough to survive storm conditions were obtained for use by HDR coordinators. In addition, the city allowed the coordinators to go through the city dispatcher to contact sampling personnel on their city radios during regular working hours.

Laboratory. Final plans were made with a local laboratory to analyze for the bacteriological parameters with a six-hour holding time. A second laboratory was retained to perform the remaining analyses. Both laboratories, furnished with parameter lists, prepared the preserved sample bottles and shipped them to the consultant. Holding times were verified in advance to determine critical and allowable delivery times. Communication with key contact personnel at each laboratory was maintained to ensure full-time service and consultation. It is important that procedures be developed and checked before field sampling begins to provide complete quality assurance.

Personnel Training. With the sampling and laboratory procedures and details finalized, it was time to train the sampling technicians. All personnel were furnished with a manual explaining the history and purpose of stormwater regulations, detailed mobilization and sampling procedures, and special instructions and safety precautions. This manual was reviewed in the classroom and each technician was assigned a primary and secondary site that were typically two locations located closest to his or her home. After the classroom review the group re-assembled at one of the sites to practice sampling procedures.

Dry Run. To assure complete readiness and to resolve potential problems, a "dry run" was conducted. This involved everyone in the sampling program: the consultant's coordinators, the city liaison, and all potential sampling technicians. All personnel were called the night before and told of an "anticipated" time that the make-believe storm was going to start the following day. The next afternoon they were called again and told of a specific time to be at the site. The mobilization was phased so that two technicians were at their assigned sites at 45-minute intervals. This allowed time for the coordinators to meet them at the site, watch them set up and begin sampling, and answer any questions. The sampling personnel were dismissed and the coordinators went to the next site where another two-member sampling team assembled. The dry run was beneficial in resolving potential problems and assuring that everyone was aware of the proper procedures for mobilization and collection.



FIELD training exercise following classroom instruction taught sampling personnel correct sampling procedures.

The Sampling Experience

All the planning in the world cannot prepare everyone for what exactly will happen when an actual storm event comes. No two storms are the same, so creativity, communication, and good judgement must be used when things do not go as planned. The following items summarize the results of Winston-Salem's mobilization and sampling activities during the summer and fall of 1992.

Maintenance. During the days before an anticipated storm event, all elements of the sampling program had to be kept in a constant state of readiness. All utility packs were loaded with fresh sample bottles and other necessary equipment. Rain gauges and flow meters were checked weekly to assure proper working order. Each sampling platform was also visited regularly and inspected for safety and vandalism.

Weather Monitoring. A weather forecasting service was contracted to provide two weather forecasts a day, seven days a week. The forecasts were faxed to the consultant's office in Charlotte, North Carolina, a 1½-hour drive from Winston-Salem; also, unlimited telephone consultation was provided. A potential representative storm event would be identified at least two days before its anticipated start. Within 18 to 24 hours of its predicted arrival, a decision would be made about whether or not to attempt to sample. Early in the project, sampling was attempted at every potential representative event to increase the chance of capturing the required number of storms.

Alerting Personnel. When a decision was made to sample an event, sampling personnel were alerted. They were told the approximate times for the storm's arrival and their assigned station. Crew members were called on a rotation at first, however, later in the program, experience favored personnel who could be contacted the quickest and easiest. Crew members acknowledging availability for an event were required to keep the coordinators apprised of their whereabouts and approximate schedule up to the point of mobilization.

Notifying Laboratories. After sampling personnel were alerted, both laboratories were notified. This was especially crucial for the lab performing the bacteriological analysis. They not only had to be given sufficient time to set up the lab, but they also had to have someone available who could perform the analysis within the six-hour holding time. A single contact person with the laboratory was arranged and then alerted in the same manner as the sampling personnel. The second laboratory only needed to be notified of the potential number of samples being delivered.

Checking All Equipment. During the period between alerting personnel and actually dispatching them to the stations, there was time for the coordinators to do a final check of last minute items. All utility packs were checked and kept locked in the plywood boxes at each sampling station. All box locks were keyed the same and each crew member had a master key. This allowed the packs to be available to all personnel at all times, and without the coordinators having to be present. Final checks were made for rain gauges and flow meters to assure proper operation. During this time, periodic checks with the weather service kept coordinators informed of the upcoming storm event.

Dispatching Personnel. When the predicted storm arrival time was three or

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four hours away, the volunteers were contacted again. Actually dispatching them to the site was handled one of two ways, based on the confidence level of the forecast. If the event seemed likely to occur as forecasted and highly probable of producing the required quantity and duration of precipitation, then personnel were instructed to proceed to the site on their own as the rain was about to begin. If there were doubts about the duration and characteristics of the storm, they were instructed to stand by (ready to mobilize) until an official word was issued from the coordinators.

Sampling. As the storm began and personnel arrived on site, the actual sampling part of the program could finally begin. Regulations required that the first composite fraction, as well as the bulk grab sample, including VOCs and bacteriological samples, be collected within the first 30 minutes of runoff. For outfalls with a base flow, personnel had to decide when stormwater runoff was actually occurring. This could take from five minutes to over an hour, depending on the intensity of the rain and the characteristics of the watershed. During the sampling period, HDR coordinators, in two separate vehicles, visited each station checking the technicians' progress. At the first visit to each station, coordinators distributed ice packs and collected the bacteriological samples. After each station had been visited, coordinators met and one took all of the fecal samples to the laboratory for immediate analysis. Repeated visits checked on the progress of samplers as well as checking rain gauges and the storm's progress. In cases where rain exceeded the maximum allowable for a representative storm within the first three hours, sampling was aborted and personnel were released.

Demobilization. When the sampling period was over, sampling personnel placed the iced utility packs containing the filled sample bottles back into the wooden box, and locked them. After this was done, they were free to go. The coordinators then collected the utility packs as soon as possible, checked the total inches of rainfall to verify that the storm was representative, and brought the containers to a central location. The bulk samples, composite and grab, were then immediately broken down from the gallon jugs into the proper containers and taken with the VOC vials to the lab.

Cleanup. The final task was to clean everything up. The utility pack equipment was dried and fresh sample containers placed in them. Later, rain gauge data sheets were changed, flow meters were downloaded, and the refurbished utility packs were locked back in the boxes. Based on the time of day and elapsed time since collection, this was usually done before the coordinators left the Winston-Salem area and delivering the samples to the laboratory.

As noted, developing the final sampling program was a continuous process of refining specified field procedures based on experiences from previous mobilizations. No two sampling events could be managed exactly the same. After each storm, sample collection events were reviewed with respect to any special circumstances of that event, and procedural adjustments were made if necessary. This process of always striving to improve kept team members focused on developing appropriate solutions to specific situations and logistics issues. Coordinators and technicians alike were encouraged to attempt different approaches. The following lists some of the issues that typically arose while developing and implementing the sampling program. Suggestions on how to best address these issues are provided based on the successful efforts in Winston-Salem.

Everyone is here, where is the rain? For rain event mobilizations, all sampling personnel should stay near a phone or city radio to receive weather updates and mobilization instructions. This not only reduces the amount of time personnel must be on site, but it also keeps sampling coordinators from having to ask an even more serious question... "The rain is here, where is everyone?"

When are the sampling coordinators ever going to get here to pick up the samples? Plywood boxes can be built for each site and nailed to the platforms. The utility pack equipment can be locked in these boxes before the volunteers arrive and then placed back in the boxes to be picked up later by the coordinators. These boxes can also be big enough to house the flow meters at each station. Since the utility packs can be left safely in the boxes, this greatly reduces the amount of time that personnel spend on site after completing sampling activities.

Where are my keys? Multiple sets of spares should be available for plywood boxes, rain gauges, storage areas, and vehicles. A lost or misplaced key ring could ruin an entire sampling event.

Where is the ..... (fill in the blank)? It is very hard to remember everything needed when making a mad dash to catch a storm; and nothing is worse than trying to download flow data, or change a rain gauge sheet, or even collect a sample, when you suddenly realize the equipment you need is back at the office. Make a checklist for *everything!* It only takes a minute to look over, and will save a lot of time and frustration.

Why won't this work? Plywood warps, locks and latches rust, and equipment breaks down from the inclement weather. It is essential to have extra of everything; locks, latches, and hinges must be routinely lubricated; and the operation of all equipment needs to be checked and rechecked.

Should we try to catch a thunderstorm? Unfortunately, this was a question best answered after the event. Sometimes a sure representative event becomes a passing thunderstorm, and vice versa. Modern technology has not produced the luxury of hindsight. At the beginning of any storm sampling program, sampling should be attempted at every potential representative event. Later, after having captured a number of successful sampling events, sampling efforts can become more selective. This situation must be dealt with on a case by case basis, and is dependent on the confidence level of the sampling coordinators and the experience and successes of previous sampling efforts.

Where is he? Other related questions may be "Why did he do that?" or "Did I tell you to do it that way?" The only thing more unpredictable than the weather is trying to determine how people will act during the stressful times of sampling. The biggest challenge is to train personnel in understanding the purpose and intent of what they are doing rather than just giving procedures to follow. This allows everyone to make competent decisions on the appropriate actions to take, even when something unexpected may happen.

Is there any way to get in touch with him? Open lines of communication are a necessity, not just a luxury. Using portable telephones and hand-held radios allows sampling coordinators to be in constant contact with each other as well as with the sampling personnel.

It's 2:00 am, pouring down rain, and I am standing here in the dark holding a bucket waiting for water to come out of a pipe ..... What am I doing here? This is a question that everyone involved in the sampling program may ask themselves at least once. It is important to keep spirits up even when everything seems to be going wrong. A few donuts and a little coffee can do wonders for morale.

It is impossible to present a perfect sampling program with universal application. No two situations are exactly the same, and there is no single "right way." This particular approach was one that worked well for us.

The ultimate success of any sampling program is a function of the following:

- Capturing the required number of representative storm events.
- Completing sampling activities within budget and on schedule.
- Most importantly, completing field sampling activities without accident or personal injury.

The Winston-Salem sampling program was a success by all measures. Much of this success can be attributed to the team approach taken by the city and the consultant. Using available resources and effectively communicating the program's desires and goals were key factors. With a little hard work and flexibility, the success of any stormwater sampling program can be just three representative storms away. □ □ □

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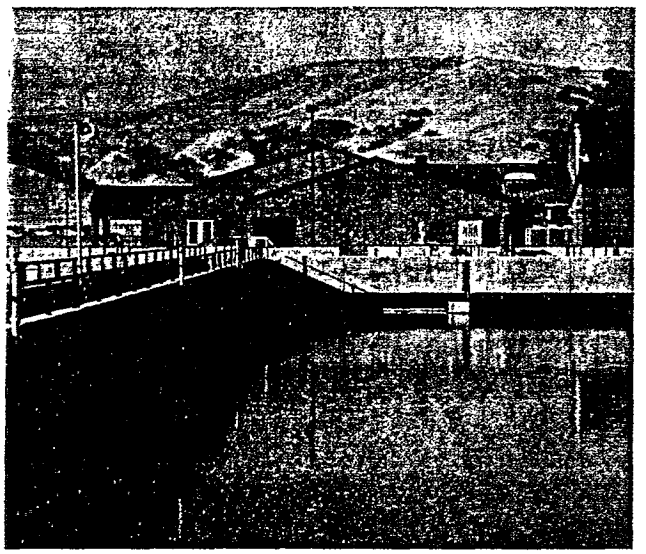



■ TWO different water sources, changing blends, and increasing water demands contributed to design complications at this California facility. Shown are the sedimentation basin and pipe gallery.

Water Plant Achieves Treatment Goals Through Flexibility

JIM BORCHARDT
Principal Engineer,
and
GLEN GRANT
Principal Engineer,
Montgomery Watson,
Walnut Creek, California

THE 40-mgd North Bay Regional Water Treatment Plant (NBR) was designed with maximum treatment and operating flexibility to respond to a number of unique circumstances. The $32.5-million plant, located in Solano County, California provides drinking water to the cities of Fairfield and Vacaville.

Both cities realized early in the planning process that creating one large plant at their border eliminated the need for two smaller treatment plants. Studies concluded that this joint venture would be economically feasible. Discussions successfully concluded with a joint powers agreement between the two cities, and plant construction was completed in 1990.

Two years of operating data show that the carefully designed and flexible process train has met and exceeded water quality standards.

Flexibility was paramount during planning and design because of the following conditions:

- Changing water supplies. The plant takes water from two different sources. The existing Putah South Canal brings generally good quality water south from Lake Berryessa. The new North Bay Aqueduct brings highly variable water—with total organic carbon from 3 to 20 mg/L and turbidities from 10 to 2500 Ntu—west through several interconnecting waterways from the Delta of the Sacramento and San Joaquin rivers.
- Changing blends. The variability of the influent water required a process train flexible enough to handle a wide range of water quality. To serve both cities' needs, the plant also had to operate over a wide range of flow rates—22.5:1—and changing blends—0 to 100 percent—for either source.
- Changing regulations. The plant was designed during a period of regulatory uncertainty following passage of the Safe Drinking Water Act (SDWA) Amendments of 1986. The plant had to be flexible enough to meet current regulations, as well as satisfy a range of potential regulatory outcomes under the SDWA. New regulations governing filtration, microbiological contaminants, synthetic organic contaminants, and disinfection by-products (DBPs) were in initial stages of development.
- Changing capacity. The plant was designed to meet the water supply needs of two rapidly growing communities. The plant has an ultimate capacity of 90 mgd and was designed to be readily expanded in 10-mgd increments, as needed. In fact, due to unforeseen growth, the plant was expanded from 30 mgd to 40 mgd during construction.

Water Quality Variables

The NBR plant is located equidistant between its two water sources. The Putah South Canal brings water south from Lake Berryessa and the North Bay Aqueduct (NBA) carries water west from the Delta of the Sacramento and San Joaquin rivers. To reach the plant, NBA water travels from the Sacramento River Deep Water Ship Channel through several waterways. The combined effects of these interconnecting waterways, local hydrology, agricultural return flows, urban runoff, tidal influences, and export pumping rates result in considerable variations in water quality. Turbidities of up to 2500 Ntu have been reported along the route. Other recurring problems associated with this water source include algae, detectable tastes and odors, and chemical (synthetic and organic) pollutants. One significant problem has been occasional high levels of total organic carbon.

Data collected during the 24 months of operation show that the plant, in addition to meeting current drinking water standards, has exceeded these specially set treated water quality goals:

	Goal	Result
Turbidity	<0.1 NTU	0.06 NTU
THMs	<20 µ/L	8 µ/L
Coliform	<2.2 MPN	<2.2 MPN
HPC*	<10 CFU/ml	<1 CFU/ml
Odor	<2 TON	no odor

*HPC = heterotropic plate count
CFU = colony forming units

The plant was designed with preozonation, flash mixing, flocculation/sedimentation, deep-bed granular

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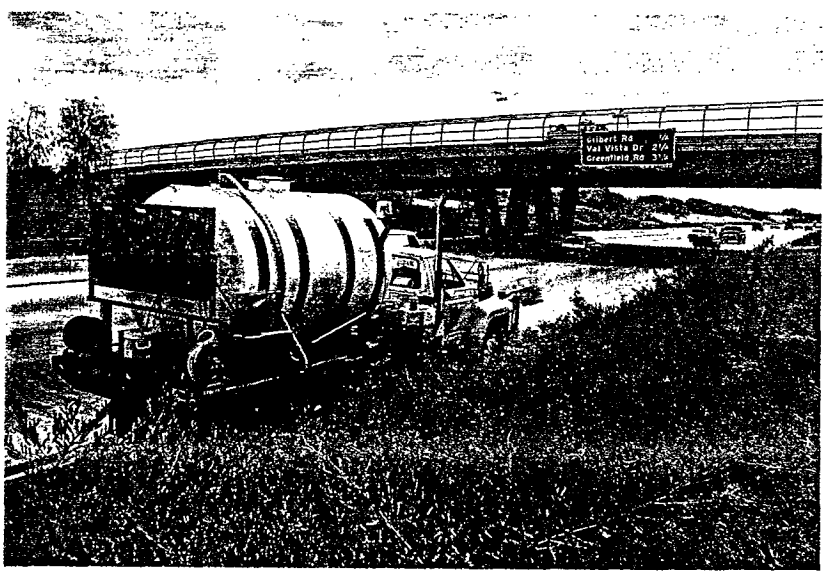
activated carbon filtration, post-ozonation, and chloramination. While none of these processes are unusual individually, the combination of processes, particularly ozonation with deep-bed granular activated carbon (GAC) filters distinguishes the NBR from a conventional plant. In addition, several conventional processes were fine-tuned to make them work more effectively under the NBR's unique conditions.

Pre-ozonation is used instead of chlorine to oxidize inorganic contaminants, color, and organic matter, and provide initial disinfection. Pre-ozonation replaces the pre-chlorination step used at most plants. Pre-chlorination is a major source of chlorinated organics. Pre-ozonation also promotes biodegradation of natural organics to remove DBP precursors biologically.

The plant also has the capability to add hydrogen peroxide. This is the first known large scale-installation of peroxide/ozone oxidation in a surface water plant. By adding hydrogen peroxide ahead of ozone, a reaction occurs that promotes a hydroxl radical, which is a faster and more powerful oxidant than ozone. Operating practice has been to add peroxide during the summer when taste and odor problems usually occur. Application of peroxide and ozone is an example of a new water treatment technology called "advanced oxidation processes" that allows the plant to control compounds (e.g. taste and odor) that previously could not be oxidized.

Without the use of chlorine, in-plant algae growth was a potentially significant problem. Montgomery Watson designed a number of changes into the basins to reduce algae growth. These included: replacing launders with end-of-basin weirs; orientation of basins and walkways to reduce the amount of sunlight on basin walls; and copper sheathing on the top four ft of basin walls to act as an algicide. These design changes have worked extremely well, resulting in almost complete in-plant algae control.



■ **THE Arizona Department of Transportation selects herbicides with the versatility to be applied in a variety of environments. Above, weed control along a busy roadside.**

Controlling Weeds Along Roadsides and Other Sensitive Sites

JAMES BREUNINGER, Ph.D.

Located in Sacramento, California, Dr. Breuninger is a Technical Service and Development Specialist for DowElanco, headquartered in Indianapolis, Indiana.

PUBLIC works professionals recognize that roadside vegetation must be controlled along highways and thoroughfares. If weed growth is not monitored, safety issues arise. For instance, due to visibility problems from uncontrolled weeds, stranded motorists, joggers, or other pedestrians could be in danger. Furthermore, uncontrolled weeds can be a fire hazard, possibly ignited by sparks from a vehicle's catalytic converter or muffler.

To reduce fire hazards and public safety risks, maintenance personnel should use an integrated approach to keep weeds at acceptable levels. Herbicides are often a necessary component of such a program.

In the past, products were selected solely because of efficacy and long residual. However, such products may no longer be tolerated in areas where drift can damage agricultural crops or in residential areas that border roads. These areas, called "sensitive sites," have changed the use patterns of many herbicides today.

Sensitive sites are a part of virtually every roadside maintenance program. The challenge for public works professionals is to effectively control troublesome weeds, yet consider environmental impact and public acceptance. The solution is choosing an herbicide program that can accomplish these goals.

In general, sensitive site describes how the use of herbicides on or near public areas will affect public reaction. Sites can be sensitive for different reasons. Sometimes sites are sensitive because members of the public are apprehensive about herbicide use. Sometimes they are sensitive because they are located in public areas such as parks where people are nearby. Sometimes they are sensitive because valued ornamentals are present.

Choose the Right Herbicide

Regardless of why a site is sensitive, public workers still need to deal gently, effectively, and economically with stubborn grassy and broadleaf weeds. And the key to controlling weeds in sensitive areas is executing an herbicide program that accommodates all needs and concerns. The ideal herbicide for sensitive sites should offer both versatility and public acceptance. In addition, the herbicide should continue to possess the features public works professionals depend on such as optimum length of control and minimal leaching—characteristics customarily expected—regardless of whether or not a sensitive site exists. For this reason, dinitroaniline herbicides have been the backbone of most roadside maintenance programs.

A versatile herbicide is one that can be used to treat numerous areas: turf, landscaping, and ornamentals. Kent Cairns, highway maintenance superintendent for the Arizona Department of Transportation (ADOT), has been successful with DowElanco's Surflan™ pre-emergence herbicide. This product does not require immediate incorporation and can be tank mixed with other products such as Roundup™. It is unique among dinitroaniline products because it does not photodegrade or volatilize readily. Therefore, incorporation through rainfall or irrigation can be delayed for up to 21 days.

Cairns' crews control weeds in sensitive sites along 150 miles of highway. In addi-

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The three objectives of the filtration process were turbidity removal, providing a barrier against chemical contamination, and taste and odor control. Pilot studies were used to investigate the right combination of media size and depth to respond to these objectives. The dual media filters are unusually deep, containing 6 ft of GAC over 2.5 ft of sand. The dual media provide effective filtration for turbidity removal. GAC adsorbs many taste and odor compounds. The deep bed of GAC provides a longer contact time, allowing the GAC to act as a better barrier against chemical contaminant spikes.

The GAC is used primarily as a filter media, not as an adsorbent. The GAC media has been in place for two years and will not be replaced for several years. Thus the adsorption capacity of the GAC for the commonly occurring compounds has probably been exhausted. Research has shown that even exhausted GAC provides an effective adsorption barrier for new compounds introduced to the media, especially when the contaminant is only present for a short time, such as would occur with a chemical spill.

One of the consequences of deep-bed GAC is high bacteria counts from the filters. Due to concern about DBP formation with chlorine and incomplete disinfection with chloramines, post-ozonation was provided. The three-stage post-ozonation process provided the strong disinfectant (ozone) required to kill bacteria. Chloramine or chlorine addition and a baffled contact basin were provided prior to the treated water pumps to ensure effective residual disinfection.

Operating results and tests show that the plant's design has produced the benefits it was designed to achieve, including control of taste and odor compounds; reduction in trihalomethane formation and other DBPs; algae control; improved coagulation; reduced sludge production; improved particulate removal; better disinfection; and increased barriers against organic contaminant spikes. □□□

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tion, ADOT contracts with 40 landscape maintenance companies to provide sensitive site weed control in landscaping and roadside areas all around Phoenix. Cairns uses several herbicides year round for ADOT.

And like many public works professionals around the nation, Cairns and his crews manage landscaping and vegetation in addition to their general roadside maintenance.

"We apply herbicides that can be used in a variety of environments," Cairns says. ADOT treats so many different areas that it is unfeasible to use a different herbicide for every problem, he says. In landscape areas, ADOT works to control several troublesome weeds and grasses, including crabgrass, spurge, and purslane, just to name a few. Some of the ornamentals to be protected include oleanders, eucalyptus and palm trees, and several varieties of ground cover.

ADOT is not the only organization that relies on versatile products. For most professionals that control weeds in sensitive sites, it is their livelihood. Just ask Don Crook, construction maintenance superintendent for Modesto Irrigation District (MID).

MID is a public-owned agency that supplies irrigation water to farmers of Modesto, California, a city with a population of 160,000. Like many cities around the nation, Modesto began as a small farming community. But as the San Francisco Bay area, only 80 miles away, has grown so has Modesto. Subdivisions developed and schools and playgrounds were built, all alongside thousands of acres of farmland and 211 miles of irrigation canals.

Crook's job is to keep those irrigation canals free of weeds. The canals are surrounded by beautiful landscaping—and weeds, that if dispersed into the irrigation water, would end up in farmers' fields. And there lies the challenge: Crook and his crew must keep irrigation canals weed free, while accommodating adjacent residential areas. These canals often border school playgrounds and neighborhood backyards. Families enjoy nightly strolls on the neatly groomed paths along the canals.

Crook knew meeting this challenge would require careful study. He needed to find an herbicide that works on Johnsongrass, but can still be used in sensitive areas along those canal banks. With careful study, he too, found the right product. "It's not easy finding an herbicide that'll control the tough weeds and still give you confidence about using it in public areas. When we find such a product, we stick with it," Crook says.

It is important to use herbicides maintenance workers understand and the public accepts. Thorough knowledge of a product—including its label—is essential. Most public workers strive to use products with the lowest toxicity possible, and that have the "CAUTION" signal word.

Cairns from ADOT knows that his crews' success depends on public acceptance. "We need to make sure we understand our herbicides inside and out," Cairns says. "Besides making sure we're using effective and safe products, we must also adequately respond to customer questions."

ADOT will not use an herbicide without rigorously evaluating it. "When we decide to use an herbicide, it's not an overnight decision. We look at effectiveness, cost and, of course, safety," he says. In the past ten years, ADOT has applied more than $1 million worth of herbicides and has maintained a positive relationship with the public.

In their effort to select an herbicide compatible with sensitive sites, public works professionals should not disregard the other herbicide benefits crucial to their weed control program. Specifically, keep in mind the herbicide's length of control and leaching potential.

Savings in Hand Weeding Labor Costs

Selecting and using the right herbicide will save public agencies thousands of dollars in hand weeding labor costs, too. ADOT's Cairns says his crews hand weed, but not nearly as much as they would without herbicides.

For instance, a recent study from Auburn University for the nursery business shows the substantial hand weeding labor costs saved by using pre-emergence herbicides. In surveying state nurseries, the study's researchers found that weed control costs could be reduced by more than 50 percent by selecting and properly using pre-emergence herbicides.

When selecting an herbicide—and considering various factors such as sensitive site usage, leaching, and length of control—the end goal should be to use herbicides as efficiently as possible. Much has been written about Integrated Pest Management (IPM). But it is not just a catch phrase, it is an important concept that allows maintenance workers to use herbicides selectively.

The key to controlling weeds through an IPM program is properly identifying problem weeds. To achieve optimal results, apply the herbicides before problem weeds germinate. By accurately timing an application, public works professionals will save time and labor during their busy season. They will also reduce dependency on post-emergence herbicides, using less herbicide overall. Always remember to read the product label for specific use and application directions.

Public works professionals need to do their homework. Sensitive sites along roadsides can be controlled effectively and in a way that is acceptable to the public. The key is choosing herbicides that can accomplish this goal. Knowledge is the most powerful tool. Compare the different products available. Study their labels and manufacturers' recommendations. Consider sensitive site concerns, such as versatility and use in public areas. But remember other important factors, like length of control and leaching. By knowing which herbicides are best for roadside maintenance programs, weeds in sensitive sites can be controlled and substantial savings realized in hand weeding labor costs. □□□

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Wetland Mitigation and Stream Restoration



■ AS PART of an 11-acre Maryland wetland mitigation project, crew installs live willow branches in a stream bank to provide bank stabilization and enhance aquatic habitat.

SUSAN D. BITTER
and
KEITH J. BOWERS

Ms. Bitter is the Ecological Sciences and Field Services Team Leader for Biohabitats, Inc. Mr. Bowers is the founder and president of Biohabitats, Inc. and Ecological Restoration and Management, Inc., design/build ecological restoration companies based in Baltimore, Maryland.

MIXING concrete and steel with buttonbush and bulrush may be more common than one might think. All across the country, local, state, and federal agencies are increasing their regulations to protect, replace, and restore wetlands and streams that are filled and altered for road construction. These same regulations often require that impacts to these resources be mitigated to replace lost ecosystem values and functions. As a result, state highway and public works agencies are often charged with designing and constructing wetlands and streams along with their roads and bridges.

Over the past eight years, we have designed over 50 wetland and stream restoration/mitigation projects for various county, state, and federal agencies on the east coast. Much of our work stems from the need to mitigate and restore impacts resulting from public works projects including highways, utilities, and channel dredging.

The restoration challenge is straightforward: plan, design, and construct a mitigation project that complies with all permit conditions, satisfies neighborhood and community associations, meets budgetary and scheduling constraints, and replicates nature. Sound somewhat complex, if not formidable? Well, yes it is—especially the replication of nature. However, there are some important premises to respect and apply that will facilitate the design, construction, and maintenance of a successful mitigation project.

Art vs. Science. Wetland and stream restoration and creation is not an exact science, but an evolving art based on scientific theories and successful experiments. Current technology and knowledge do not afford us the opportunity to completely plan, design, construct, and manage all the biotic and abiotic resources that comprise a wetland or a stream. Furthermore, like all landscapes, wetland and stream systems evolve and change over time, and are subject to a host of changing land use activities throughout a watershed. At best, one can plan, design, and construct for the fundamental wetland components: hydrology, hydric soils, and hydrophytic plants; and basic stream morphology components: discharge, gradient, sinuosity, width/depth ratio, channel material and size, soil stability, channel entrenchment, and valley confinement. As form follows function, art follows science. The rule of thumb in restoration/mitigation is "Use what you do know and build upon that foundation through application," but be aware of the "dynamic equilibrium" inherent in all natural systems.

The Landscape is a Continuum. Streams and wetlands are complex ecosystems that we are still trying to understand and comprehend. To say we can "create" a wetland or a stream sounds a bit egotistical, and perhaps naive, but to give into the complexity of the undertaking and do nothing at all may be more of a disservice to our landscape than attempting to do something constructive. Wetland mitigation and stream restoration must be approached with caution and an affirmation that Mother Nature is the best instructor.

The restoration ecologist must look at the whole system and then analyze the parts. For example, if contemplating stream restoration, look at the top of the watershed and attempt to understand what makes the stream look and behave as it does. Travel downstream and learn what happens when that water leaves your site. Not only are these systems connected geographically, but are bridged by time as well. Your actions today will trigger events in the future, some predictable and some not. Everything that is done to manipulate and change a stream will have some effect on that system either down stream or up stream. Be sure to understand to the fullest extent possible the consequences of your actions and how they may affect the surrounding landscape.

Setting a Goal. Mitigation of wetlands and streams must begin with a goal. The goal must be achievable and at the same time meet the expectations of all project participants. Goals are often established based on the lost values and functions of the resource(s) being impacted. The goal may be as simple as reconstructing a stream bank to arrest erosion or as elaborate as recreating the exact habitat of a rare plant. Goals can also combine resource values and functions with cultural and economic factors. It may not be enough to just stabilize a stream bank, but to stabilize the stream bank while increasing trout habitat and enhancing water quality. Furthermore, the goal must be a result of a consensus between all interested parties. Once the goal is determined, a mitigation or restoration plan can be set into action. We have found it advantageous to meet with the client and regulatory agencies before beginning design concepts and develop a goal, or set of goals, that meets the expectations of all parties involved with the project.

It Takes a Team. Preparing and constructing a wetland or stream mitigation project is one of many steps in the regulatory process and often involves the expertise of a multi-disciplinary team of natural resource scientists, restoration ecologists, engineers, and collaboration with the regulatory agencies and the permit applicant. Very few successful projects are the result of individual efforts. Restoration ecologists are still learning a great deal about wetland and stream ecosystems and how they function, not to

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mention how to put them back together again, and the expertise of many people and disciplines are needed.

When team building, do not forget to include the input of concerned citizens and local neighborhood and environmental organizations. Often their insight into a particular site and their knowledge of local ecological processes and resources will provide valuable information for design and construction. Also consider including a wetland or stream restoration contractor on your team. Their expertise about construction techniques, plant availability, access considerations, and logistics can result in substantial cost savings not only during construction, but throughout the maintenance period.

Water, Water Everywhere. The long term success of any wetland mitigation and stream restoration project depends on restoring or creating the appropriate water budget (hydrology). Unfortunately, for nontidal wetland creation, this is one of the most difficult variables to manage. Groundwater levels must be monitored, surface runoff and flood flows must be modeled, precipitation and evapotranspiration must be calculated, and a water budget must be created. The water budget determines the amount and duration of water moving in, through, and out of the wetland. Water budgets govern the final elevations and grade of the wetland, dictate plant selections, and define specific wetland values and functions. Without reliable, long term monitoring data, accurate planning and design for specific water budgets is limited at best. Likewise with streams, water controls all other ecological processes. Whether it be sediment transport, stream bank erosion, or trout habitat, water is the key to defining stream values and functions.

Know your water budgets and hydrology. Know how water gets to the site and how it leaves the site. Apply field experiments and set up monitoring devices to record stream flows, groundwater levels, and surface runoff. Remember the three main principles of a successful wetland and stream restoration project: hydrology, hydrology, and hydrology.

Build a Stable Foundation. Wetland soils are the primary medium for many chemical transformations that support wetland plants, and are a reservoir for minerals and nutrients required by both plants and many other biotic resources. When designing and constructing a wetland or stream, soil properties must be considered in response to the anticipated hydrologic regime. Soil characteristics that must be contemplated include texture, organic matter, pore space, and chemical properties such as pH. In most cases, a soil's chemical and physical properties must be managed or altered to attain an optimum foundation for hydrophytic plant growth, chemical transformations, and mineral and nutrient cycles. Without a stable base from which to build, desired plant communities and wildlife habitat are a guess at best.

Like hydrology, know thy soils. Learn both the physical and chemical parameters of the site's soils and how these parameters will affect the desired plant community. Of equal importance is knowing everything about any soils imported onto the site too.



■ **FOUR months after installation, willows have leafed out. Roots growing into the stream bank prevent erosion and protect the bank from storm events.**

Green Side Goes Up. If the hydrology is predictable and the appropriate soils are in place, wetland and riparian plant selections can then be made. Wetland and riparian plants can grow in an environment that is typically inundated periodically throughout the growing season. The tolerance to inundation, which includes both the frequency and duration of water contact, varies depending on the physiology of each plant species. Some plants may require constant inundation of water to survive (e.g., cattails) where others may tolerate only short periodic inundations (e.g., ash). Plant survivability is not only dependent on hydrology and soils, but also on microclimate, topography, solar radiation, orientation, and biological interaction.

Native plant species found growing in environments similar to the created wetland provide a reliable source for plant design selection. Additionally, the use of *local* native species provides a genetic advantage for plant adaptation and survivability. Plant selection in mitigation and restoration projects must also take into consideration plant availability and costs, estimated mortality, reproduction rates, sizes and spacing requirements, pests and diseases, and biotic interactions.

Start Early and Stay Late. Successful wetland mitigation and stream restoration projects are often incorporated into the project early in the planning and design process and are a part of the project for up to five years after completion. By analyzing wetland and stream impacts early in the planning stages of a highway, it is possible to avoid impacts by altering alignments and minimize impacts by changing design details. Why do wetland mitigation and stream restoration when you do not have to?

If wetland mitigation or stream restoration is required, assign it a prominent role in the design process. Often mitigation and restoration requirements can be satisfied and incorporated into the design of a highway with minimal additional costs and time. Furthermore, integrating the design of wetland mitigation and stream restoration with the rest of the project will help ensure its long term success.

The other critical time often ignored by agencies and permit applicants is the post-construction period. No matter how well planned and executed, *all* mitigation and restoration projects *need* maintenance. Remember, ecological systems change over time and space, often in unpredictable ways. Federal and state agencies are now requiring maintenance and warranty of wetland mitigation and stream restoration projects for up to five years, and longer in some cases.

Maintenance must be incorporated into the project to reach and satisfy the goals of the project. Maintenance activities may include wildlife predation protection, dead and diseased plant removal and replacement, exotic plant eradication, trash and debris clean-up, soil supplements, and hydrologic modifications. Additionally, plant material often needs watering throughout the establishment period, primarily throughout arid regions of the country. A successful mitigation and restoration project has a contingency plan(s) to handle unexpected situations.

Landscaping vs. Ecological Restoration. The failure of many past projects can be directly attributed to the inexperience of the construction/landscape contractor combined with the lack of proper supervision. In mitigation and restoration projects it is impossible to

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design for all conditions at all times. Consequently, it is imperative that the contractor or a construction manager be able to make intelligent field changes to ensure the success of the project. This requires a thorough understanding of the project goal and thorough knowledge of project components including plant hydrologic regimes, plant material, soil conditions, and surrounding potential influences. Manipulating the final grade three inches or moving a specific plant three feet may mean the difference between a successful project and a failure.

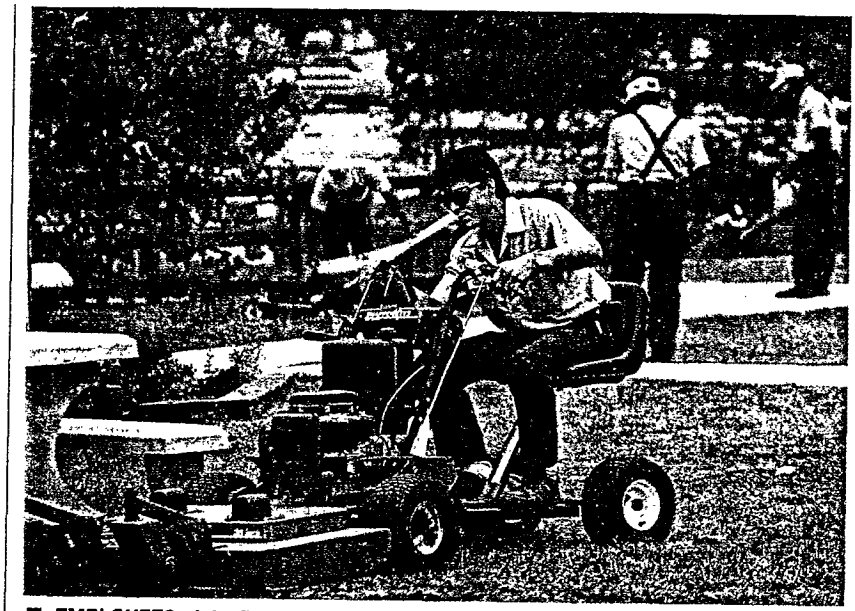
Ecological restoration construction firms should possess the skills and experience to make sure the project is installed and maintained properly. If you contract with a standard landscape contracting firm that does not possess the required expertise, make sure you retain the design consultant or a construction manager with the right qualifications that can supervise the project.

Scruples. Ecological restoration is an attempt to reverse the trend of unsustainable development. Everything we do to the landscape affects the capacity of the landscape to sustain an environment suitable for life as we now know it. The use of exotic plant material, unnecessary fertilizers and pesticides, and other high maintenance "improvements" will ultimately limit the earth's capacity to support life. Ecological restoration represents a significant step in reversing this trend to restore and create sustainable landscapes.

William McDonough stated our ethical responsibility rather succinctly, "Nature doesn't have a design problem, after all; human beings have a design problem." A few sustainable design and construction points to follow include:

- Minimize the destruction of one habitat for the benefit of another. (Remember, peat moss is mined from wetlands. Specify alternatives if available.)
- Advocate the minimization of extremely invasive procedures to native landscapes including wholesale regrading, major changes in drainage patterns, and replacement of native plant material for non-indigenous plants.
- Emphasize landform and grading to create designs, rather than hard structures and surfaces. Balance cut and fill.
- Do not plant any species that may become invasive and decimate native habitats. A few plants that should not be planted include Norway maple, Russian olive, Amur and Tartarian honeysuckle, multiflora rose, kudzu, common reed, purple loosestrife, and red fescue.

Aldo Leopold, one of the great naturalists said, "Things are wrong, morally wrong, whenever our biotic community is degraded." Ecological restoration can be a powerful mechanism to reverse global ecological degradation. □□□



■ **EMPLOYEES of the Parks and Recreation Department take great pride in ensuring that Hinesville's many parks are kept beautifully manicured following the management change.**

Public-Private Partnership Works for Georgia City

ONETHA MINGLEDORFF
and
ADRIENNE MOCH

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LUSH green lawns and stately live oak trees, many with Spanish moss gracefully cascading through their branches, are indicative of the atmosphere that permeates the southeast Georgia city of Hinesville (population 21,603). Residents are proud of their community, which plays host to the 24th Infantry Division housed at Fort Stewart, and that pride is evident to even the most short-term visitor.

In early 1992, Hinesville's city council and staff made the difficult decision to contract out its entire public works department to a private firm, Operations Management International, Inc. (OMI). They knew that this public-private partnership would receive continual scrutiny from citizens of the community.

Now, more than a year after the private firm took responsibility for operating the public works department, Hinesville leaders are congratulating themselves on their foresight. Residents are pleased with the professionalism they see exhibited by company employees; the morale of the staff, most of whom are former city employees, is at an all-time high; and although cost figures have not yet been reconciled, it seems that the positive changes that have occurred in the department have resulted in a more cost-effective operation.

Good Track Record

The management company is no newcomer to Hinesville. The firm has operated the city's 7.2-mgd trickling filter/solids contact wastewater treatment facility since 1984. Because of the success of that arrangement, the addition of other public works functions to the company's scope of work was contemplated.

City administrator Billy Edwards believes that having a previous relationship with the company through which a trusting partnership was developed made the decision to expand its scope of work a little easier. He said it is difficult to design a contract that includes all potential public works issues, so trust must go both ways to ensure the partnership is successful.

One of the biggest early challenges that faced the management company was gaining the trust of the staff, many of whom were wary of their new employer. "We had to convince the employees that we were there to help them," said Larry Harper, project administrator. "A lot of people thought we would be 'the terminator' and were put in a sheer terror zone. One of the most exciting things we've seen is how the employees have adapted to being paid to think," Harper added, referring to the company's "Obsessed With

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Quality" process that stresses employee empowerment.

An indication of how well employees have adapted to new management came with the June 1993 publication of a special edition of *The Pride,* an in-house newsletter, that featured comments from several staff members about how they feel about their jobs since the management change was made. The publication's tone is overwhelmingly positive. In addition to winning over the employees, another big challenge for the company was gaining an understanding of the city's operations within the first 60 days, maintaining services while learning about current practices. It was only after that process was completed that improvements could be initiated.

Harper stresses that the talent core was always there, and it has been allowed to flourish through the successful partnership. In addition to continuing to manage the operation of the wastewater treatment facilities, OMI employees are charged with the overall administration of the public works department, water treatment and distribution, meter reading, streets and vehicle maintenance, parks and grounds maintenance, mosquito control, and sanitation.

Perhaps the most significant operational changes have occurred in the vehicle maintenance and sanitation areas. Organizational and scheduling alterations have increased employee morale and led to pride in exceeding their customers' expectations.

The vehicle maintenance department has become a 7-day-a-week operation, eliminating the backlog of work that occurred with the previous 5-day-a-week schedule. In addition to receiving excellent mechanical service, customers' vehicles are washed before being returned.

Computerized Routes

The sanitation department has computerized its routes, posted daily schedules, and streamlined the operation so that more work is completed with less equipment and personnel. Just recently, the entire solid waste pickup schedule was altered to plan for the city's future growth, and a recycling program is in the works.

Most important, however, is the change in the way sanitation employees view their jobs. Cross-training has improved employee morale and led to improved service, with all employees assisting as necessary to pick up both household refuse and dry trash. To commemorate employees' dedication to their work, the ROC(K) Award is presented quarterly to the sanitation department employee who best exemplifies pride in his job, and recipients' photos are featured in the local newspaper.

In addition to improving public works management, one of the goals of the city in hiring the management company was to save money. The books will not be closed on the initial period of OMI operation until the end of October 1993 (to coincide with the city's fiscal year), but both city and company officials are optimistic that the bottom line will be another reinforcement of the benefit of their partnership.

Harper said cross-training will definitely have a positive effect on the budget, especially in the sanitation and utilities areas, where staff consolidation has resulted in more cost-effective operations. For example, he pointed out that meter readers are being trained as operators and being encouraged to study for their Georgia certifications.

Mayor Allen Brown notes that he does not know if the city could have gotten through the aftermath of the unexpected severe winter storm in March without the management firm in place. With refuse pickups more than five times the norm, supervisors were out on trucks to assist with the cleanup, and those actions impressed city officials, residents, and employees alike.

The management company can see things that city employees did not see. Having the chance to take a fresh look at established procedures has benefitted residents to the point that even the city's mosquito population has declined. Instead of continuing the spraying program the city had in place, the company researched the situation and implemented a program based on specific data and able to be monitored for effectiveness.

Harper attends city staff meetings as a department head, so he is well aware of the pulse of thle community. He and all other company employees work hard to ensure that the public works department responds to both stated and unstated resident needs. For example, employees have gone to several areas around the city and cleaned them up, often on their own time, actions that serve to strengthen the bond between the city and its contract operator.

Synergistic Management Style

The company's synergistic management style has also afforded many Hinesville employees the opportunity to assist at the company's other Georgia projects. Being empowered to contribute in a global fashion to their employer's success is one of the main focuses of the quality process. This emphasis on quality has spilled over to Hinesville, as it is working with a quality consultant to implement its own Obsessed With Quality process.

Another sign of the benefit of the city-company alliance is that since turning over the operation of its public works department to the private company, Hinesville has been visited by officials from several communities that are curious about how its public-private partnership works. Edwards is pleased to see the city as a role model and even more pleased that the decision to contract out the public works department has resulted in significant benefits for Hinesville residents.

One benefit is the continued presence of Fort Stewart, which is the city's leading industry and employer. While many military bases across the country are being closed or scaled back, another brigade is being moved to Fort Stewart. Hinesville believes this shows the military's confidence in Hinesville's ability to serve its personnel. □□□

■ **SANITATION crews work on routes that have been computerized to enhance efficiency. The department successfully coped with an unexpected workload after a storm in March.**



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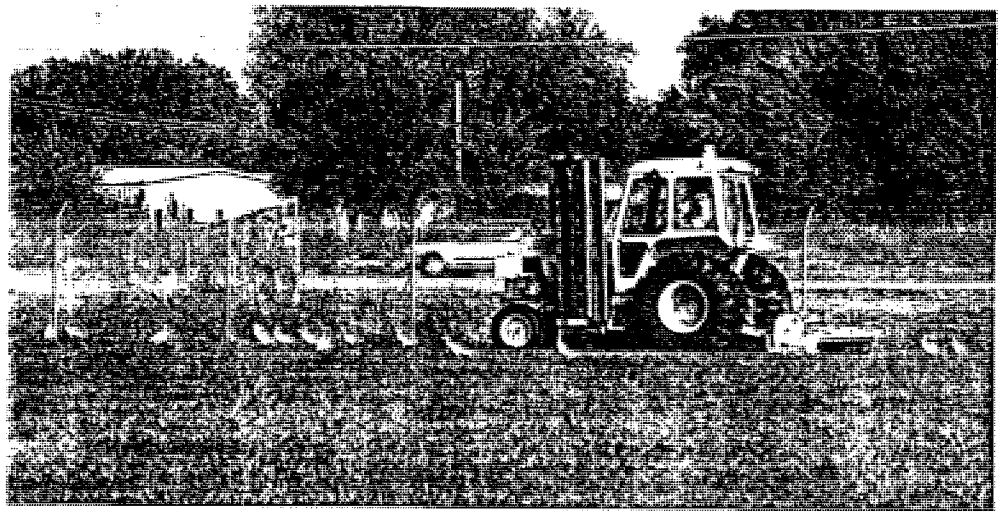

■ BIRDS attracted to insects stirred up by mowing activities may be hazardous to aircraft operations.

Airports Use Herbicides to Improve Safety, Lower Costs

USING herbicides to manage airport utility turf can offer substantial safety and economic advantages over conventional and repetitive mowing cycles, according to managers of several Florida airports and a leading southern agronomic consulting firm.

Several years of field trials and commercial use of herbicides on airport turf show that "chemical mowing" greatly reduces the safety hazards associated with mowers working in close proximity to runways and active aircraft.

Herbicide programs have also allowed airport operators to reduce the mowing cycles necessary. This reduction in mowing translates into lower equipment depreciation and overall operation costs.

"Use of herbicides is especially advantageous for maintaining turf in the south," said Ron Hill, an agronomic consultant with Weed Systems Equipment, Inc., a Keystone Heights, Florida firm that designs and builds precision spray equipment for research and commercial use. The company also conducts contract research and turfgrass consulting services.

Frequent Mowing Cycles

More frequent mowing cycles are necessary under southern conditions because of longer growing seasons, adequate rainfall, and the degree of vegetative competition, according to the consultant. "Nine-day mowing cycles are common in the south, and the number of mowings per season can range into the 20s," he stressed. "By using herbicides, the number of necessary mowings can be reduced by one-third or even one-half."

Hill also pointed out that many Florida airports apply herbicides along airport perimeter fence lines to keep weeds from encroaching on runways. It is difficult to mow along fence lines, damage to fences and equipment is common, and mowing along fence lines is very labor intensive.

Perhaps the biggest plus of chemical mowing is improved safety for aircraft and mower operators alike. At most airports, runways cannot be shut down during mowing operations. Consequently, mowing is often accomplished piecemeal between take-offs and landings, or during night or early morning when flight activity is minimal.

"Murphy's Law comes into play where airport mowing is concerned," said Murl Mitchell, maintenance supervisor for the Sarasota/Bradenton airport in Sarasota, Florida. "Anytime you mix airplanes with mowing equipment, the possibility for accidents is very high."

Considerable danger is also posed by birds feeding behind mowers, Mitchell commented. Mowing attracts large flocks of birds that congregate to feed on insects stirred up by mowing activity. By reducing the number of mowings, bird activity that can interfere with flight operations is greatly reduced. According to Hill, birds also gather and cluster in tall, unmowed grass. When airport maintenance crews get behind schedule with mowing, the number of birds attracted to the airport perimeter increases significantly.

The mowing season at Sarasota/Bradenton Airport runs from late April to early October. Two 15-ft mowers pulled by diesel tractors make between 18 and 21 cycles during that period of time every year. It takes nine working days to complete a single mowing cycle at an average of 152 man-hours per cycle.

Seventy-five percent of the 1100 acres within the airport perimeter is mowed. Since 1989, Mitchell and his crews have experimented with herbicide applications on several plots within the perimeter. Herbicides used include Campaign® (Monsanto Company, St. Louis, Missouri), Oust™, and Velpar™ (E.I. duPont de Nemours and Company, Wilmington, Delaware).

"In some areas where we've applied herbicide, we've been able to get by with two mowings—compared to a norm of five mowing cycles," Mitchell pointed out. "If we can reduce mowing by one-third, it will amount to a significant savings for us."

Reducing Foreign Object Damage

At Lakeland Linder Regional Airport in Lakeland, Florida, herbicides are also being evaluated as a means of reducing mowing costs and improving safety. Every spring, during the annual Sun 'n Fun Experimental Aircraft Association Fly-In, the airport will conduct over 30,000 flight operations in a single week. By comparison, the Atlanta airport—often billed as the world's busiest—conducts only 10,000 flight operations per week.

"During the week of the Fly-In, we become the busiest airport in the entire world," said Gary P. Quill, airport director. During the rest of the year, the airport will have an additional 120,000 operations. With such a high level of flight operations, safety concerns are first and foremost. Herbicides are used to eliminate weeds in runway cracks and the special dangers that these weeds pose.

"Weeds growing in runway and taxiway cracks pose a real safety hazard," Quill explained. "They contribute to the chipping away of pavement. These pieces of pavement—if sucked into aircraft engines—can threaten aviation safety. They can also do extensive damage to planes. We're trying to eliminate this type of foreign object damage."

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Weeds growing in cracks also speed up the deterioration of runway and taxiway surfaces, especially when water gets into the cracks and freezes. Not surprisingly, damage to these surfaces is expensive to correct. Spraying weeds in cracks and crevices with herbicide eliminates this problem and decreases runway deterioration.

According to Bill Morton, Jr., maintenance supervisor at Lakeland Linder Regional Airport, herbicides have also proven useful for turf maintenance around runway lights. "Keeping grass mowed and trimmed around runway lights is very labor-intensive," Morton explained. "These lights are also delicate and easily damaged by mowers. Using a backpack sprayer for herbicide application, we can treat a circle around runway lights and avoid using the mowers for this job altogether."

Herbicides used at Lakeland include Campaign, Oust, and Roundup®. Along 15 miles of ditchline within the airport perimeter, Rodeo® herbicide is used. Rodeo is a specially-formulated herbicide for use in and around water. Rodeo and Roundup are Monsanto products.

"Keeping our drainage ditches clear of vegetation ensures fast, efficient drainage and minimizes potential dangerous sheet flow of water over runways," Morton said. "Poorly draining ditches that are clogged with vegetation increase the potential for increased sheet flow or ponding of water on pavement surfaces. We also reduce the environmental impact of the airport by keeping water moving through ditches that serve as mitigation areas, to improve the quality of runoff water."

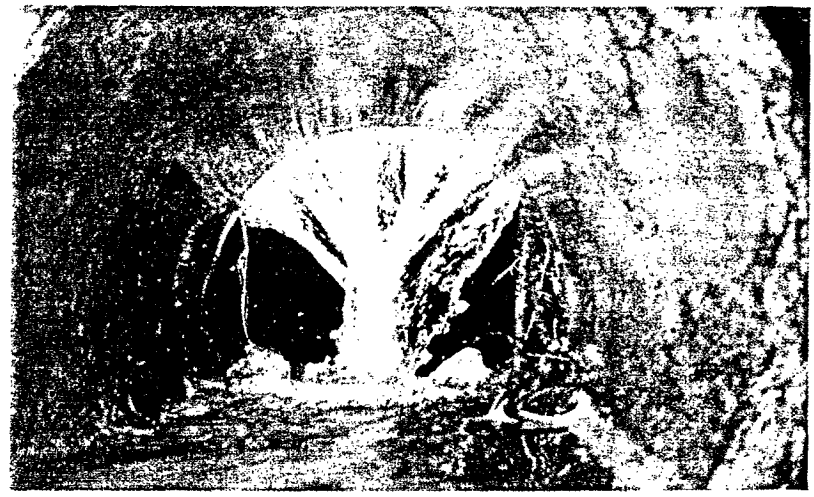
Esthetics Are Important

The annual Sun 'n Fun Fly-In routinely draws almost 300,000 people to the Lakeland Airport grounds. Many of these visitors camp on the airport grounds, and media coverage of the event is constant.

"Because of the Fly-In, esthetics are more important for us than they are at most other airports," Morton explained. "We try to maintain our utility turf almost to golf-course standards."

Two employees spend all of their time on mowing chores. "We're trying to find ways to free up these people so they can concentrate on landscaping and other esthetic chores—especially in front of the terminal," Morton added. "Use of herbicides is helping us accomplish this."

Morton says that cattle egrets feeding behind mowers can also be a problem at times. "Birds can go through an aircraft windshield during take-offs and landings, causing serious injury to pilots. Also, birds can total an aircraft engine if one gets sucked in. Even the damage caused by a bird striking the a wing can be significant—both in terms of repair costs and the threat to safety." □□□



■ RAINFALL induced infiltration enters sheared pipe at the rate of 45,000 gpd.

Municipal Program Combines Rainfall Induced Infiltration

JAMES D. McGREGOR, P.E.
HAROLD M. KLEIN
and
JOHN LYONS

Mr. McGregor is a senior associate with Killam Associates, Millburn, New Jersey. Mr. Klein is the Township Administrator and Mr. Lyons is the Superintendent of Sewers, Piscataway, New Jersey.

THE Township of Piscataway, located in northern New Jersey, has a population of about 47,100. The township has a mixture of low density and condominium residential connections and significant commercial and industrial wastewater users.

The township owns and maintains a sanitary sewer system containing over 165 miles of municipal sanitary sewers. The sewer system also contains a network of building connection sewers of unknown length. Approximately 73 percent of the municipal sewers are 8-in. diameter pipes consisting of clay, asbestos cement, and plastic pipe.

Wastewater flow from the community is treated by the Middlesex County Utilities Authority (MCUA). The wastewater reaches the wastewater treatment plant through the MCUA interceptor sewer system. The MCUA meters Piscataway wastewater flows at eight metering chambers. The wastewater costs are partially apportioned on the basis of flow. These flow-related charges fluctuate significantly during dry and wet rainfall years because substantial rainfall-related extraneous flows enter the sanitary sewer collection system.

Although the extraneous flow problem has existed since the sanitary sewers were constructed, no concerted program was undertaken to control the extraneous flows until 1989 when the township retained Killam Associates to assist them with the extraneous flow problems.

The decision to retain a consultant was not solely prompted by high wastewater treatment costs. Within the township the sanitary sewer extraneous flows were causing additional problems. The problems were most critical during significant prolonged rainfalls when peak extraneous flow rates developed. The hydraulic loading imposed by the peak extraneous flows caused the following:

- sewage overflows from some manholes;
- sewage backups into some homes;
- bypass pumping into storm sewers at some sites to prevent backups into homes;
- activated high water alarms at pumping stations;
- increased pumping costs;
- required emergency responses by the department of public works (DPW);
- required responses to residents' complaints;
- restricted potential development in some small sewer drainage basins;
- made the township vulnerable to a future sewer ban or regulatory fines.

The predominant subsurface geology is soft red shale with sandstone beds. This geology provides ideal conditions for rainfall induced infiltration (RII), a type of groundwater infiltration prevalent in collection systems with subsurface rock.

A 1990 EPA report to Congress, *(Rainfall Induced Infiltration Into Sewer Sys-*

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tems, Report to Congress August, 1990, 430/09-90-005), indicates the characteristics and problems associated with RII include:

- rapid infiltration increase that mirrors the rainfall event followed by a somewhat similar decrease when the rain stops;
- frequently mistaken as surface water inflow, which results in poor achievements by some sewer rehabilitation programs;
- peak RII can cause dry weather wastewater flows to increase by 3.5 to 20 times;
- RII can represent 60 to 90 percent of wet weather extraneous flows;
- rainfall enters the sewer system by percolating through the soil of sewer trenches;
- sewer trenches channel the water to defects along the sewers;
- shallow sewer trenches (4-in. diameter building sewer connections) are more vulnerable to RII;
- deeper interceptor sewers are less susceptible to RII;
- subsurface rock maximizes the influence of RII because the groundwater cannot infiltrate into the ground below the sewer pipes;
- appreciable hydrostatic heads develop in rock sewer trenches, rapidly accelerating infiltration rates at sewer defects.

Killam Associates previously identified RII as a significant problem in northern New Jersey during sewer investigations in nearby communities with identical subsurface rock geology and extraneous flow problems. To accurately identify RII sources, the consultant modified its sanitary sewer investigation procedures. Traditional sewer system evaluation techniques were abandoned, and field investigations focused on identifying peak RII. This meant developing dry weather base flows, then mobilizing during RII periods to conduct metering, record instantaneous flow measurements, and identify manholes and specific sewer lines with RII. Most importantly, television inspection of the sewers was only scheduled when RII was active. These procedures ensure that major sources of RII are correctly identified and appropriate sewer rehabilitation work recommended.

The consultant initially investigated a small sanitary sewer basin designated as the Gramercy Park area. The basin contains about 38,000 ft of asbestos cement municipal sewers. The field investigations revealed the following:

- RII caused the extraneous flows;
- peak RII was 13 times the dry weather flow;
- 21 percent of the municipal sewers contained 90 percent of the RII;
- interceptor sewers partially blocked with grease and debris from vandalism were contributing to sewage backup problems;
- 4-in. diameter building connection sewers contributed 62 percent of the RII within television inspected sewers;
- some manholes contributed high RII flows (80,000 gpd maximum measured in one manhole);
- RII entering municipal sewers could be eliminated by spot repairs and grouting.

Engineering Recommendations

The consultant recommended that the township DPW become actively involved with the RII investigations and sanitary sewer rehabilitation because the DPW had a television inspection rig, sewer jet flushers, and the capability to excavate and repair damaged sanitary sewers. A cooperative venture between the DPW and the consultant would minimize contractor costs for television inspection; fully utilize DPW capabilities to investigate and rehabilitate the sanitary sewer; provide training to DPW personnel in television techniques needed to locate RII; train DPW personnel in flow measurement techniques to identify and quantify peak extraneous flows; train DPW personnel to make water tight sewer repairs; and demonstrate the need for high quality work during RII investigations and sewer rehabilitation work.

The township administrator and governing body evaluated the Gramercy Park sewer investigation findings and decided to adopt an aggressive program to reduce sanitary sewer system extraneous flows. They recognized that controlling extraneous flows would require reducing extraneous flows from the network of 4-in. diameter building sewers as well as the municipal sewer pipe. They also recognized that the field investigations were detecting significant maintenance problems. This added benefit enabled DPW to resolve some sewer backup problems and prevent future sewer backups.

Township officials made the important decision to adopt a policy of investigating and rehabilitating defects along building connection pipes. The DPW is viewed as a department with a responsibility for assisting the public with various problems. This is especially important where sanitary sewers are concerned because the sewers are underground and require specialized investigation techniques to evaluate problems. A mini-camera gave the DPW the ability to inspect 4-in. diameter pipes.

Existing records and television findings within the Gramercy Park sewer basin indicated that many building connection problems existed in the municipal right-of-way.

TV Inspection Equipment

The new television inspection equipment purchased by the township to improve its sanitary sewer inspection capabilities and permit inspections of the 4-in. diameter sewers included a 360-degree radial view color camera and a mini-camera for small diameter pipe (Cues Inc., Orlando, Florida). The equipment has proven valuable for identifying extraneous flow problems within accessible sewers. The radial view camera has determined that some building connection pipes are leaking within 1 ft of the municipal sewer. These leaks are the result of poor quality construction work or non-watertight connections by plumbers. The radial view camera has also identified some utility poles that damaged asbestos cement pipes.

The mini-camera locates extraneous flow problems and maintenance problems along building connections. Most identified problems along the 4-in. diameter pipes are related to structural damage caused during the original construction or caused by construction of nearby utilities after the pipe was installed.

Continuing Investigations

The township recognizes the benefits of the cooperative venture to identify sanitary sewer extraneous flows. The consultant's field procedures expedite the process of identifying major extraneous flows and minimize the costs for non-productive investigation tasks. For instance, the traditional tasks of smoke testing and dye water testing have hardly been used.

Investigations are ongoing in two additional drainage basins that also have severe extraneous flow problems. Similar sewer defects and building connection extraneous flow problems are being detected. Flow from both of these drainage basins is metered by the MCUA. Therefore it will be easy to monitor the extraneous flow reduction effects of proposed sewer rehabilitation work.

A successful flow reduction program is anticipated because some major extraneous flow sources have been pinpointed by the field investigation procedures. The most noteworthy finding has been the detection of a 1430-ft portion of 8-in. diameter municipal sewer not shown on the sanitary sewer map. The sewer alignment is in a right-of-way partially along a small brook. Smoke testing by the DPW identified five homes connected to the sewer. The dry weather average daily flow from the sewer is about 2000 gpd. During a 1.83-in. rainfall in November 1992, the peak RII flow from the sewer was 240,000 gpd, which is 120 times the dry weather flow. Even more astounding was the peak RII flow of 900,000 gpd, measured during a 4.29-in. rainfall in December 1992. The RII rate was 450 times the dry weather flow!

The planned rehabilitation of this sewer will have a dramatic impact in reducing extraneous flows from the sewer basin. Future wastewater treatment cost savings will be appreciable. □□□

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Connecticut DOT Turns to Partnering

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Director of Construction,
Connecticut DOT,
Wethersfield, Connecticut

THE Connecticut Department of Transportation (ConnDOT) has instituted a voluntary "partnering agreement" as part of the project management strategy for a series of bridge rehabilitations along State Route 8 in the town of Seymour. The goal of this action is to foster carefully-coordinated teamwork necessary to overcome fast-track scheduling challenges, to avoid potentially high monetary penalties, and to minimize the number of claims associated with the $12-million contract. Work began in April 1993 and must be completed on or before November 30, 1994.

Like many other states, ConnDOT has battled a rising number of claims on projects in recent years. Currently, the state has more than 50 active claims on its books worth an aggregate total of about $50 million. The state began studying partnering in 1990-1991, but delayed implementing it until this year due to staff and other cutbacks. The Seymour project presents an ideal candidate to test the concept in this state.

The project has been awarded to O & G Industries, Inc., a Torrington, Connecticut general contractor with past experience in partnering on a U.S. Army Corps of Engineers project in Louisiana. The practice has gained favor after proving successful on hundreds of millions of dollars worth of Corps and Arizona Department of Transportation (ADOT) projects and others under the auspices of major public and private construction buyers.

How it Works

Construction buyers in the private sector were the first to accept partnering, especially on design/build projects. Other entities, including the Corps, ADOT, General Services Administration, Federal Highway Administration, state and local governments, and the Associated General Contractors of America (AGC), foresee the practice as the trend for the future and have encouraged it on hard bid programs, as well.

The implementation of partnering normally begins before construction begins, although it has also been used to rescue projects running behind schedule or over budget. The process starts with an orientation, or partnering conference, attended by representatives of the owner, major contractors, design consultants, and others likely to interact regularly throughout the work.

This initial meeting is normally run by an outside facilitator and often involves administration of behavioral/personality trait tests to provide participants with insight into their communication styles and other people skills. Following that step, the facilitator then has the group mutually develop the terms of a formal "charter," the accord that all participants sign.

This agreement corresponds to the project's business plan, outlining mutual goals and methods essential to the project's success. The other key elements normally include a team evaluation process by which the team can assess its progress or shortfalls, a process for identifying methods of improvement, and a protocol for instilling decision-making at the lowest level of authority possible, ideally with field supervision personnel to expedite the process. Follow-up workshops are also held to review the level of team commitment thereafter.

Partnering does not displace the obligations and protection of the legally-binding contracts, however. Partnering agreements are strictly voluntary so their success depends on the moral integrity and mutual trust achieved between all parties. The practice has been termed analogous to "restoring the handshake" that once characterized the industry. This level of mutual trust has been compromised in recent years by: the onerous nature of contemporary contracts; the practice of some contractors intentionally bidding a project low on the premise that an adequate profit can be salvaged later on through

Partnership Agreement Between State of Connecticut Department of Transportation, O & G Industries, Inc., Greiner, Inc., and The Maguire Group for the project 124-146 Reconstruction of Bridges 587, 588 and 1062, Route 8, Seymour, Connecticut

The general objective of this partnering agreement is to construct a quality project in a way that provides a well-designed, well-constructed bridge deck consistent with the construction time frame and safety for the general public and construction workers, so that the bridge will have a significant life span and minimal maintenance.

To do whatever is possible to keep a high degree of cooperation and to ensure the proper lines of communication remain open between all parties involved.

To create an atmosphere minimizing liquidated damages, claims, disputes, and litigation in a way that is consistent with the intent of the contract and the interests of all parties so that no party bears an unfair financial burden.

To minimize public inconvenience in a way that recognizes, plans for, and monitors disruptions to the normal operation of the roadway throughout and adjacent to the construction site so that the public can be informed as to the status of the project.

To institute a testing program that provides timely and on-site results, consistent with recognized testing standards so that on going quality of construction can be maintained and decision in regards to Monday morning openings can be made based on measured results.

To develop a chain of command that acts in a timely manner to resolve all design and construction problems with the express purpose of keeping the project flowing efficiently. Standard operating procedures will be modified where necessary.

To recognize the unique schedule requirements of the project and work cooperatively to reduce schedule impacts and complete the overall project on or ahead of schedule.

To resolve all conflicts at the lowest possible level by establishing an issue resolution and escalation procedure.

To recognize and respect the mutual financial goals of the participating organizations in the decision making process.

To institute an enjoyable work environment in a way that individuals maintain their professional perspective and meet their personal project goals so that the partners can be proud of the project.

To institute an enjoyable work environment in a way that individuals maintain their professional perspective and meet their personal project goals so that the partners can be proud of the project.

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change orders and claims; and by a general inclination to litigate rather than mitigate differences.

This has resulted in too much energy being devoted on many projects to "building a case" for resolution later than to focusing on expeditious correction of errors and to maintaining open lines of communications and trust at the field level. The ultimate outcome throughout the industry has been higher costs, lower profits, and compromises in productivity, schedules, and quality. Frankly, a judge or jury lacking the technical expertise to objectively assess construction claims seldom proves advantageous to anyone.

Where partnering agreements have been utilized, average schedule reductions of 11 percent have been reported (at no loss in quality) and with fewer unresolved claims. Using the practice, ADOT anticipates $7 million worth of savings on $415 million worth of infrastructure projects. ADOT expects an 18 percent average reduction in schedules, a 33 percent reduction in consulting engineer costs, and has identified $880,000 in value engineering savings, which are split 50/50 between ADOT and contractors. Twenty-one projects, worth $64 million, of the 97 subjected to partnering have been completed since 1991. This and Corps achievements caught the attention of ConnDOT.

Challenges of Route 8

Work on the Route 8 viaducts is restricted to continuous 59-hour periods on weekends. Potential penalties range in amounts from $5,000 for the first half-hour up to $9,900 for the third half-hour increment for missing the 6 a.m. deadline on Mondays to reopen the roadway to traffic. Liquidated damages in the amount of $10,000 per diem also apply for each day the contractor exceeds the total schedule of 508 days or for each day exceeding certain work packages therein. ConnDOT has subdivided the work into two phases and three sites.

Site 1 involves two northbound and two southbound lanes of Route 8 over Route 313 and the Naugatuck River. Site 2 addresses a four-lane Route 8 viaduct over Route 67 and the Metro-North Railroad. Site 3 is a four-lane bridge carrying Route 67 across the Naugatuck River.

The Route 8 viaducts are divided roadway structures with 7-in., reinforced-concrete decks composite with steel rolled beams and supported by hammerhead-type piers. The first has ten simple spans totalling 1,000 ft. in length and variable widths from 70 to 125 ft. The second has 24 simple spans that carry the two northbound and southbound roadways with a total length of 1,725 ft and each is 35 ft wide. A 1991 traffic census showed an ADT of 19,500 SB and 18,400 NB vehicles. The Route 67 bridge over the

(Continued on page 82)

Co-Composting Serves Tennessee County

As municipalities struggle to make their way through increasing disposal costs created by the litigation- and regulation-strewn landscape of modern waste management, they might do well to consider the experience of Sevier Solid Waste, Inc. (SSWI), a county-wide public authority whose waste management solution serves as a model of cost-effectiveness and environmental soundness.

In Sevier County, Tennessee, located to the southeast of Knoxville in eastern Tennessee, the solution has been to co-compost both solid waste and sludge in a state-of-the art facility, and sell the compost end product. Since the SSWI plant came on line in September 1992, the municipal waste stream in Sevier County has been cut by nearly 75 percent, far exceeding the current state waste diversion mandate of 25 percent.

The county's year-round resident population now stands at about 51,000, though tourists, drawn by the attractions of Great Smokies National Park, swell that number significantly in the summer months. While the population density does not place Sevier County in the same category as its counterparts in northern New Jersey, it is enough to have caused concern about diminishing landfill resources and escalating tipping costs.

The Search for Alternatives

In 1990, when SSWI began considering an alternative to its system of wholesale landfilling, awareness of co-composting as a technology was very low, among both Sevier County municipal officials and the general public. The same was true of Tennessee as a whole.

Municipal officials in Sevier County were keenly aware of the need for an alternative waste disposal method. SSWI had been formed two years earlier to deal with just this issue. The county's population had grown 23 percent from 1980 to 1990 while per-capita waste had grown 100 percent in the same period. The existing waste disposal resource—a ten-acre landfill—was expected to exhaust its capacity within a year.

Waste stream and population projections showed that replacing the landfill would require acquiring a new site of at least 100 acres. Moreover, that site would have to conform to the new Subtitle D federal landfill construction standards, involving considerable topology and hydrology analysis, design, and engineering—factors that would have substantially increased both development and management costs.

"We expected our tipping costs would rise to $30 a ton when everything was done," said John DeMoll, general manager of the Sevierville co-composting plant. "That would have been a 100 percent increase, with no slowing down on landfill consumption."

Incineration would slow landfill construction, but was ruled out because of the experience of nearby Knoxville, where objections from the National Park Service, based on the city's proximity to the Great Smokies National Park, had effectively scuttled plans for an incineration plant. Sevier County actually contains part of the park, making the odds of overcoming similar objections virtually impossible.

When members of the SSWI board began investigating recycling as an alternative, board members ruled out curbside separation recycling as unreliable and ineffective. Composting then emerged as a preferred alternative, particularly after members of SSWI made a number of trips to composting facilities around the country.

In Sevier County, the nature of the solid waste stream imposed certain conditions on prospective composters. The growing local economy, with its large tourism sector, produced wide fluctuations in waste stream volumes between summer and winter seasons. SSWI wanted the large amounts of restaurant waste grease produced by the county's many restaurants, at the time collected by a private carting service, included in a disposal solution.

The SSWI issued an RFP for a solid-waste composting plant, and ended up with four short-listed companies. Bedminster Bioconversion Corporation, a Cherry Hill, New Jersey firm, was chosen on the basis of its operational experience and patented technology.

Co-Composting: Nature's Own "Technology"

The core of the Bedminster system is the Eweson® (pronounced AY-ve-sun) digester, an enclosed rotary vessel, as large as 16½ ft across by 220 ft long, into which combinations of solid waste with sewage and septic sludge are introduced under perfect environmental conditions that support rapid microbial activity. The result is humus, the organic component of soil.

In an Eweson digester, where temperatures reach 160°F, the natural process of decomposition is accelerated dramatically. After three days, nearly 70 percent of the municipal solid waste (MSW) and 100 percent of the sludge emerges as compost. The balance is nonbiodegradable material that can be screened off, and either further processed for recyclable materials or landfilled.

Even this "reject" material is inert and sanitized, a major issue for those with landfill leachate or methane gas concerns. Unlike some composting systems whose

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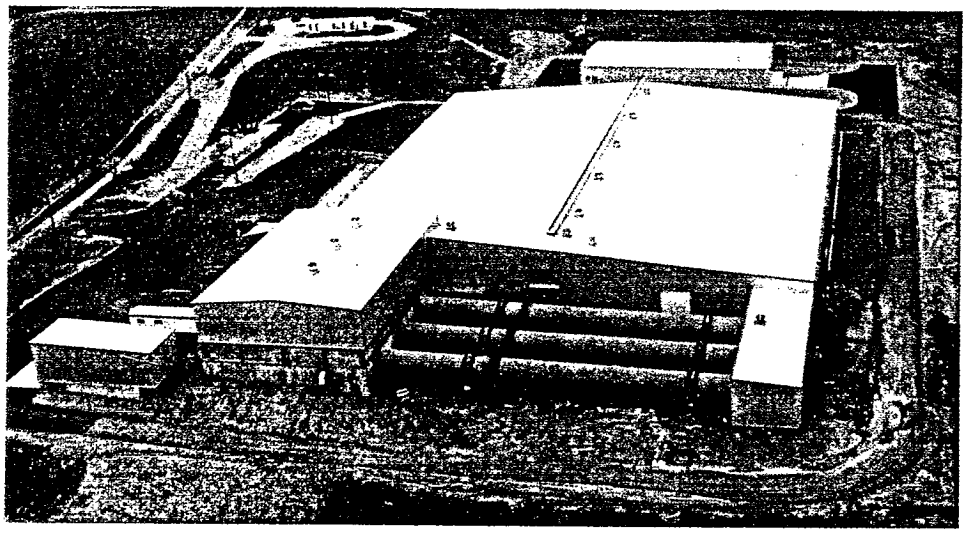


■ CO-COMPOSTING facility in Sevier County, Tennessee. The three digesters are in the foreground.

end product resembles shredded paper in consistency, the end product of this composting process looks and feels like dirt.

That the chosen system can process sludge was an added plus for SSWI, because sludge in Sevier County had also been landfilled. Sited on 2½ acres, the 90,000-sq ft Sevierville plant uses three digesters, each with three compartments. The three digesters can process over 150 tpd of solid waste and at least 75 tpd of sludge. Unsorted solid waste arrives at the plant in packing trucks and is offloaded onto the tipping floor. There, oversized objects such as tires and rolls of carpet are pulled out of the mix before it is loaded onto the digester.

Sludge is then introduced to bring the moisture content up to 50 percent and the carbon:nitrogen ratio up to 30 to 1. The Bedminster system can successfully process sludges with solids content of two percent or higher.

Each digester contains three compartments, corresponding to a different stage of the composting process. In each compartment, a small percentage of the previous digester's load is left inside to act as a bacterial catalyst, much as "starter" dough is used to raise sourdough bread. The microbial activity causes the temperature to exceed 131° to condition the material and begin the process of killing pathogens.

At the end of the first day, the contents of the first compartment are batchloaded into the second compartment, with a small portion left behind to catalyze the next load. At the end of the second day the process continues, and the material in the second compartment is transferred to the third compartment, again leaving an inoculum for the incoming load. At the end of the third day, the batch is unloaded from the end of the digester. What emerges is a mixture of finely digested organic material and undigested inorganic material. It falls from the digester onto a conveyor belt and is moved onto a 1¼-in. trommel screen. Glass and ceramics emerge from the process in a sandy consistency, analyzing out as silica in the final product. Heavy plastics, metal cans, and other non-biodegradable materials emerge intact and are separated by a trommel screen for further processing. Metal and plastic can be removed for recycling, and the balance of the residuals can be landfilled.

The composting process in Sevierville is free of odors. All the composting takes place in a completely enclosed facility, equipped with an air treatment system that eliminates odor problems and creates no air, water, or soil pollution. Air from the plant is processed through 3-ft deep bio-filters where aerobic bacteria—working on the air through layers of stone, gravel, compost, and bark topped with plants—remove any remaining odor.

The compost is aerated for six to eight weeks to complete the curing process. It is then final-screened to meet specifications for the agricultural, landscaping, or nursery market. The batch system allows independent control of each day's waste flow.

The technology itself is only one piece of the "right fit" equation. Whether the technology was in fact turn-key, and whether it required extensive maintenance and retraining the work force were questions that faced the SSWI board. The potentially sensitive subject of effective privatization of this previously public function was solved by reassigning SSWI workers into the new plant (under a Bedminster manager) and by public ownership of the plant.

A false perception exists that co-compost made with sludge and solid waste must invariably contain high concentrations of either pathogens or heavy metals such as cadmium and mercury. In Sevierville, Bedminster used the compost standards of Florida, since Tennessee is still formulating co-composting standards. When measured for organic nutrient value, inert matter, and foreign matter against the three grades of Florida compost—agricultural, horticultural, and private home use (the finest)—SSWI's compost has registered only half the maximum parts-per-million permitted.

When SSWI solicited proposals for its plants, a major concern was the ability to find markets for the compost end product. In the case of the Sevierville plant, all the compost for the next year has already been sold to two soils dealers in Pigeon Forge and Knoxville.

The efficacy of Bedminster's plant design and the quality of the end product would be moot if they were not tailored to SSWI's cost considerations. SSWI financed the Sevierville plant through a $9-million public bond issue. The issue covered not only the costs of acquiring the new landfill site and constructing the plant, but also erecting a new recycling building adjacent to the plant, and purchasing additional machinery such as a tub grinder to pulverize large pieces of wood.

During the building of the plant, Bedminster provided turnkey construction services. SSWI owns the plant, and has contracted with Bedminster to operate it for five years under an operating agreement with five-year renewal periods, which includes an annual operating and maintenance fee. SSWI and Bedminster share compost sales revenues.

With its new co-composting waste stream system in place, SSWI has projected its current disposal costs to be approximately $30 per ton of total waste processed. In the meanwhile, landfill consumption in Sevier County has decreased from 4½ acres a year to ½ acre a year. □□□

R0013723

Washoe County Stakes Its Claim on Effluent Reuse

JOHN COLLINS, P.E.
Director, Utility Division
Washoe County, Nevada
and
FRANK APPELFELLER, P.E.
Project Engineer,
Black & Veatch
Cincinnati, Ohio

NEVADA earned the name the "Silver State" from the famous mining boom of the last century. Now Nevada is undergoing a modern day boom. Stimulated by gaming industry growth and its attractiveness as a retirement location, Nevada has recently led all states in population growth rate. The mushrooming of Las Vegas in southern Nevada has been well publicized. To the north, the city of Reno and surrounding Washoe County have seen their fortunes rise in similar fashion.

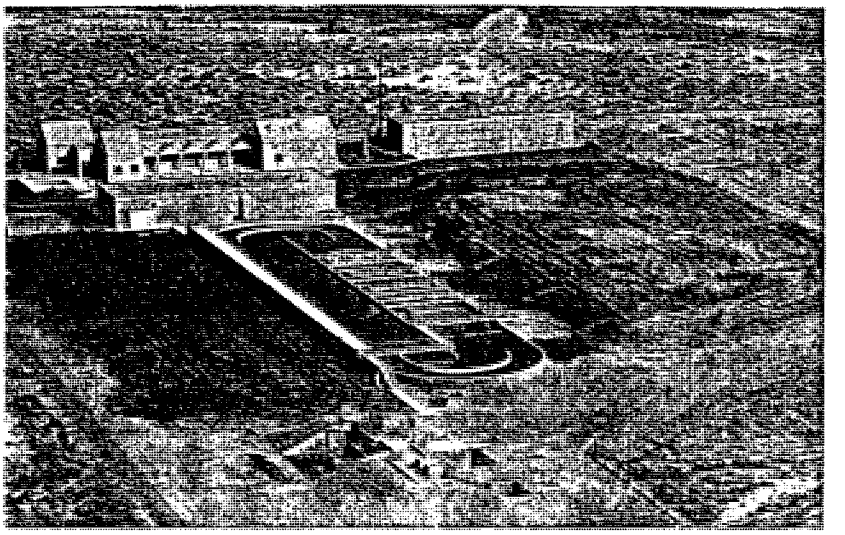
The heart of Washoe County is located in the Truckee Meadows between the Virginia and Carson mountain ranges, northeast of Lake Tahoe. Typical of much of the western U.S., the region is arid, receiving less than 10 in. of rainfall per year. Increasing demand has made water as precious as the silver ore that made Nevada famous in times past. The rights to own and manage water are often overriding concerns in the political arena. Practices that maximize the benefits of available water supply, such as wastewater reuse, are becoming an essential part of successful growth strategies.

Washoe County foresaw the current boom. In the early 1980s, three major developments were proposed for the Truckee Meadows area south of Reno. These developments were planned for a population equivalent of nearly 66,000 people. Until then, most utilities in the county were privately installed and operated. The county recognized the need to take a role in water management and created its utility division to provide water and sewer services.

In 1984, the county completed a water and wastewater facilities plan for the south Truckee Meadows area. To help conserve the available water supply, the plan recommended that wastewater be collected, treated, and reused within the drainage basin. A special sanitation assessment district was formed to finance the building and operation of the planned sub-regional wastewater facilities. Preliminary design of the South Truckee Meadows Wastewater Treatment Plant was initiated in 1987.

Implementing the project involved numerous challenges, including:

- A legally imposed construction start deadline.
- Site considerations relating to Native American cultural resources and wetlands.
- The need for treatment process flexibility to meet anticipated discharge limitations.
- Provision for storage of treated wastewater during the off-season when irrigation is not practiced.



■ RACETRACK-type oxidation ditch is designed to provide both biological treatment and secondary sedimentation at the South Truckee Meadows Wastewater Treatment plant.

Site Considerations

The plan called for the wastewater treatment plant to be located at the entrance to a draw in the Huffaker Hills south of Reno. With high ground on three sides, this draw was a natural enclosure for entrapping wild game by early Native Americans. It was expected that artifacts from these hunting activities would be found scattered throughout the area. To locate and preserve these artifacts, extensive cultural resource investigations were conducted, including some excavation. Based on the results of these investigations, treatment facilities were sited to avoid impacting these cultural resources.

The plant site is in a low area in the 100-year flood plain. The southeast corner of the property is adjacent to where Thomas Creek enters man-made Alexander Lake. A wetlands delineation performed by the Corps of Engineers classified about one-third of the site as wetlands. The county made an extensive effort to preserve these wetlands. The plant perimeter fencing was designed and installed to separate the wetlands from construction activities and future plant operations.

However, the relative locations of the plant and the collection system meant the 36-in. incoming sewer would pass through the wetlands. Although a Corps of Engineers nationwide general permit (under the Section 404 rule) allowed, with certain limitations, sewer construction through the wetlands, the county wanted to preserve wetlands in their existing state. Thus it was required that the sewer be designed and constructed on a less direct alignment that bypassed the wetlands.

Phased Construction

The plant's preliminary design was completed in May 1988. However, a fast construction start was necessary if the county was to build on the planned site. A legal arrangement set forth in the early 1980s gave Washoe County free use of the site, provided construction was initiated no later than October 1988. Failure to meet the deadline might have resulted in new and extensive site selection work, plan revisions, and significant project delays.

To meet this short time requirement, a phased construction plan was devised. Because extensive site development was necessary for access and flood protection, the site work was designated the initial fast-track construction project. Design work was completed and bidding soon followed. A notice to proceed with site development was issued in September 1988—enabling the county to meet the required deadline. This initial contract covered the plant access road construction, filling and grading the site to above the 100-year flood plain, and installing perimeter fencing to protect the wetlands and treatment plant site during and after plant construction.

R0013724

Construction was completed in early 1991. The plant's initial phase has an average flow capacity of 1.5 mgd; the planned ultimate capacity is 6.0 mgd. The treatment processes include preliminary treatment, biological treatment using an oxidation ditch activated sludge system, secondary sedimentation, and disinfection. The plant can operate in the extended aeration mode up to a capacity of about 0.75 mgd to achieve the required sludge age for solids stabilization. Once actual flow nears 0.75 mgd, the need for additional solids treatment capacity must be reviewed.

The discharge permit for the plant issued by the Nevada Division of Environmental Protection (NDEP) requires the treated wastewater to meet average limits of 30 mg/L biochemical oxygen demand (BOD) and 45 mg/L suspended solids; the fecal coliform limit is 200 coliform forming units (CFU) per 100 mL. The permit allows discharge to state groundwaters by means of spray irrigation.

Before completing design work though, the project team coordinated its efforts with NDEP to identify two significant probable future discharge limitations. Because of concern for nitrate levels in potential groundwater supplies, NDEP indicated that future discharge permits were likely to include effluent limits for nitrogen. In addition, NDEP was then developing statewide guidelines governing wastewater effluent reuse. These guidelines have since been codified in Nevada state regulations.

Previous reuse guidelines as they applied to the county's spray irrigation operation generally required that the effluent meet secondary treatment standards. The new guidelines established requirements beyond these standards and set tiers of required disinfection efficiency based on the reuse method and the available buffer zone (to limit human contact). For example, under the new guidelines, a feed crop spray irrigation operation with no restriction to human access (i.e., no buffer zone) requires disinfection to an effluent fecal coliform limit of 2.2 CFU/100 mL. The same operation with a buffer zone of 800 ft or more requires no disinfection. Similar ranked limits are set for additional reuse methods, including other types of irrigation, industrial or commercial applications, and impoundments.

The county's initial reuse program consists of agricultural spray irrigation that requires a coliform limit of 200 CFU/100 mL. However, the county plans future reuse applications (for example, golf course irrigation) within the basin that will require the effluent to meet the 2.2 CFU/100 mL disinfection limit. Because advanced treatment processes are generally required to reliably achieve this lower limit, the plant was designed with flexibility for future installation of additional treatment processes.

To meet the anticipated future nitrogen limit, the biological treatment process was designed to reduce total nitrogen to less than 10 mg/L. The oxidation ditch is configured to achieve carbon oxidation, nitrification, and denitrification using a single-stage aeration system. The oxidation ditch is a "racetrack" type. Carbon oxidation and nitrification are achieved in an aerobic zone that spans one straight run of the 260-ft ditch. Aeration is accomplished using a coarse bubble diffuser system with air supplied by centrifugal blowers. Secondary clarification is also performed in the ditch through an intra-channel "boat" clarifier.

Denitrification occurs in an anoxic zone of zero dissolved oxygen ahead of the aerobic zone. This anoxic zone is produced by introducing the raw wastewater at an appropriate distance ahead of the aerated zone. In the absence of applied air, the raw wastewater exerts sufficient oxygen demand to bring the dissolved oxygen level to near zero, thereby creating conditions for denitrification.

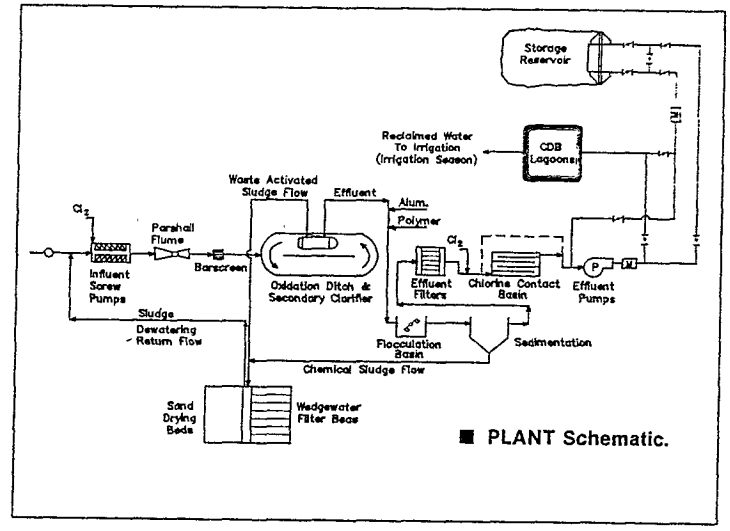
To consistently achieve a coliform limit of 2.2 CFU/100 mL, flocculation, filtration, and second-stage sedimentation facilities will eventually be required. These processes will be located between the oxidation ditch and the chlorine contact basin (part of the initial facility). These additional facilities will be installed without intermediate pumping as the plant is designed with a hydraulic drop of about 8 ft between the boat clarifier and chlorine contact basin water surface elevations.

Off-Season Storage

The growing season in Washoe County generally runs from about May through October each year. During the rest of the year, conditions do not warrant irrigation and a means of storing treated effluent during this "off-season" is required. A rock-filled dam 120 ft high was built north of the treatment plant. The dam creates a reservoir capable of storing all plant effluent (at the ultimate average capacity of 6 mgd) for a full off-season period—3790 acre-feet.

The rock-filled design was selected because this dam type did not require an overflow spillway, thereby reducing the project cost. In the remote event of an overflow, the reservoir can overtop the dam crest without causing significant damage to the downstream rock face. The dam's upstream face is lined with reinforced concrete, and a grout curtain under the upstream toe minimizes leakage. The reservoir is also lined with a bentonite clay and soil mixture to reduce bottom leakage.

Two parallel force mains extend from the treatment plant effluent pump station to the reservoir. The pipes are encased underneath the dam embankment and connect to a multi-valve inlet/outlet structure at the upstream toe. This pipe network is designed with extensive flexibility. It allows flow in either direction in each pipe; it also permits several pumped and gravity flow options to convey effluent between the treatment plant, reservoir, and the reuse facility.



■ PLANT Schematic.

In the arid West, reusing treated effluent has become a key element of water management programs for communities like Washoe County. Cooperation and creativity minimized impacts on cultural and ecological resources. Good planning produced systems that can be conveniently adapted to changing regulatory demands. With the foresight shown in developing the South Truckee Meadows Wastewater Treatment Plant, Washoe County assured the community maximum utility from its scarce water resources. □□□

R0013725

Street Sweeping and Stormwater Regulations

WHETHER you are affected by the requirements of the new stormwater provisions of the national Clean Water Act, it is important to know that street sweeping has been shown to reduce stormwater pollution.

To achieve "fishable, swimmable standards," the Clean Water Act was amended in 1990 with provisions regulating the quality of stormwater discharged into public waters. Phase I of these regulations requires municipalities with populations greater than 100,000 and uncombined stormwater sewer systems to apply for NPDEs permits. For these municipalities, the NPDES permit requires that stormwater discharge pollution levels be monitored and managed, and that the volume of pollutants entering the system be reduced by the maximum extent possible.

Many industrial activities are also defined in the regulations and required to apply for stormwater permits. Examples include various manufacturing and mining industries and activities. Also, some municipal facilities may be engaged in industrial activities that are covered by the regulations. Examples would be hazardous waste treatment, storage and disposal facilities, landfill and land application sites that have received industrial wastes, facilities that recycle materials, portions of certain transportation facilities, treatment works treating 1 MG or more of sewage, and construction activities of clearing, grading, and excavating that disturb five or more acres.

Controlling pollution at its source has and continues to be the primary objective of the Clean Water Act. The provisions being implemented now require affected industries to document that rainfall will not flush contaminants from their site into an untreated stormwater system.

Methods proven to reduce the pollutant content of stormwater, or that prevent pollutants from entering stormwater systems, are Best Management Practices, or BMPs. For industry, frequent sweeping of site surfaces will be a prominent BMP in many compliance plans.

Affected municipalities will be required to reduce stormwater pollution both at its point of origin and at nonpoint sources including streets and byways. While these nonpoint surfaces are primarily just collectors of pollutants from other sources, they direct stormwater into public waterways. Activities that contribute to nonpoint source water pollution include agriculture, construction erosion, urban runoff, hydrologic modifications, and resource extraction activities.

Demonstration Data

Federal and state funded demonstrations conducted in several municipalities in the late 1970s and early 1980s showed that street sweeping removes important amounts of pollutants from streets and highways. Street sweepers also remove tons of debris and pollution that otherwise would be whisked into the air by passing vehicles or flushed into stormwater drains by rainfall.

Street sweepers fall into three basic operating categories: broom, vacuum, and recirculating air. Among EPA sanctioned studies thus far there appears to be no real evidence to conclude that one type of sweeper is better than another in the management of stormwater pollution. All appear to be as effective as part of a regular sweeping program. The best way to choose a street sweeper type is to evaluate your full range of sweeping needs. Choose the best overall balance of performance and features for the kind of sweeping applications you face most often.

Frequency and concentration of a sweeping program are by far the most important variables in reducing pollutant loads. The differences between monthly and weekly sweeping schedules can be measured in tons per curb mile per year. Plans for sweeping frequency should include consideration of variable such as traffic volume, condition of the road surface, and seasonal debris. Pre-determined route patterns and schedules are most likely to provide an optimum combination of efficiency and cost-effectiveness.

Street sweeping has always been recognized as an important and effective method of capturing construction debris before it can enter drainage systems. Currently, construction sites impacting five acres or more must apply for a stormwater permit. This application must include a description of the location and area of land to be disturbed, proposed erosion control measures, a runoff coefficient of the area, and the name of the receiving water.

The EPA has established a National Stormwater Hotline number: 703-821-4823 to help answer questions about stormwater management and to provide contacts for additional information. Note that this is not a toll free number. Further information can also be obtained from your state or regional EPA office, shown in Table 1. □□□

The preceding information was supplied by Elgin Sweeper Company, Elgin, Illinois.

Table 1—State and Regional EPA Phone Numbers

Region 1—617-565-3580
Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont

Region 2—212-264-2911
New York, New Jersey, Puerto Rico, Virgin Islands

Region 3—215-597-1651
Delaware, Maryland, Pennsylvania, Virginia, West Virginia

Region 4—404-347-2391
Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee

Region 5—312-886-0236
Illinois, Indiana, Michigan, Minnesota, Ohio, Wisconsin

Region 6—214-655-7185
Arkansas, Louisiana, New Mexico, Oklahoma, Texas

Region 7—913-551-7418
Iowa, Kansas, Nebraska, Missouri

Region 8—303-293-1630
Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming

Region 9—415-744-1906
Arizona, California, Guam, Hawaii, Nevada

Region 10—206-553-1214
Alaska, Idaho, Oregon, Washington

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Boston Harbor Project $500 Million Under Budget

The Massachusetts Water Resources Authority (MWRA) has released a progress report on the Boston Harbor Project indicating that the project is $500 million under the budget initially projected in 1988. One-third of all construction needed to end pollution entering Boston Harbor has been successfully completed.

The report also indicates 3000 direct private sector construction, engineering, management, and support jobs have been created and that the overwhelming majority of contracts and jobs have gone to local firms and residents.

"The MWRA needs to report to the public on how, where, and why its money is being spent," said MWRA Executive Director Douglas B. MacDonald. He said rate relief remains his number one priority for residents living in the MWRA service area. According to the MWRA report, the first half of the new primary sewage treatment plant on Deer Island is 53 percent complete.

R0013726





■ CREWS assigned by the Ohio Department of Transportation planted 200,000 daffodil bulbs last fall. By April, roadside along Interstate 71 had blossomed in an eye-catching display.

Roadside Rainbow Beautifies District Highway

PIETER WYKOFF
Special Projects Coordinator, Ohio Department of Transportation, Columbus, Ohio

ROADSIDE space along the interstate highway system has to be one of the most neglected examples of landscaping in the nation's urban areas. Think of it. There are thousands of miles of interstate highways inside cities. The acres and acres of roadsides and medians are often the first and the last things a motorist sees when visiting a city. However, rarely does this vast area receive more than cursory care and attention.

"In our urban areas, the roadside interstate space is some of the most visible in the community," says Bill Sherman, a landscape architect with the Ohio Department of Transportation (ODOT). "Yet, we often ignore this space completely."

Sherman and his boss, Mike Flynn, an ODOT Deputy Director in charge of an eight-county district in Central Ohio, decided that space along their district's highways should no longer be wasted. Their solution was a program called Roadside Rainbow, a pilot project to beautify their district's highways by planting dozens of varieties of daffodils along the medians and shoulders. "I'm probably the only engineer in the world who grew up in a greenhouse," says Flynn. "My family has been in the florist industry for more than 100 years. Most people don't realize how much a part of their lives flowers are and what a difference they can make."

Flynn credits a private, non-profit organization called Colour Columbus with providing both the inspiration and the $20,000 worth of daffodil bulbs it took to get the project going. Last year, Colour Columbus President Cherie Lucks offered to donate the daffodil bulbs if Flynn would supply the labor to help plant them at 11 highway sites in the Columbus area. Additional labor and materials were supplied by the City of Columbus, and Colour Columbus volunteers and corporate sponsors.

"This is the state capital," says Lucks. "It's interstate highways are like the chamber of commerce for the City of Columbus and the State of Ohio. Millions of people see them. This project will have a visual impact on those people. It will make them feel good about the city and the state."

Attitudes Changed

Flynn says he "drafted" 15 project inspectors, three groundskeepers, and a few truck drivers as volunteers for the project. State and city workers took soil samples along the highways to determine the best sites to plant the daffodils. The workers then spent about two weeks last fall planting 200,000 bulbs, mostly along Interstates 71 and 70 in Columbus. Flynn says that while some of his employees were initially skeptical of the plan, most ended up becoming big supporters. Many have asked to be reassigned to the program this year.

ODOT Project Inspector Hugh Williams says "At first, we weren't happy about it. We normally inspect bridges and roadways. This wasn't really our line of work." However, Williams says, by the time the three-week planting assignment was over, he and his co-workers were convinced that Roadside Rainbow would be a success.

Colour Columbus President Lucks says planting daffodils is a subliminal way to educate people about the value of beautification. Flynn says there may also be an economic spin-off from the project. If Roadside Rainbow is successful, he says, the state may set up Roadside Rainbow Routes along all of Ohio's main interstate corridors. If people then route themselves through Ohio just to see the flowers, it may have a ripple effect on the economy.

Colour Columbus, with state and local assistance, hopes to plant one million daffodil bulbs in the Central Ohio area by 1995. The organization has already applied for grants from the state and the city to pay for the purchase of an additional 400,000 daffodil bulbs the group hopes to plant beginning this fall. The money would come primarily from federal funds that Congress has designated for road enhancement projects.

ODOT Director Jerry Wray says the Roadside Rainbow project is a good example of a successful public-private partnership. State and city officials worked together with a non-profit organization and its corporate sponsors to achieve a common goal.

The yellow and white daffodils should bloom each year for at least a month. As perennials, they will return for generations. □□□

County Integrates Scanned Raster Files Into GIS

TERRY E. BIEDERMAN, P.E.

Mr. Biederman is the Operation and Maintenance Engineer, County Drain Commissioners Division of Water and Waste Services, Flint, Michigan.

BY 1991 the Genesee County Drain Commissioners Division of Water and Waste Services had accumulated over 9000 as-built construction drawings detailing the entire water and sewer systems. Primarily high quality mylar, the drawings comprise the sole existing record of some 25 years of construction. These records are used daily to operate and maintain the system, to analyze existing problems and conditions, and to design and build new facilities. Due to the importance of these drawings, we began to investigate ways to integrate this information into an electronic environment.

I worked with Daniel J. Potter, Genesee County Chief of Operations and Maintenance, to develop a GIS to incorporate all our utility plans and a comprehensive database into an integrated system. Base maps were already being developed by a sister agency containing all property lines, legal descriptions, road right-of-ways, easements, tax information, property owners, road center lines, etc., for the entire area. Thus, we began to work closely with a consultant to build a customized, yet versatile and powerful GIS for water and waste services. The system runs under the SCO-UNIX Oracle environment to display the base maps and their sewer and water main locations.

During the initial development of the GIS, we were convinced that the archived construction drawings must also be placed on electronic media in a form that could be used in both the GIS and existing AutoCAD (Autodesk, Inc., Sausalito, California) systems.

Integrating Scanned Paper Drawings

There were four basic reasons we decided to integrate our mylar construction plans:

- As the sole existing record of 25 years of construction, a fire or other natural disaster could completely wipe out all our records.
- Our existing drafting package, AutoCAD, would become even more versatile if the drawings, in an electronic format, could be utilized directly by AutoCAD for revisions or new design work.
- To provide a fully functional GIS package, the as-built plans should be accessible from either the graphic environment or the text/database environment in a seamless fashion.
- With over 9000 construction plans, our operation staff had become disenchanted with the existing tub file system and the accompanying confusion every time a specific plan was needed. This was a particular problem in emergency situations, when the archive staff were not available. Often, unnecessary delays were caused in resolving emergencies.

As we investigated various ways to transfer the mylar plans to electronic media, it became clear that in-house scanning would be the most practical and cost-effective approach.

Direct digitizing (conversion to AutoCAD files) represented a huge time commitment, well beyond the capabilities and budget of our existing staff. Using a service bureau to scan and convert 9000 drawings at $10 to $25 per sheet was also out of the question.

At this point, we were fortunate to meet the Rassey Corporation and learn about raster technology. They convinced us that a low cost scanner combined with CAD Overlay ESP, ViewBase, and CAD Overlay GS from Image Systems Technology, Inc. (Troy, New York), could achieve our goal.

In early 1992, we purchased the hardware and software to develop the methodology to successfully convert the mylar plans into a useful electronic imaging system. We scanned the plans in IG4 format to maximize our storage on a 6.5-gigabyte optical disk jukebox. We chose to develop our database to let users search for an individual plan with minimal information. ViewBase was easily linked to the Paradox drawing database using a "hot key" configuration. Once we have done a query through the database, we hit our hot key to start ViewBase and load the requested scanned image automatically. This image can then be marked-up by a supervisor or engineer, plotted, and given to the appropriate personnel for repairs or information. An on-call supervisor can come in at any time, view the needed construction plans in ViewBase, and mark them to repair a water main or sanitary sewer problem without ever having to manually thumb through a tub file or even lift a pencil.

The marked raster files are sent over the network to an AutoCAD operator using CAD Overlay ESP to modify the scanned raster file and draw the revisions in vector format. The resulting hybrid raster/vector file is plotted out and/or sent back to be archived on the jukebox.

The remaining issue was providing the seamless link to our SCO-UNIX based GIS. This was resolved by DOS-merge, which allows us to run ViewBase from inside our GIS with no noticeable loss in speed. We are able to view construction plans in raster format associated with any of the base maps in our customized GIS.

The Future

We have scanned over 6000 drawings or roughly two-thirds of our total construction plans into our database. As we complete our archive, we will be investigating the integration of aerial photographs and other gray scale images into AutoCAD using CAD Overlay GS from ImageSystems.

Until a couple of years ago, we felt that scanning technology was not an operational solution. Today, with new scanners and software products we have found an economical way to store and utilize these scanned images without converting them to a vector based drawing. We often think that if we had undertaken this venture a few years earlier, we would have spent a lot more money to convert these drawings to vector files for use with AutoCAD or other packages. In this case, patience paid off.

The Genesee County Drain Commissioners Division of Water and Waste Services provides potable water, sanitary sewer collection and treatment, and solid waste services to the Genesee County, Michigan area, excluding the City of Flint. We provide these services to a customer base of 27,000 water connections and 61,000 sanitary sewer connections. □□□

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Pennsylvania Borough Gets PMS System

Carlisle, Pennsylvania has chosen ArcCAD geographic information software from Environmental Systems Research Institute, Inc. (Redlands, California) and Earth Information Service's Roadway Inventory and Management System (RIMS) to manage the borough's road and highway system. Upon completing a comprehensive analysis, the borough determined that its primary need was to implement a computerized system that could meet Carlisle's road maintenance management needs, with easy access to information such as pavement history and repair, traffic flow, and report generation.

Borough officials have indicated that they are very pleased with the capabilities of the ArcCAD/RIMS package during its first six months of use. Borough staff members have begun adding other layers to the database, such as roads, bridges, building footprints, streams, ponds, catch basins, hydrants, manholes, utility poles, curbs, sidewalks, and fence layers.

R0013728

■ CROSS-SECTION of pavement core showing the asphalt supported matrix.



Stone Filled Asphalt Pavement

HARRY SCHMERL, P.E., P.P.
Port Authority of New York and New Jersey

As traffic loads and volumes increase, complaints about pavement performance are becoming more prevalent. This is especially true in a region like the New York and New Jersey Port District, an area within a 25-mile radius of the Statue of Liberty that includes some of the world's heaviest-trafficked facilities.

The Port Authority of New York and New Jersey (Port Authority) owns and operates some 30 facilities within the Port District including the six major tunnels and bridges that link New York and New Jersey, three major airports, and two major container ports. The Port Authority's jurisdiction includes 460 lane miles of roadway, 16 miles of runway, 60 miles of taxiway, and over 2700 acres of paved parking lot, marine terminal upland area, and aircraft apron area.

Flexible pavements are the most common type of pavement used within the Port District. Pavement thicknesses range from 6 inches in our parking lots to 38 in. in our aircraft areas. Structural deck wearing courses range between 2 to 4 in. thick. The value of pavements at the Port Authority alone exceeds $1 billion.

As these pavements are challenged to handle more frequent and heavier loads, pavement rutting and shoving has become more evident. As early as the 1970s, standard, high density, hot mixed, asphalt pavement could no longer resist the high surface stresses induced by commercial aircraft tires inflated to 200 psi (over 300 psi for some military aircraft), or the super compaction caused on a facility carrying an ADT count of 270,000 vehicles, 10 percent of which are heavy trucks, or the abuse heaped on pavements by solid-tire cargo handling equipment. High surface temperatures, which reach 140°F during the New York-New Jersey metropolitan area's "dog days," also exacerbate the problem.

While plastic deformation of pavements is common to both aviation and interstate roadways, the problem's magnitude is much greater on the aviation facilities. Thus, the Port Authority has focused its efforts primarily in this area.

A series of cores taken from various distressed pavements throughout the Port District during the early 1970s was analyzed. While the original construction records showed that the pavement materials met or exceeded specified Marshall design parameters—stabilities of 900 lb for roadway pavements and 1800 lb for aircraft pavements, examination of cores showed that almost all pavement deformation took place in the asphalt surface layers.

Research conducted as part of the investigation into ways of producing a more stable asphalt led us to try the Trinidad Lake Asphalt (TLA) modified binders being used by both English and German road authorities. In 1975, two test installations using TLA modified binders were installed. The first was on a short but steep ramp in Port Newark, New Jersey. The second was on the helical approach to the New Jersey entrance of the Lincoln Tunnel. The ADT for the Port Newark ramp was 10,400 with 42 percent trucks; the ADT for the Lincoln Tunnel approach was 45,900 with 10 percent trucks.

Standard AASHTO H-20-S-16-44 designated trucks braking on 5 percent and 8 percent down slopes, respectively, proved how tough the new pavement was, and the TLA modified binders became a Port Authority standard for use in highly-stressed highway and aviation pavement areas.

A series of extensive laboratory tests were also performed in 1984 to analyze further the viscoelastic properties of our standard binders. The study included binders composed of AC 20 [binder A], AC 40 [binder B], a 25/75 blend of TLA and AC 20 [binder C], a 40/60 blend of TLA and AC 20 [binder D], and a 95/5 blend of 25/75 TLA and AC 20 and latex additive [binder E]. The aggregate gradation of the tested mixes fell within the FAA's Mix-3 gradation band and was similar to the gradation used in our standard runway and taxiway top course mixes. Table 1 shows Port Authority specified Marshall parameters and the Marshall results for each mix.

Four specifications resulted from this study. Two specifications use a blended binder having by weight 95 percent TLA/AC 20 (25 percent/75 percent respectively) with 5 percent latex, and two use TLA/AC 20 (25 percent/75 percent, respectively) without latex. Material conforming to the former specification is used for pavement placed on structures and for aviation pavements that are subject to stop and go operations (hold bars and queuing traffic). Material conforming to the latter specification is used for aviation pavements subject to continuously moving operations (mainline taxiways and runways).

These pavements provided adequate service until the 1990s when plastic deformation of the heavy duty pavements became evident again.

Table 1—Specification and Marshall Result at 5.5 Percent A.C.

Items	P.A. Specification	Asphalt A	B	C	D	E
Stability, lb	1800 min.	1870	2185	2358	2770	3177
Flow, 0.01 in.	8 to 16	7.5	8.3	9.0	9.0	10.06
Air Void in Mixture (%)	2.0 to 5.0	3.04	2.88	3.49	3.7	4.2
Unit Weight, pcf	—	153.1	153.5	153.6	154.1	152.4
Void Filled with Bitumen (%)	74 to 84	81.2	82.1	79.03	76.31	74.5

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Cores taken through various, newly-distressed pavements such as those located at LaGuardia and Port Newark were analyzed and found to exhibit most, if not all, the following characteristics:

- All deformations occurred in the asphalt layers.
- In-place air voids were below 3 percent.
- The mix contained a large percentage of natural sand.
- Aggregate gradations were along the upper or finer edge of the specified gradation band.
- Asphalt viscosities were less than that of the original AC 20. (The asphalt appeared to be contaminated with fuel and hydraulic fluids.)
- 5 to 8 percent of the mix passed the 200 sieve.

Core cross-sections also show that there was an insignificant amount of stone-to-stone structure within the mix and that the asphalt binder floated the loads.

The approach taken to alleviate the rutting and shoving problems combined several elements as follows:

- Continuing the use of modified binders (AC 20 with Trinidad Lake Asphalt (TLA); AC 20 with TLA and latex; AC 20 with Styrelf, an asphalt modifier. Installations with other asphalt modifiers such as Vestoplast S, Kraton, Elvax, and Novaphalt are being evaluated.
- Adding a crater percentage of 1¼-through ¾-in. sized stone.
- Requiring manufactured (angular) sand in lieu of natural (rounded) sand.
- Narrowing the aggregate mix gradation band around the bottom of the original gradation band (provides more stone-to-stone contact).
- Reducing the percentage of less than 200 sieve size material.
- Increasing the Marshall voids.

The effectiveness of the new stone-filled asphalt mixes (SFAM) were verified both in the lab and on a taxiway.

A SFAM conforming to the FAA's 1¼-in. nominal size stone gradation was developed in the lab using standard Marshall design methods (with a 6-in. mold and 120 blows). The SFAM plug, using AC 20 as the binder, had a 4.6 percent asphalt content, 4 percent voids, and stabilities over 3000 lb. Adding blended binders to the Marshall specimens boosted stabilities approximately 20 percent. Cross-sections through the Marshall plugs showed a stone-to-stone supported matrix.

Test Sections

Two, 400-ft long test sections were placed on Taxiway "P" at John F. Kennedy International Airport in spring 1991. Both sections used blended binders with the new gradation. One section had the 95 percent Trinidad Lake Asphalt-AC 20 (25/75) with 5 percent latex as the binder; the other section had Styrelf as the binder. Both sections were constructed using two, 3-in. loose lifts over old concrete pavement. Thermocouples were placed in both sections below each lift. Using a Dynapac CC-50 vibratory compactor, 16 passes were required to achieve 98.6 percent compaction. This represents a two-fold increase over the compaction effort usually required to achieve the same level of compaction on our standard pavements.

Plate bearing tests, using 6-in. diameter plates, were performed on the pavements before they had a chance to cool. A maximum deflection of 0.11 in. was observed on the TLA/latex binder section after the vertical deformation reached its maximum value and the 300 psi stress sat for an additional one-half hour. The maximum deflection on the Styrelf section reached 0.20 inches. Pavement temperatures at the time of maximum deflection were approximately 135 °F. Six-in. diameter cores were extracted from areas adjacent to each plate bearing test and brought into the lab where they were subjected to a static creep test. To approximate the field deflections, chamber pressures had to be increased to 100 psi, while the 300 psi vertical stress was applied, and the 135 °F environment was maintained.

Table 2—Field Test Results

Marshall Data	In-Place Density
Voids-4.6 %	Voids-6%
Stability-3400	98% of Marshall Density
VMA-14.5	
Flow-17	
Voids Filled with AC-69%	
AC-20 Modified with Styrelf Grade D Binder-4.2%	

The following conclusions were drawn from the tests:

- The new, SFAM spec improves mix stability.
- The SFAM looks boney.
- Cohesion plays an active role in providing resistance to load-induced stresses.
- Once cohesive forces are known, the static creep test is a good predictor of pavement performance.
- Cohesion is dependent on mix gradation and binder.

Several projects were constructed in 1991 and 1992 using the SFAM pavement. Large areas of the mat appeared boney and segregated, especially at the joints and in those areas where hand work and raking took place. Several non-technical personnel also expressed concern about premature ravelling. Daily pavement sweeping dispelled that impression.

The remedies taken to reduce surface boniness require the contractor to eliminate all handwork and raking. The paving machine must start on blocks to compensate for compaction of the loose material and to eliminate the need for adding material to bring the joint up to grade (the height of the block is generally one quarter the height of the paving course). A full-course thickness transverse end joint must also be cut across the paving lane whenever work in that lane is completed or the paver runs out of material. Excess material may be broadcast back into the hopper when paving operations are expected to start up immediately, and the paver is elevated. The minimum thickness of each compacted paving course has been raised to 3 in. to permit proper seating of the stone under the rollers. The paver also must be set so that it overlaps the adjacent mat's longitudinal joint by approximately half the compacted course thickness to create a tight joint. Here too, excess material must be broadcast back into the hopper.

An inspection of the aviation pavements after they had been in service for only one year indicates that the surface had tightened up and no longer gives the impression of eminent ravelling.

Drainage Considerations

Because the voids in the new mix are greater than those of the original mix, special consideration must also be paid to drainage. For new construction, each successively lower layer must be designed with a relative permeability one order of magnitude greater than the layer it underlies. For overlay construction, the crown of the existing surface is retained and bleeder drains are added beneath the overlay to get the infiltrated water out of the pavement.

Based on our airfield experience, a new roadway mix was developed in 1992. The new mix, designated I-4A, added 1 in. stone to the Authority's standard nominal ¾ in. I-4 mix and narrowed the gradation curve around the I-4's lower band limit. The mix was placed along a major truck route at Port Elizabeth. Here again, while the surface looked boney, cores proved that stone-to-stone contact was achieved. In-place Marshall and field density data is shown in Table 2.

Work is also continuing, using the static creep test, to determine the effect that new modifiers have on pavement stability. Test installations are also being planned to demonstrate the value of any promising new additive. Installation of a Vestoplast-S test section was planned for spring 1993.

The information presented in this paper represents the Port Authority of New York and New Jersey's progress towards strengthening pavements to withstand the high stresses induced by both high-pressure aircraft and truck tires. Thus far, these efforts seem to be working. We have improved pavement resistance to deformation and a number of our improvements agree with conclusions reported by the National Center for Asphalt Technology, Auburn University. □□□

R0013730

Vegetation Control for Safety

DURING the growing season, grass, weeds, and brush often limit a driver's view of approaching vehicles. Likewise, lush vegetation can act as a screen that hides pedestrians and bicyclists from drivers and vice versa. Be alert for places where vegetation needs to be cut back.

The main safety goals for vegetation control include:

- Keep signs and vehicles visible to drivers as well as pedestrians and bike riders in cross walks, at street lights, at uncontrolled intersections, and on bike paths;
- Help pedestrians and bike riders see on-coming traffic more easily;
- Improve winter road maintenance in snow and ice areas.

Line of Sight Clearance

Drivers approaching an intersection need a clear line of sight along crossroads early enough to see any conflicting vehicles, pedestrians, and bicyclists and avoid a collision. Drivers also need an unobstructed line of sight to any roadside signs or hazards far enough in the distance to allow them to react safely to each situation.

Suggested maintenance steps to keep signs and traffic control devices visible include:

- Look for signs and other traffic control devices blocked by brush, trees, grass, or weeds when on routine maintenance patrol. Often a small branch near the sign is all that needs to be cut back. If vegetation along the ditch or shoulder blocks a driver's view of a sign, cut enough to allow the driver sufficient time to see the sign and respond to its message. If your agency has a policy on how far from a sign vegetation has to be cleared for a safe view, follow that policy. If there is no such policy, Table 1 is a suggested guideline to allow a driver 3 to 5 seconds to read and obey the sign.

Critical signs are STOP, YIELD, DO NOT ENTER, ONE WAY, WRONG WAY, and other regulatory signs. Noncritical signs are destination guide signs, parking regulations, advance warning signs, and similar warning or information signs.

- Pull the maintenance vehicle off the traveled lane and place traffic control warnings.
- Cut or trim trees, brush, weeds, or grass to clear a driver's line of sight to the sign or traffic control device. *Always wear protective leather gloves, safety glasses or goggles, orange safety vests, hard hats, and leather boots (not sneakers or soft shoes).*

Table 1—Clear Distance to See Sign

Speed Limit (MPH)	Noncritical Signs (feet)	Critical Signs (feet)
30	150	250
40	200	350
50	250	450
60	300	600

- Paint the stubs of brush or small trees with a weed killer solution to keep them from growing back.
- Collect limbs and large brush to haul away for disposal or run them through a chipper.
- Look for moving traffic when removing the temporary traffic control warnings and leaving the site. Drivers may not realize you are through working and probably will not expect you to pull onto the traffic lane.
- Watch for overhead power lines and electrified farm fences when cutting brush. Never touch a wire farm fence when an electrical storm is in the vicinity of your work.
- Take along the following equipment: leather gloves; hard hats; safety glasses or goggles; orange safety vests; chain saw, fuel, bar oil; gasoline powered "weed eater"; brush knife or machete; loppers (long handled side cutters); tree trimming saw with small branch lopper; tall step ladder; and axe.

Vegetation Control in Cities

In cities, you will often be cutting vegetation so drivers can see signs and other traffic control devices at intersections. When one of the streets is a minor street and you can work safely away from the traffic, try to park your vehicle on that street and carry your equipment to the major street. This will interfere with fewer drivers and create fewer hazards to you and other workers.

When an intersection has no STOP or YIELD signs to control who enters the intersection first, drivers must be able to see each other, pedestrians, and bicyclists soon enough to avoid a collision. The property line for a city corner lot will probably be a square corner that comes right up to the street corners. Usually you are not permitted to work outside the right-of-way lines. Some cities have an ordinance giving the city a sight distance easement. Such an ordinance authorizes the maintenance worker to ask the property owner to trim back any trees or shrubs that block the corner sight triangle; if the property owner does not comply, the ordinance authorizes the maintenance worker to trim the trees or shrubs as he sees fit. However, check with your supervisor before working outside the city's right-of-way. No shrubs or plants in such an area should be allowed to grow more than 3 ft high.

Table 2—Stopping Sight Distance

Speed Limit (MPH)	Stopping Sight Distance (feet)
20	125
30	215
40	330
50	470
60	650

At intersections with no stop signs (or with stop signs only at the cross street), drivers from all (both) directions need to be able to see oncoming traffic soon enough to be able to stop. Table 2 lists the stopping sight distance needed for different speed limits on a street.

Rural intersections also need to have clear intersection sight distances. In rural areas we expect higher speed limits and need the longer stopping sight distances listed in Table 2.

When vehicles are traveling along the inside of curves, drivers must be able to see ahead around the curve for the same stopping sight distance as at intersections. Cut brush, weeds, or trees growing in the roadside ditch that block the drivers' view on the inside of the curve to let them see a full stopping sight distance.

On divided roadways with median crossovers, drivers entering a median crossover must be able to see approaching vehicles for a clear distance at least as long as for an intersection. Vehicles using a median crossover will usually be entering the traffic lanes at slow speed. Providing good sight distance at median crossovers allows the higher-speed drivers on the through lane to avoid collisions with vehicles entering their lane from a median crossover.

R0013731

At-grade railroad crossings are special intersections. The most important thing to do in vegetation maintenance at railroad crossings is to make sure the crossing signs and signals can be clearly seen by drivers, bike riders, and others approaching the crossing.

- Clear vegetation to the railroad crossing signs and the advance warning signs to provide good sight distance.
- Clear vegetation to provide good sight distance of all flashing signals when a crossing has signals.

Do not enter the railroad right-of-way to cut vegetation unless you have been authorized to do so by your maintenance supervisor and are supervised by railroad employees. Cut the vegetation enough so that normal growth will not reach to a 3-ft height for at least one month.

Most private property owners are willing to cooperate in improving traffic safety. They should be required to keep all bushes and shrubs at a height of 3 ft or lower and to trim all trees and hanging branches to a minimum height of 7 ft. If notice of a violation is provided and a homeowner does not respond in a reasonable time, most public agencies have regulatory powers to remove the designated vegetation at the homeowner's expense.

Clearing Clear Zones

Trees growing in a clear zone are a special problem. Evergreen trees or trees in full leaf in the highway right-of-way block the driver's sight distance for signs and intersections. Trees with trunks larger than sign support posts (typically a 4-in. diameter) can be a hazard to any vehicle hitting them.

On highways we want to keep the roadside clear of trees and other obstructions for up to 30 ft if the right-of-way has that much room. A clear zone gives a driver who runs off the road a good chance to bring the vehicle under control without a crash. Cut trees close enough to the ground so that no stump remains to be a hazard. All trees within the clear zone should be cut while they are still small saplings rather than even small trees. At that time they are easy to cut off at ground level and cause no stump problems. Also, no one will be tempted to try to save a beautiful but hazardous tree in the highway clear zone.

Mowing for Safety

Road and street maintenance workers do three general types of mowing. In order of importance, these are: safety mowing, transition mowing, and selective mowing.

- Safety mowing ensures that signs, other traffic control devices, guardrails, and safety features can be seen and provides good sight distance for drivers approaching intersections, driving along curves, and approaching interchanges.
- Transition mowing makes a smooth change from a narrow mowed width to a wide mowed width when different widths of right-of-way are mowed.
- Contour or selective mowing makes a natural blending of the maintained roadside with native or planted growth and shows off landscaping or wildflower areas or dresses up an interchange entrance to an urban area.

DO NOT mow too often. This wastes money, exposes mowing crews to traffic hazards more than necessary, and can damage vegetation. DO NOT mow at the wrong time. Good timing reduces the frequency of mowing required by cutting the vegetation in the right stage of growth. DO NOT mow too short. Leaving the proper height helps maintain the stand of vegetation and keeps small litter objects hidden.

DO NOT mow steep slopes unless necessary. Steep slope operations increase the risk of mower accidents. DO NOT mow patterns inconsistently or mow a regular area incompletely. Drivers watch the pattern of a mowed area to help understand the safety of an area. Consistent mowing of similar areas helps drivers evaluate the safety of the roadway. DO NOT mow when wet; this is hard on equipment. DO NOT operate equipment carelessly and scar trees and shrubs. Mowing is tedious but care must be taken to avoid accidents and preserve valuable plantings.

DO avoid mowing slopes steeper than 2.5:1 with a regular mower unit. Mow steep slopes with a side-mounted mower on a boom if the tractor unit remains on flatter surfaces while mowing. DO operate side-mounted or boom mower units on the uphill side of the tractor to limit the possibility of overturning the tractor. DO replace broken or lost chain guards to deflect debris immediately. Using flail type mowers reduces the amount of debris thrown. DO cover all v-belts, drive chains, and power takeoff shafts. DO raise mowers when crossing driveways or roadways. DO shut off power before checking any mower unit. Block a mower before changing, sharpening, or replacing a blade. Any blade being reinstalled should be checked for cracks or damage that might lead to failure. DO use flashing signals and slow-moving-vehicle signs on all mower tractors. DO warn traffic with signs such as MOWING AHEAD, MOWING AREA, or ROAD WORK AHEAD. Signs saying MOWING NEXT (____) MILES may be used in advance of the operation, but the distance limits should not be shorter than two miles nor longer than five miles.

Traffic Control

Mowing is a moving operation taking place off the roadway. Therefore, it requires different traffic control from other maintenance operations. The most important thing to remember is to make the mower unit highly visible to drivers. That way drivers will be alert to you and will be able to avoid potential collisions.

- Operate rotating yellow beacons on mower tractors.
- Install slow-moving-vehicle signs on all mower tractors.
- Install yellow flasher lights on roll bars or the top of tractor cabs and operate these at all times.
- Install an orange flag or pennant on a whip to show the location of the tractor in high grass or over the edge of slopes.
- Operate the tractor with headlights on at all times.

Warning signs such as MOWING AHEAD, ROAD WORK AHEAD, and similar signs my be placed along the road. The MOWING AHEAD sign is preferred. The sign is to be used in advance of mowing operations on the right of way. Place it on the shoulder so the approaching driver can read the message easily.

As work progresses, move signs one to two miles from the actual mowing work. Mount signs on sturdy portable supports that will not be knocked over or blown down easily. Cover or remove signs during lunch breaks or other times when work is not in progress. Do not cover or remove signs if you have stopped mowing to repair or adjust equipment because the warning to drivers is important to safety operations. □□□

Information for the preceding article was taken from *Vegetation Control for Safety: A Guide for Street and Highway Maintenance Personnel,* Publication FHWA-RT-90-003, U.S. Department of Transportation, Federal Highway Administration Office of Highway Safety, and prepared under the Rural Transportation Assistance Program Project 70 by the Technology Transfer Center, Iowa State University, Ames, Iowa 50011.

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Consultant Chosen for Data Conversion Services

The Calgary Waterworks Division, Alberta, Canada, has selected RJN Computer Services, Inc. (Wheaton, Illinois) to provide facilities management data conversion services associated with implementing a new Waterworks Division maintenance management system.

The goal of the project is to develop from existing records, an ORACLE database of the city's water valves, valve chambers, and water hydrants that can be used with the city's CASS WORKS® maintenance management system and the city's geographic information system. The consultant will develop a numbering scheme for all structures and physically identify and number valves and hydrants on the city's existing maps.

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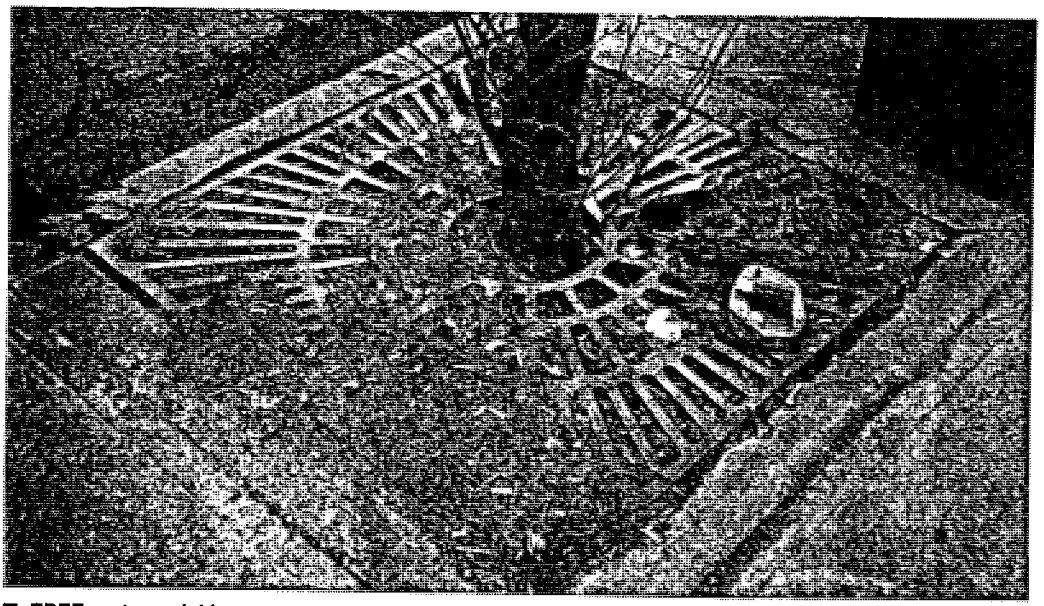

■ TREE grates quickly accumulate litter and weeds if not periodically cleaned and filled with new gravel.

Tree Grates and Guards—Scrapping the Heavy Metal

DAVID GAMSTETTER
Urban Forestry Specialist, Park Board Urban Forest Management Section, Cincinnati, Ohio

FOR nearly 100 years botanists have understood that iron, as a micronutrient, is necessary for tree survival. Iron contributes to chlorophyll formation and, when not readily available in the soil, may cause leaf discoloration (chlorosis) and mortality. However, when it is formed into tree grates and tree trunk guards that are not properly maintained, iron can severely injure or kill valuable street trees. In Cincinnati, improperly maintained tree grates and guards have killed or injured over 300 trees. These trees could cost $90,000 to replace. This figure does not include the actuai value of the trees based on "The Council of Landscape Appraisers Guide for Plant Appraisal," which takes into consideration tree size, species, location, and condition values before their premature death. The one-time cost to make corrective repairs to tree grates and guards citywide could approach an additional $60,000. Cincinnati now has a maintenance program in place to make certain that trees and "heavy metal" can coexist.

Iron tree guards and grates have been used in the United States since the late 1890s. As early as 1903, William F. Fox, Superintendent of the State Forests for the State of New York strongly recommended using tree trunk guards. Fox stated that "the necessity for some such protection is readily apparent on examining trees from the curbstone side, and observing the large number on which the bark has been gnawed by horses." (Fox, W. F., *Tree Planting on Streets and Highways*, Albany, J.B. Lyon Co., 1903.) While Mr. Fox's observations were very important in 1903, today most municipalities in the United States have relatively few equine problems but may experience occasional bumper damage caused by poor parallel parkers or inattentive drivers of large vehicles.

Tree grates have been popular streetscape amenities for the last 30 years because they are attractive and increase the amount of walkable sidewalk surface. Tree grates are perceived as being low maintenance because they supplant the need for mulch and, when properly backfilled with gravel, suppress weed growth.

A Grating Problem To Guard Against

As tree diameters increase, the aperture in the center of the grate must be enlarged to prevent it from girdling the tree. Depending on the size of the tree when planted and the aperture size, fast growing species such as London Planetrees and Callery Pears can be girdled in just a few growing seasons. This problem is greatly compounded if the tree is planted off center or develops surface roots or a buttress at a graft. Once the tree begins to grow into and around the grate, repairs are difficult and cause further injury to the tree. Grates must also be periodically reset in their frames to prevent a tripping hazard when they become unlevel or raised. Broken grates must be replaced when damaged by trucks or buses that use the sidewalk as a lane extension.



■ MOST tree grates are designed to be expandable so inner rings can be removed as the tree grows in diameter. If grate is not enlarged it will injure the tree.

Tree trunk guards, by their design, are temporary at best. Designed to protect the trunks of young trees, they can injure a tree when it moves in the wind or when the guard loosens from the grate and rubs the tree. A loose tree trunk guard can girdle a tree in just a few weeks. Dr. Roser C. Funk, vice president of human and technical resources with the Davey Tree

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Expert Company believes that "tree trunk guards and tree grates are a leading cause of mechanical damage to trees. They have no value other than they are helpful if you have a vandalism problem. Tree grates may be helpful to avoid soil compaction."

Now we get to the real problem. Trees and tree hardware can coexist if the hardware is properly maintained—if tree grates are periodically enlarged and tree trunk guards are repaired or removed to prevent tree injury. The problem is that many cities do not have a mechanism and sufficient funding to periodically inspect and maintain tree hardware. In the grand scheme of city infrastructure projects, it seems tree hardware maintenance falls somewhere between constructing a country club for city employees and upgrading the city fleet to Corvettes!

The Cincinnati Program

Over the past 20 years, tree grates and guards have been standard issue for all capital improvement streetscape projects constructed in Cincinnati's central and neighborhood business districts. In Cincinnati, as in most cities, capital improvement projects do not set aside funding for long term project maintenance. Streetscape installation usually includes new sidewalks, curbs, lights, street trees, tree grates, tree trunk guards, street furniture, and the occasional kiosk, with the intent that the abutting property owner will sign a maintenance agreement to maintain the new amenities.

On most streetscape projects the city enters into a signed maintenance agreement with either the owner of the abutting property or the business district association, a group of abutting property owners who share advertising and maintenance costs. In theory this approach makes excellent sense; proper facility maintenance attracts more customers to the business and increases property values. The fallacy of this is that in hard economic times maintenance of the city-owned streetscape becomes a luxury when compared to meeting payroll or paying suppliers. In some cases where the agreement is not transferrable, the property may change owners with the new owner not legally responsible for maintenance.

As an example, in the Cincinnati central business district there are 1040 streetscape trees; about 40 percent are covered by 27 maintenance agreements with abutting property owners. Of these 27 agreements, only 5 abutting owners actively maintain the streetscape trees and maintain tree grates and guards when asked to do so by the city.

In 1989, Cincinnati's Urban Forest Management Section met with all property owners in the city's central business district who own or manage property abutting a streetscape. A forester discussed each tree's specific maintenance needs and asked property managers to provide routine maintenance such as watering and weed control and to enlarge, reset, or replace problem tree grates and remove tree trunk guards as necessary. As a result, five property owners who hold maintenance agreements with the city and two who are not responsible for maintenance, repaired defective hardware.

When an abutting property owner fails to maintain the tree hardware, the city must assume the maintenance responsibility because broken or unlevel tree grates pose a tripping hazard and thus, a liability problem. When the city recognized the need to maintain tree grates and guards, no specific city agency wanted to assume the responsibility. The street tree program is funded by a small special street tree assessment authorized by the state of Ohio and restricted specifically to street tree planting and maintenance. The assessment cannot legally be used to maintain sidewalks or streetscape hardware.

In a legal opinion rendered by John Hanselman, assistant city solicitor, "Ohio Revised Code grants authority to municipal corporations to levy special assessments on property owners for various purposes including construction of sidewalks. Cincinnati Municipal Code Sections... provide for the responsibility of sidewalk repairs at the property owner's cost. If tree grates serve no purpose in the maintenance of street trees their placement is arbitrary, a decorative part of the sidewalk. As such the sidewalk maintenance provisions of the city code should apply to the repair of tree grates in the sidewalk."

Clyde Hunt, urban forestry specialist with the U.S.D.A. Forest Service agrees with Mr. Hanselman's opinion, "tree grates do not provide any benefit to the tree, they are primarily ornamentation. I would rather put mulch around the trees."

Because Mr. Hanselman determined that tree grates are a part of the sidewalk, their maintenance falls under the jurisdiction of the city public works department's technical support section. When sidewalk problems occur, a sidewalk inspector from the technical support section inspects and marks defective or condemnable sidewalk blocks and orders the abutting property owner to make necessary repairs. If corrections are not made to the city's satisfaction, the city makes the necessary repairs and the property owner is billed for incurred costs. The city administration realized that using this same process with tree hardware repair could be a public relations nightmare—while some property owners signed agreements to maintain the streetscape hardware, many had no agreement and had no idea that they would be required to perform future maintenance on city property.

To avoid the potential public relations problem, the public works department agreed to divert infrastructure improvement funds to pay for a one-time citywide tree grate and guard repair project. Under this comprehensive project, 130 tree guards will be removed, 330 offset tree grates repaired, 260 enlarged, and 62 missing or broken grates will be replaced. All abutting property owners will be notified that the work that was performed and that the property owner will be legally responsible for streetscape hardware maintenance.

Maintenance Procedures

After the one-time repair project, the city's urban forest management section will inspect all streetscape trees every two years and process emergency complaints as they arise. Upon inspection, a forester will mark tree grate problems with paint and complete a form developed by the technical support section to document the problem, location, and corrections needed. The form will be sent to technical support, which issues legal orders to the property owner responsible for repairs. If repairs are not made within a specified time, a work order will be given to the city's sidewalk repair contractor to make the repairs, and the property owner will be billed for all incurred costs. A forester will perform a follow-up inspection to assure that the work was done properly and no harm caused to the tree.

The city uses the following criteria to mark tree grates for repair:

- Broken, cracked, or missing grates are replaced;
- Any grate offset more than ½ in. is reset to proper level;
- Broken light covers or lenses are replaced;
- Space between the grate and soil level greater than 1 in. is filled with gravel;
- Grates are enlarged if the distance between the aperture and tree is: 2½ in. for fast growing species or 1½ in. for slow growing species.

Trees can coexist with streetscape hardware only if the hardware is periodically maintained so it does not hamper tree growth. Some cities such as Cleveland, Ohio, simply remove problem tree grates and fill the opening with mulch. This solution is acceptable only if the remaining sidewalk area is wide enough to accommodate pedestrian traffic and wheelchairs per the Americans with Disabilities Act. In many cases, the tree grate must be considered as walkable sidewalk surface and remain in place.

If your city is considering installing streetscape hardware, designate the agency that will assume the maintenance responsibility and establish the funding source and process before installing the "heavy metal." Otherwise you may encounter problems similar to Cincinnati's. □□□

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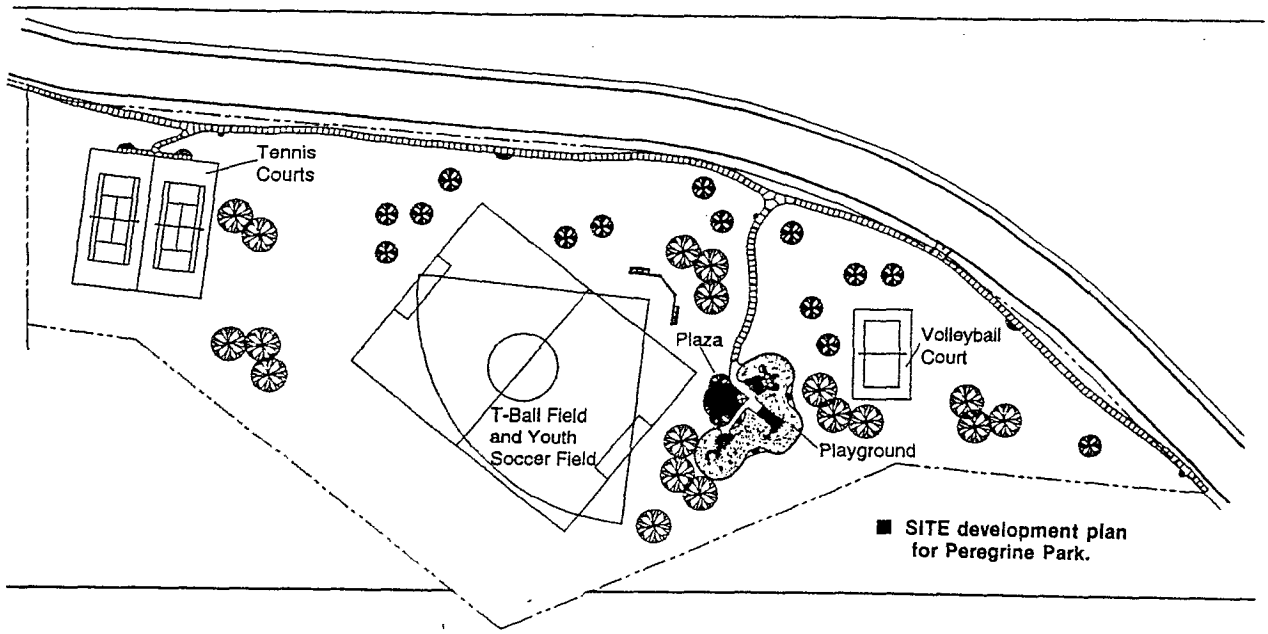

■ SITE development plan for Peregrine Park.

Pencil and Computer Compared in Park Design Project

PHIL PUTERBAUGH
Parks and Recreation Department, Colorado Springs, Colorado

NESTLED in the eastern foothills of the Rocky Mountains, near the base of Pikes Peak, lies Peregrine Park, a 5.9-acre neighborhood park on the northwest side of Colorado Springs. Design of this park was one of the most exciting projects I have had during my 19-year stay at the Colorado Springs Parks and Recreation Department.

As a drafter/illustrator for the department, my usual mission on such a project is to prepare all the park development construction drawings on our CAD system. But my role this time was different. I had recently expressed to my superiors a desire to become more involved in design. I had experience in architectural and civil engineering design and had been exposed to the landscape designs of others in the department. So on this project I was granted a significant amount of the design responsibility; in fact, more than I had anticipated.

The first thing I had to design was the playground for the park, and I soon realized that I had a problem. Before I came to the parks and recreation department in 1973 I had never had a computer with a CAD system. All my previous work had been done using conventional pencil and paper techniques. Since I had been at the parks and recreation department, most of the design work was landscape design and was always done by our landscape architects. So even though I had been drafting on CAD for years, I had not yet had the experience of designing on CAD. So my dilemma was this: Should I design on paper first, as I had done in the past, and then draft my design on CAD, or should I go ahead and design directly on CAD?

Pencil First?

I have heard some designers say that they like drafting in CAD, but would rather design in pencil first. I have wondered if they were speaking from the position of a person who had tried it both ways and had made this decision on that basis, or if the decision was based more on resistance to change. I then wondered if I was considering doing the design on paper because I was resistant to change, or because I actually thought it would be easier.

On the Peregrine Park playground design I decided to put the comparison to a test and try it both ways. My first design was done in pencil on sketch tissue. I drew the design elements (the shelter, the individual pieces of playground equipment, and lines indicating necessary clearances around the equipment) on separate pieces of tissue and maneuvered them around until I had what looked like a meaningful layout. Then I refined the design by using layers of tissue to "pull through" good aspects of the design from lower layers, and then drew changes to each progressive layout on the top layer of tissue. This is pretty standard design practice and my usual style, but in the end the process would prove by comparison to be cumbersome and time consuming, and I was not particularly happy with the design.

Then I tried it again, this time drawing the design elements on CAD. The benefits were numerous.

- Everything was easily visible and I did not have to squint to see through layers of tissue.
- I did not have to discern between scribbled lines and decide which one to keep.
- Any element or group of elements could be rotated without shifting other elements that were to stay stationary.
- Everything stayed in place once it is moved.
- I did not have to deal with all those layers of tear-prone tracing tissue and drafting tape.

The process went quickly and easily, with all elements located with absolute accuracy. I felt I had a good design with no tearing tissue, no taping, and no graphite on my hands and shirt sleeves.

Since making the comparison, I decided that for my own preference, where simple drafting is concerned, of course, I would rather draft on CAD than in pencil whenever possible. Where design is concerned, it can depend. When developing a broad concept, pencil design can have its merits over CAD, but when it comes to the nitty-gritty of actually putting design elements that have dimension together, CAD is decidedly the way to go for me.

One factor that made this playground design particularly challenging was the Americans with Disabilities Act of 1990, which requires public facilities—playgrounds included—to be accessible to all disabled persons, including those in wheelchairs.

Quick Approval

The playground design had to be approved by all the neighbors of Peregrine

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Park before being finalized and made part of the construction plans. A neighborhood meeting was arranged at the elementary school next door to the park. I presented the plan and was pleased that there were no requests for changes to the design.

Next, I had to design the planting plan for the park. This was no special feat in terms of CAD design, especially with the LANDCADD software (LANDCADD International, Inc., Englewood, Colorado) we are using, because it has so many landscape architecture related commands and symbols. The challenge was in creating a meaningful planting plan using the principals and practices that landscape architects use: selecting trees appropriate for this climatic zone and considering their general hardiness, their water and soil needs, their shape, their spring and fall flower colors; spacing appropriate for easiest mowing; and the utilitarian purpose intended for each tree's specific location, such as shade, windscreen, visual effect, etc.

In the two shrub beds in the playground area, small ornamental trees were used to provide visual esthetics and shade in the playground area, evergreen shrubs were used for fall color, and thorny barberry shrubs were used as barrier plantings to discourage entry into the shrub beds.

There was a great deal of political pressure in our community during this project for us to complete the construction plans as soon as possible, so many processes had to be overlapped. While sometimes this helped things move faster, other times it caused problems.

One major problem we encountered was with the grading plan. Once the site development plan was complete, the project landscape architect prepared a grading plan and sent it to a consultant for cut and fill calculations. In the meantime, I was completing other plans in the set of drawings. Then the consultant returned the earthwork calculations, showing that we had an excessive amount of earth to be imported. This happened on a Friday and the plans were due at our city purchasing department for bidders at 8 a.m. on the following Monday morning, so we quickly had to find a way to balance the site.

If the project had been drafted manually, I would have been faced with the task of erasing and redrafting the location of these play fields, along with any related labels, notes, and dimensions on every plan in the set. Had that been the case, I do not believe I would have made my deadline. But on the CAD system I had all the plan sheets (as opposed to detail sheets) layered in a single drawing file. The file was structured so that any change I made on one plan would automatically be reflected on the other plans, in this case, the play field shift.

In the layering structure I like to use, all layer names end with a dash, followed by a suffix. The suffix identifies the sheet or sheets on which the layer will appear:

-A —All Sheets.
-D —Demolition Plan.
-E —Existing Site Plan.
-S —Site Development Plan.
-L —Layout (dimensioning) Plan.
-G —Grading Plan.
-I —Irrigation Plan.
-P —Planting Plan.
-DE—Demolition Plan and Existing Site Plan.
-SLGUIP—Site Development Plan, Layout Plan, Grading Plan, and Utilities Plan. This suffix is common for all proposed entities that will appear on those plans that reflect proposed conditions.

With this system, if I want to view the grading plan, I would first turn off all layers, using the asterisk wildcard to specify all layers. Then I would use the asterisk again to indicate the following layers to turn on: *-A, *-G, *-SLGUIP. With this layering system, the changes went quickly and were completed by deadline.

Under certain circumstances on some projects a degree of manual drawing will occasionally be necessary despite CAD, such as when you need to make minor changes to an already existing hard copy plan. But after experiencing CAD as the normal course for producing our construction plans for building parks, I would find it hard to ever go back entirely.

In utilizing our AutoCad (AutoDesk, Inc., Sacramento, California) and LANDCADD software to prepare our construction plans, we experienced better productivity, information organization, accuracy, and drawing neatness, all the while meeting tight deadlines.□□□

• • •

Consultant to Provide Services to Fort Myers

The city of Fort Myers, Florida has chosen Camp Dresser & McKee Inc., Cambridge, Massachusetts, to design wastewater residuals stabilization modifications to two of the city's 12-mgd advanced wastewater treatment plants. The modifications will allow the facilities to meet the Class B stabilization requirements for EPA's new Part 503 sludge management regulations. The project will be managed out of the consultant's local west coast Florida offices.

Based on recommendations contained in the Residuals Stabilization and Management Master Plan developed by the consultant, modifications to the facilities include constructing new aerobic sludge digesters, blower building, and appurtenances at the Fort Meyers Central wastewater treatment plant.

JAMES E. KOVAS, P.E., RLS
Wade-Trim, Inc.,
Plymouth, Michigan
and
GISELE GREEN-CZAJKA
GIS Coordinator,
Kalamazoo, Michigan

KALAMAZOO has developed a geographic information system (GIS) to better track, manage, and analyze the region's infrastructure, environment, and economic development. A program was developed that will eventually convert information on parcels, zoning, floodplain limits, annexation, historic districts, and storm, water, and sewer systems into a digital format. These data will provide input to applications for the departments of public works, planning, assessing, utilities, housing, public safety, management information services, and Kalamazoo's 77,000 residents.

The first layer to be created for the GIS was the base map, generated by digitizing the assessor's parcel maps. This layer was chosen for the initial conversion due to the current condition of the assessor's maps. Drafted on linen in the early 1920s, the maps were disintegrating from years of use and were difficult for the public to use. Sections of the city maps were also in different scales. These maps accurately represented parcel boundaries and dimensions of city property, but not streets surrounding the parcels.

Increasing Accuracy

The city hired Electronic Data Systems (EDS, St. Louis, Missouri) to convert the 1,016 assessor's maps into a digital format and renumber more than 27,000 parcels to coincide with the county parcel numbering system. We also decided to increase the map's level of positional accuracy with a global positioning system (GPS) control network. The GPS survey was conducted by Wade-Trim, Inc. in cooperation with Gove Associates Inc., the city's surveying consultant. The project consisted of surveying existing section corners, quarter section corners, centers of sections, and centerlines of major streets to determine the Michigan State Plane Coordinates of each corner. This allowed EDS to determine the true distance between street intersections and section corners for comparison with the assessor's recorded distances.

Gove personnel researched existing records. Old surveying maps, section corner witness records, and county and city deeds were used to verify the authenticity of monuments found in Kalamazoo streets. With all section corner locations for the assessment mapping, Wade-Trim

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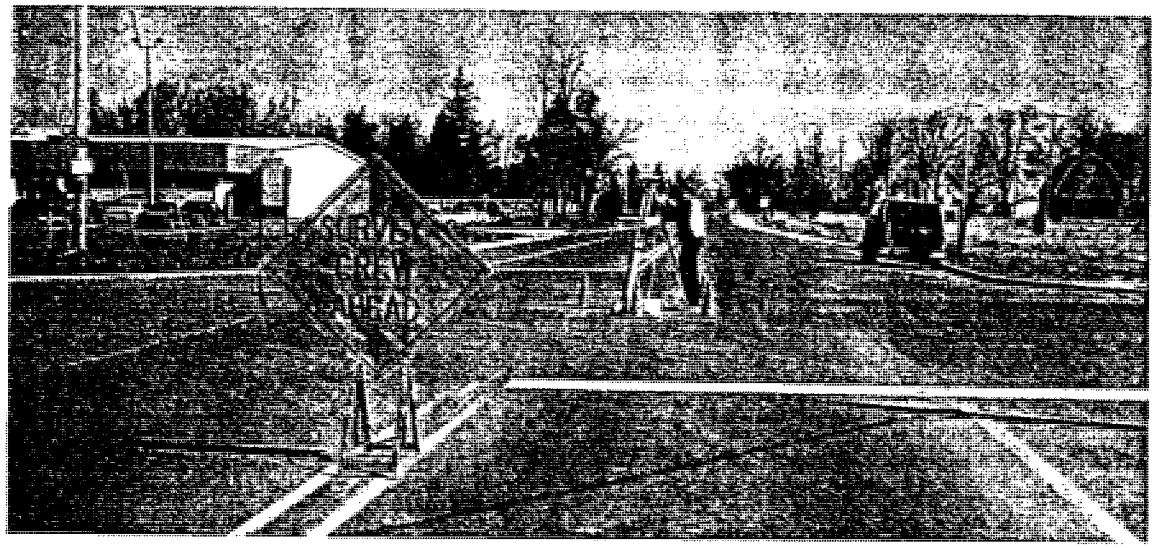
GPS Supports Assessment Mapping Project



developed a plan for the GPS control survey. A GPS network was used in which GPS fast-static techniques were utilized to locate and tie together all the section corners included in the survey.

Using Trimble Navigation (Sunnyvale, California) *4000 SSE Fast-Static* equipment, the GPS technicians proceeded to occupy each section corner and quarter corner included in the network. The tree-lined streets, one of the charms of Kalamazoo, presented a problem in many areas of the city. Since GPS works by measuring signals sent down by numerous satellites in orbit, trees present the most common obstacle for this signal. These signals are received through an antennae mounted on a tripod or pole. Signal reception problems were resolved by scheduling observation sessions at times when the satellites were high in the sky and by elevating the antennae 12 to 15 ft above the ground.

Another concern of the GPS field technicians was the heavy traffic on Kalamazoo streets. Each operator worked by himself and was responsible for setting up necessary traffic cones and signs to alert drivers. Occasionally a flagman was needed to direct traffic around an antennae setup that blocked a traffic lane.

Operators were kept busy as their equipment collected satellite data at each section corner. They recorded the heights of the antennae above the ground, filled out log sheets, and answered many questions from curious children walking home from school. At the end of each 10-to 15-minute data collection session, the operators packed up their equipment and moved down the street to their next assigned section corner. During the seven-day collection period, about 60 sessions were completed during daylight hours. Most of the 76 section corners were iron pins protected by a cast iron box and lid. Three operators with GPS receivers collected satellite data during the same time interval for each session. These data were later processed to determine the distance between each section corner at an accuracy better than a quarter of an inch.

Using the section corner coordinates established by the GPS survey, the small parcel map features of the new computerized assessment maps are currently being repositioned. A digital representation of the converted parcel map is manipulated to match the coordinate locations specified for each section corner. This creates a template and permits repositioning of city block polygons, as well as the parcel making up the polygons.

The original parcels' dimensional shape and size are protected from the stretching process of rubber sheeting. Topological structures are then added to the parcel elements and other map features. This gives "intelligence" to the maps and provides a complete GIS interface with the city's VAX computer relational database.

Immediate Benefits

There were immediate benefits of this GPS/GIS project. More timely and accurate tax assessor related information is available to city staff and the public. The digital maps and database provide cost-effective maintenance, increased analytical capabilities, improved operational efficiency, and customer service. This will allow city staff to become more productive, while providing additional services at current staff levels.

Staff from the departments of the assessor's office, management information systems, public utilities, and public works were involved in planning all phases of this project. Assessing staff will maintain the parcel information; engineering users will catalog surveys conducted for local construction projects and enter new survey information into the GIS. This will increase the accuracy of the base map over time and tie all projects to common base coordinates.

Combining digitized assessor parcel maps with GPS surveying has been the most cost-effective way for the city to develop a GIS database. By surveying existing monuments rather than setting new monuments, the city produced an inventory of existing section and quarter corners that can be used by the county's re-monumentation program. Under a 1990 state law that created the program, all Michigan counties are required to re-establish their section corner monuments by the year 2010.

The city and county may establish an ordinance to densify established monumentation by requiring local surveys to be tied into the network. Such an ordinance will generate more accurate and less expensive property surveys, more accurately determine community utilities and roadway alignment, and facilitate a county-wide GIS system. The city has formed the Kalamazoo Area Geographical Information System Committee (KAGIS) to study the design and implementation of such a system.

Kalamazoo has committed itself to the GIS concept. The assessor's map conversion project is an important and integral part of the city's GIS development program. Upon this layer of information will rest the remainder of the city's infrastructure database and the applications that will evolve to benefit the citizens of Kalamazoo. □□□

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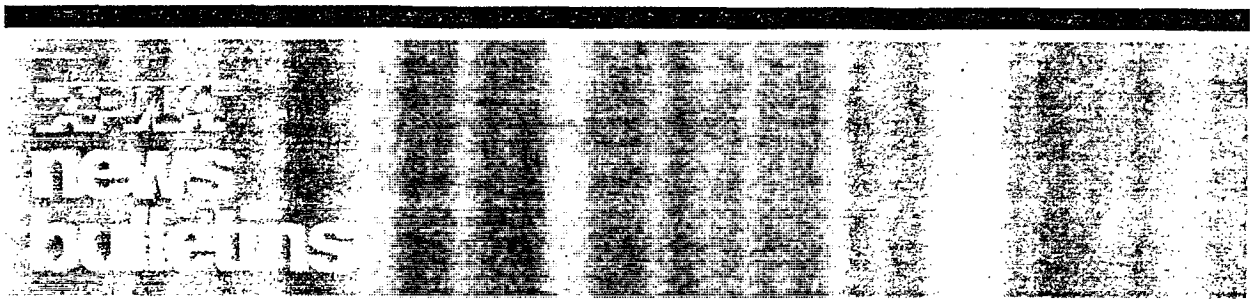

American Public Works Association
106 West 11th Street, Suite 1800
Kansas City, Missouri 64105-1806
(816) 472-6100

Celebrating National Public Works Week

Public works officials throughout the United States and Canada celebrated National Public Works Week (NPWW), May 16 to 22, 1993. For the third consecutive year, "Quality of Life Through Public Works" was the theme of this week dedicated to recognizing public works engineers and administrators as resourceful, effective professionals.

Children's laughter and street sweeper "swooshes" came together in over 200 cities that week. The cities outdid themselves with proclamations declaring National Public Works Week, press releases to local media, radio and television talk show appearances, school presentations, flyers, equipment shows and demonstrations, parades, tours of public works facilities, and open houses at government offices or local shopping centers.

In Eugene, Oregon, Burger King distributed more than 15,000 informative tray liners, announcements about NPWW were printed on side panels of shopping bags, and children learned the "Adventures of a Raindrop" at the annual fair; in Gresham, Oregon, water treatment tours were given; in Thousand Oaks, California, there were paint striper and aerial lift demonstrations; and in San Francisco, the Ninja Turtles were spotted in a simulated sewer where children could learn what it is really like under the streets. Clark County, Las Vegas, Nevada, used a "guest" weatherprinter on the evening news the entire week; and in Yaughan, Ontario, the Committee of the Whole proclaimed May 16 to 22, 1993 "National Public Works Week."

The celebrations continued across the continent where in Jefferson City, Missouri, over 40 fourth graders participated in an equipment show; in St. Louis demonstrations took place in several area schools; in Bloomington, Indiana, demonstrations of the city's new geographic information system; in Covington, Tennessee, orientation on a natural gas vehicle; and in New Orleans, Louisiana, an equipment parade with a jazz band.

Also, in Concord, New Hampshire, an employee appreciation luncheon; in Harrisonburg, Virginia, the local newspaper carried the city's newsletter; in Norfolk, Virginia, a large sign was displayed across an elevated walkway and picnics were thrown to honor 3200 employees; and in Burlington, North Carolina, over 70 employees participated in a basketball shootout with proceeds going to a local charity.

"This is a great way to give the taxpayers a hands-on look at the workings of municipal professions and what their departments do, what tools they use, and the contributions they make," explained Steve Stewart, the city manager of Harrisonburg, Virginia.

As in Norfolk, Virginia, many cities recognized their staff by designating an Employee Appreciation Day. Captain Charles Fehlig of the Public Works Center at Norfolk, recognized the employees, saying, "You are part of the public works groups of the United States who really make a difference to the people who depend upon our services. You make a tremendous contribution out here."

National Public Works Week was established in 1960 with the objectives to increase citizen's understanding of public works; promote awareness of the need for public works professionals and the contributions they make to everyone's health, safety, and comfort; inspire excellence and dedication in public service by recognizing public works professionals and their achievements; and encourage talented young people to prepare for public works careers.

APWA Names New Executive Director

A nationwide search has culminated in the naming of William J. Bertera to succeed Richard H. Sullivan as executive director of the American Public Works Association. Bertera joined the Kansas city staff as executive director designate on August 9, and replaced Sullivan on October 1.

Bertera comes to APWA with 18 years experience in not-for-profit organizations representing both trade and professional entities in the public and private sector. He has a strong background in chapter development and service, membership sales and retention, state and federal government affairs, strategic planning, and fiscal management.

Most recently managing director of the private-sector National Solid Wastes Management Association, with a staff of 80 and a $90-million budget, Bertera headed the chapter relations, membership, public affairs, technical assistance, and state and federal advocacy programs. He was also responsible for 12 institutes and councils representing specialized constituencies.

Prior experience in the public sector includes service with the National Association of Counties as an associate director for federal affairs and as an administrative assistant to a member of Congress. He also served as a consultant to several federal agencies.

Bertera holds a B.S. degree in Business Administration and an M.P.A. in Urban Affairs. He is a member of the American Society of Association Executives and the American Society of Public Administration.

Congressman Receives APWA Service Award

The Honorable Norman Y. Mineta, chairman of the U.S. House of Representatives' Committee on Public Works and Transportation is the recipient of the APWA Distinguished Service Award. Mineta has a distinguished career in politics, and became the first Japanese American mayor of a major U.S. city, when he won election as mayor of San Jose, California, in 1971. In 1974 he won a seat in Congress and immediately established himself as a leader of the 75 new Democratic members in the 94th Congress. Fellow new members elected him chair of the New Members Caucus. Mineta has won every bid for reelection ever since, and is now serving in his tenth consecutive term.

As chair of the Committee on Public Works and Transportation, Mineta has leadership authority over much of the nation's public infrastructure investments—including roads, bridges, transit, safety, aviation, water resources, public buildings and grounds, and economic development assistance programs. As chair, he is a member of all six committee subcommittees: Surface Transportation, Aviation, Water Resources and Environment, Economic Development, Public Buildings and Grounds, and Investigations and Oversight.

For details circle No. A-34 on card

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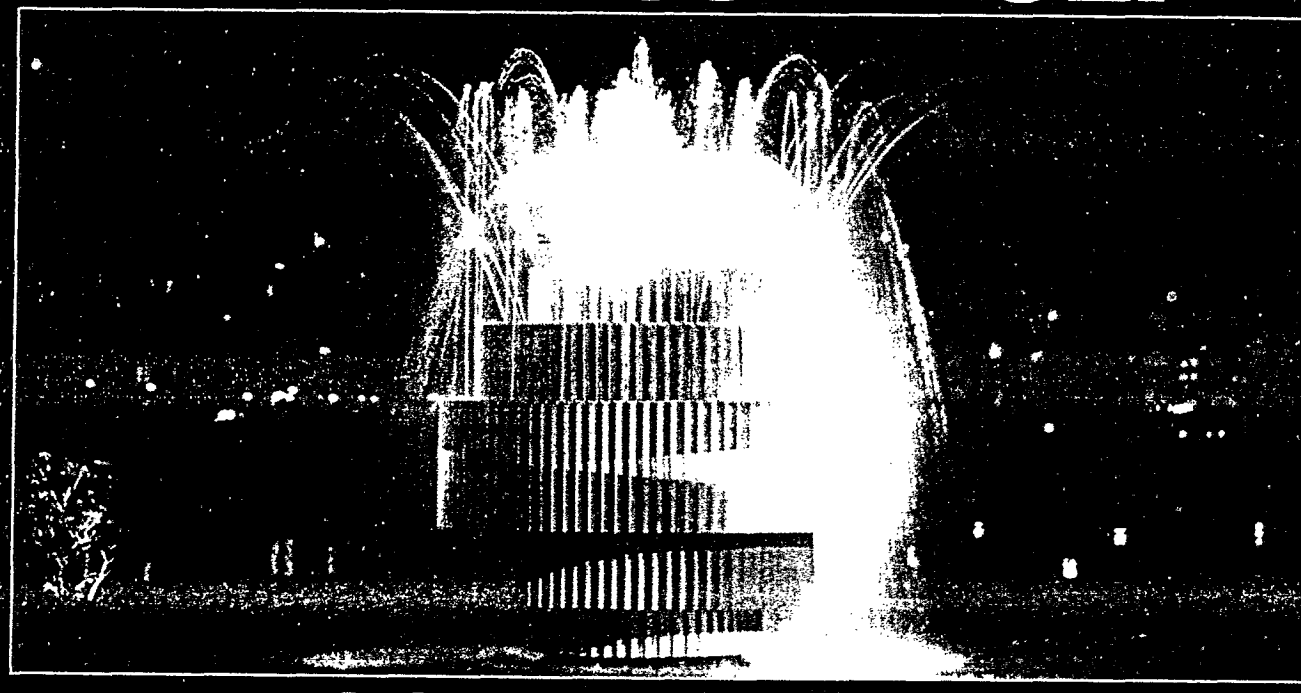

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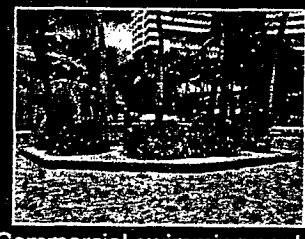
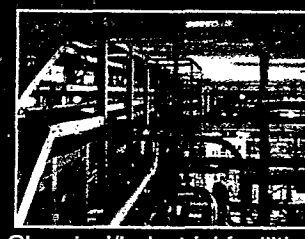


Commercial swimming pools



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transportation digest

Prepared by Paul S. Kobelt
Associate Editor

Oregon Commission to Review Six-Year Plan

Faced with a shortage of up to $400 million for transportation projects between 1995 and the end of the century, the Oregon Transportation Commission will re-evaluate all the projects in its Six-Year Transportation Improvement Program.

"We are going to have to make tough decisions on some important projects," said commission chairman Michael P. Hollern. "Given the magnitude of the shortfall," Hollern said, "we will have to look at every project on the six-year plan."

The shortfall is the result of several factors. Federal matching funds for transportation projects will be only 80 percent of the amounts originally authorized by Congress. State gasoline tax revenue also is lagging behind projections. A funding package presented to the state legislature to implement the Oregon Transportation Plan (OTP) was unsuccessful.

"We are committed to the philosophy of multi-modal transportation systems outlined in the Oregon Transportation Plan," said Hollern. "We need to begin that shift away from reliance on highways as the prime mode of transportation.

"Oregon's transportation system is the biggest single investment made by the citizens of this state. By doing all we can to preserve that investment, we will be able to divert funds from modernization or improvement projects to other projects that are more in line with the goals of the OTP."

Oregon Department of Transportation News, August 18, 1993.

Hiker/Biker Trail To Be Extended

The Maryland Department of Transportation has announced an improvement to lengthen the Baltimore/Washington Airport hiker/biker trail under construc-

Modernizing Road Repair Operations

DISTRICT 20 of the Texas Department of Transportation (TxDOT) is using two recently purchased BOMAG MPH-100 Recyclers (Compaction America, A United Dominion Company, Kewanee, Illinois) to improve repairs and save time and money on hundreds of miles of secondary and tertiary roads and other highways through its eight-county area.

The recyclers cut into existing bituminous surface to a 12-in. depth, pulverizing it with the sub-grade, mixing cement into the soil, and providing a homogeneous material. The cutting rotor is held at selected depths by positive down pressure.

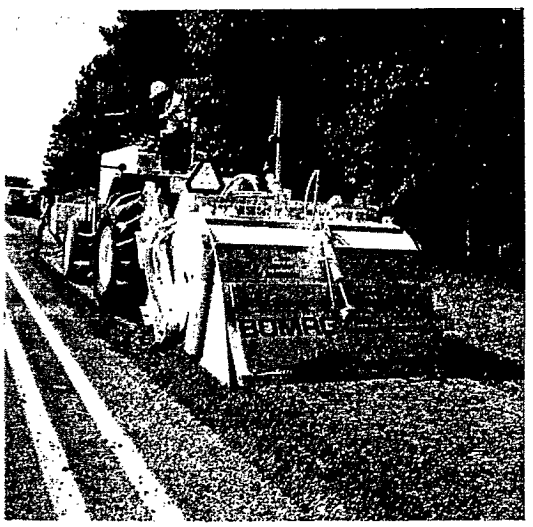
Tyler County Maintenance Supervisor Mark Hanks reported that his maintenance crew recently used one of the new recyclers to correct several base failures near the town of Woodville. Earlier the same crew had repaired five such roadbase failures with the same machine. Two reasons for base failures of the roads in Tyler County, according to Hanks, who has been with TxDOT for over 18 years, are weather and heavy logging operations. Most of the roads were not designed or built to carry the heavy loads they now do.

"In the old days, before we got the BOMAG MPH100, we repaired the base failures by using the scarifer teeth on a motor grader. An older farm tractor with disk was pulled behind it," said Hanks. "We used the tractor/disk to mix the cement with the soil after the grader operator broke up the asphalt and bladed the material out to where the failure was exposed. In the past it took five or six passes with the disk to get proper mixing. Now we can do the same thing with the BOMAG with only two passes. And we can go deeper a lot faster when need be," he added.

"I'm not sure how others do it, but we add cement to the soil simply by pacing off the distance of the failure area. We then add one bag of cement for each step or 3 ft of distance when we are repairing one half of a normal 20-ft wide road. If the repair goes across both travel lanes of the road, we use two bags of cement for each 3 ft," continued Hanks.

Hanks feels that the recycler mixes the material to a uniform consistency, avoiding the clods of soil that were common with the previous equipment. "We add cement and mix it to a uniform consistency. We add water to the correct proportion and then compact the material. Normally we use a pneumatic, rubber-tired roller to get the proper density. The next to last step is to reestablish the proper grade with our maintainer or motor grader. This is a very critical operation because the only thing we do after this is to come back after a few days and put down a coat of oil and stone.

"The initial difference in repairing base failures with the BOMAG MPH100 is going to be a better quality repair that will result in a longer lasting road. Long range, a savings in time and money," Hanks concluded.



■ **THE Recycler repairs damaged road by mixing existing bituminous pavement with subgrade material and cement. The mixture is then graded and compacted.**

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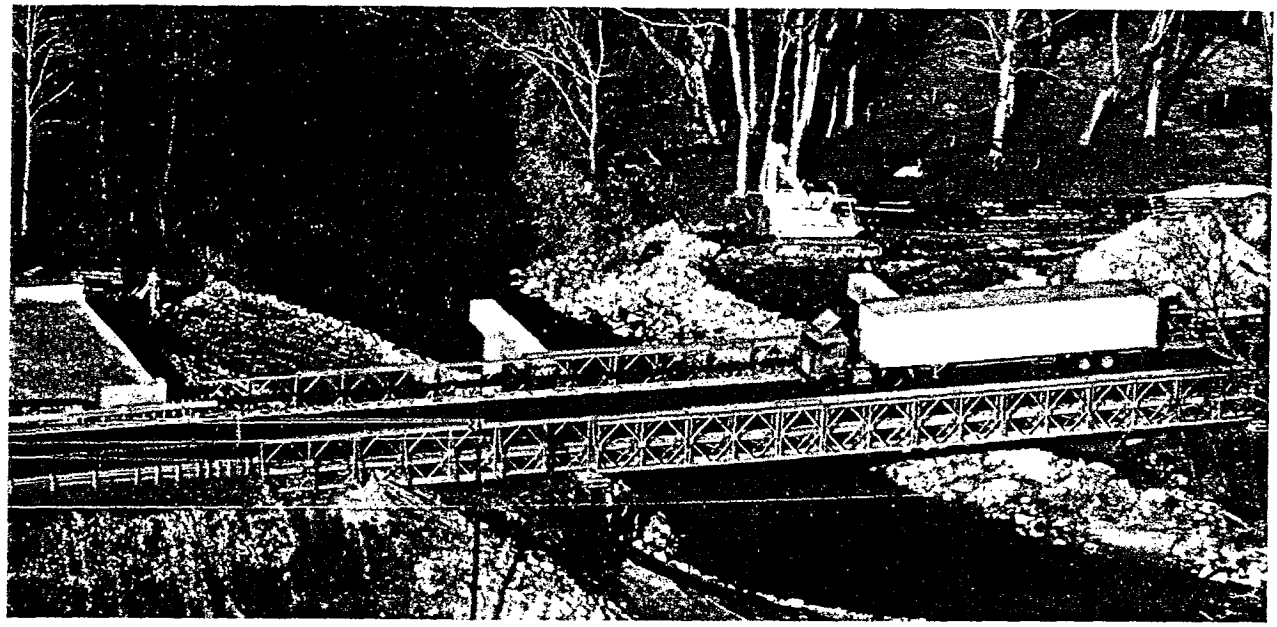

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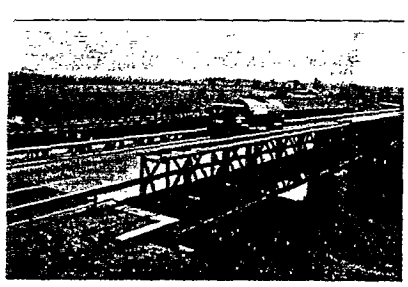
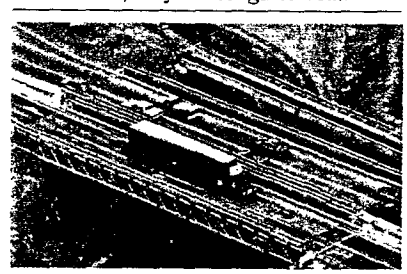
Twenty Four Hour Response

When an emergency arises, you can count on Mabey Bridge for a fast solution to your bridge problems. When flash floods in New Mexico washed out a highway bridge, Mabey responded in less than 24 hours and designed a replacement utilizing Mabey components already stocked by New Mexico DOT. The new 100 ft., two lane, clear span bridge was up within a week. The fast response earned a commendation from the governor for all involved, and, probably much gratitude from the highway travelers.



An Economical Solution

Baltimore County, Maryland, like many others, uses Mabey prefabricated panel bridges for economical bridge replacement. They go up fast. The initial cost is very competitive with other construction methods. And, on total lifetime overall cost, they are tough to beat.



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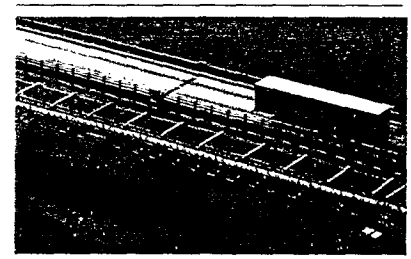

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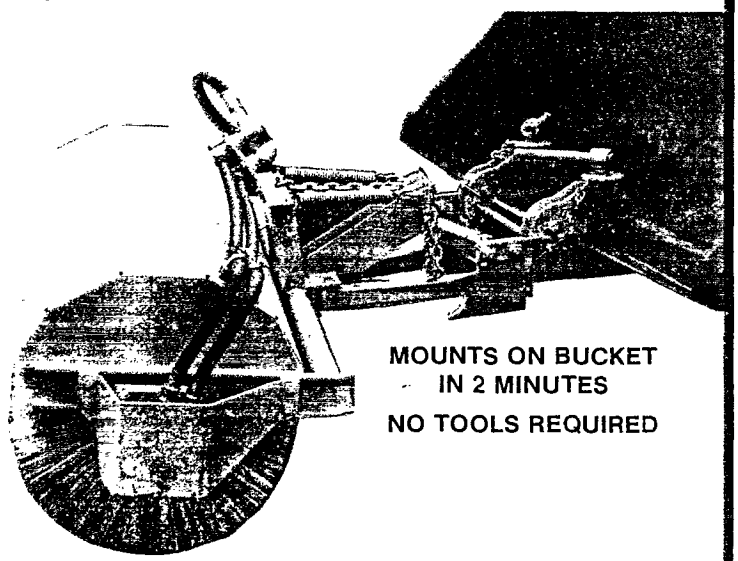

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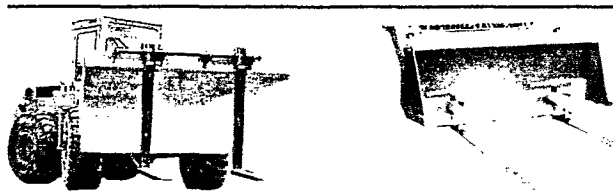

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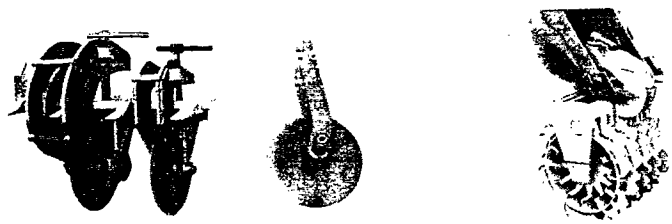

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R0013742

tion in Anne Arundel County. The addition will extend the trail from North County High School to the new Linthicum Light Rail walk-up station, encouraging more people to use mass transit.

"With the opening of the light rail in Linthicum, extending the trail to improve pedestrian and cyclist access is ideal," said Maryland DOT Secretary O. James Lighthizer. "Local residents will be able to walk to the station along the new scenic path and employees from area businesses can travel by light rail and walk to work. The project is an excellent example of intermodalism in our department."

Construction of the 10.5-mile trail will be completed in four phases. Originally estimated at $225,000, the extension adds about $133,000 to the trail construction cost of which $66,750 are Federal Highway Administration enhancement funds. Averaging 10 to 12 ft wide, the asphalt and boardwalk trail will be built mainly on public property.

Maryland Department of Transportation News, July 16, 1993.

History of Urban Transportation Planning

The history of urban transportation planning in the United States is enlightening. Edward Weiner, in *Urban Transportation Planning in the United States: An Historical Overview*, presents the fourth edition of a work first published in 1983. The history focuses on key events in the evolution of urban transportation planning, including developments in technical procedures, philosophy, processes, and institutions. The current work brings the planning process history up to date and includes material on the Intermodal Surface Transportation Efficiency Act of 1991.

For more information contact Edward Weiner, Office of Economics, Office of the Assistant Secretary for Policy in International Affairs, Office of the Secretary of Transportation, Washington, D.C. 20590 (202-366-5403). The report (DOT-T-93-02) is distributed in cooperation with the Technology Sharing Program, U.S. Department of Transportation, Washington, D.C. 20590.

Newsline, July 1993, Transportation Research Board, National Research Council, Washington, D.C.

New Program Draws Many Applications

A new federal program that earmarks about $7.5 million a year for "enhancement" projects complementing Virginia's transportation systems has netted 219 applications requesting nearly $69 million. Requests range from landscaping and beautification along highways to developing hiking trails and bicycle paths to renovating railroad stations and creating



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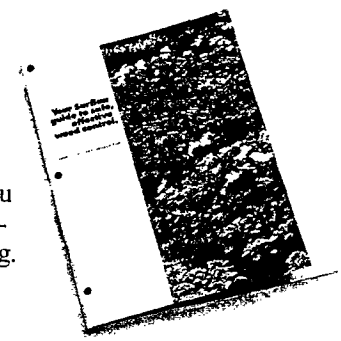

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R0013743

"talking highways" that would allow motorists to hear on their car radios about the area they are driving through.

Virginia Department of Transportation (VDOT) officials were not surprised at the number of applications, three fourths of which poured in during the last three days before the deadline. Private and public sector groups and individuals applied for the funds.

"There's been a lot of interest in this program," said Commonwealth Transportation Commissioner Ray D. Pethtel, "and the quality of the project proposals is consistently high. It's a unique program that encourages recreational opportunities as well as historic preservation along our highways."

Pethtel said a 15-member Transportation Enhancement Advisory Committee would evaluate the proposals and recommend projects for funding no later than October.

Requests for funds have come from all over the state and range from $675 to $3 million. Federal funds provide 80 percent of the funding for projects under the federal Intermodal Surface Transportation Efficiency Act. The remaining 20 percent must come from localities or private sector applicants.

To ensure that the applicants can come up with the additional 20 percent, the local board of supervisors or city council must approve the projects before being submitted to VDOT.

VDOT News, August 13, 1993.

Maryland Using Fly Ash In Interchange Construction

As part of its efforts to positively impact the environment, the Maryland State Highway Administration (SHA) is using fly ash in the construction of a new interchange and bridge at MD 213 and U.S. 301 in Queen Anne's County. Fly ash is the remaining residue from burning coal in electric generating power plants. About 50 million tons of fly ash were produced nationwide in 1990. In the past, fly ash was stored on the property of utility companies until it could be landfilled.

Research shows that fly ash is a successful borrow (soil and earth) replacement and it is being used increasingly for construction in several states such as Delaware, Alabama, Texas, and Pennsylvania. Twenty to thirty percent of fly ash produced each year is being used in highway construction.

Fly ash is replacing conventional borrow for embankments in the MD 213 and U.S. 301 interchange. The Delmarva Power Company, a coal burning plant at the Indian River Facility, is providing SHA and project contractor David A. Bramble Inc., Chestertown, Maryland, with over 60,000 cu yd of fly ash for the construction. The Southern Maryland Pepco Plant, Brandywine, Maryland, is also providing 140,000 cu yd of fly ash for the project. The fly ash is being surrounded with earth on the top, bottom, and sides of the embankment.

By using fly ash instead of standard borrow, SHA and Bramble Inc. will save 80 cents per cu yd in construction costs, or a combined anticipated savings of $160,00 for the project. The $4.8-million bridge and interchange project will improve traffic flow in the area. Construction began in February and should be completed by fall 1994.

Maryland Department of Transportation News, August 18, 1993.

New Rules Make The Going Scenic

New rules now allow county state-aid highways to be declared as Natural Preservation Routes to protect natural and historic resources, the Minnesota Department of Transportation has announced. Designation as a Natural Preservation Route allows designers greater flexibility in selecting design standards for new construction or rebuilding existing roadways. The relaxed standards reduce impact on the surrounding environment while ensuring that the roadway remains safe for

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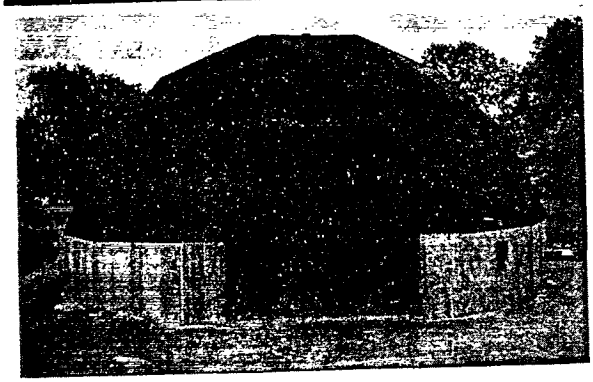

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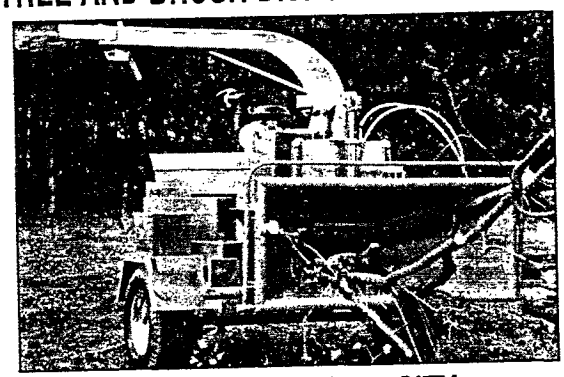

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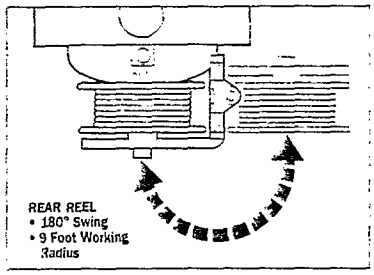

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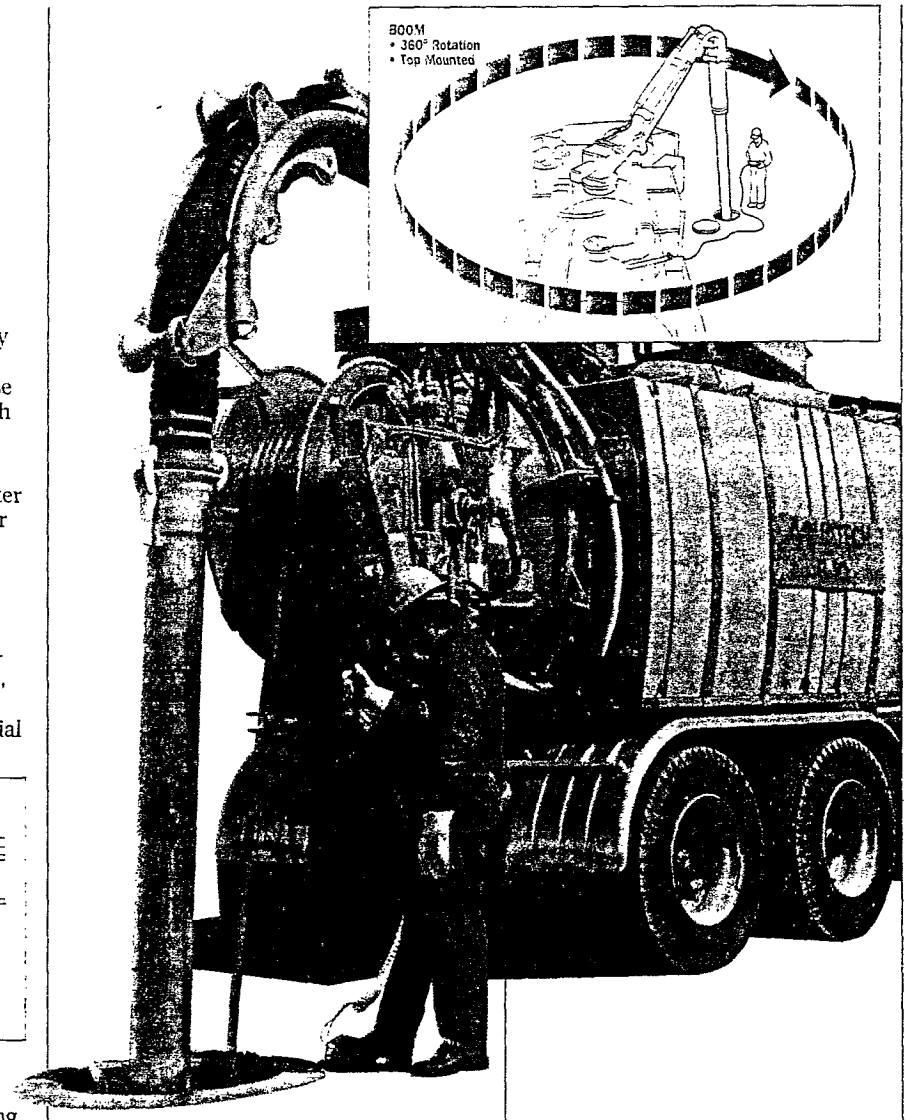

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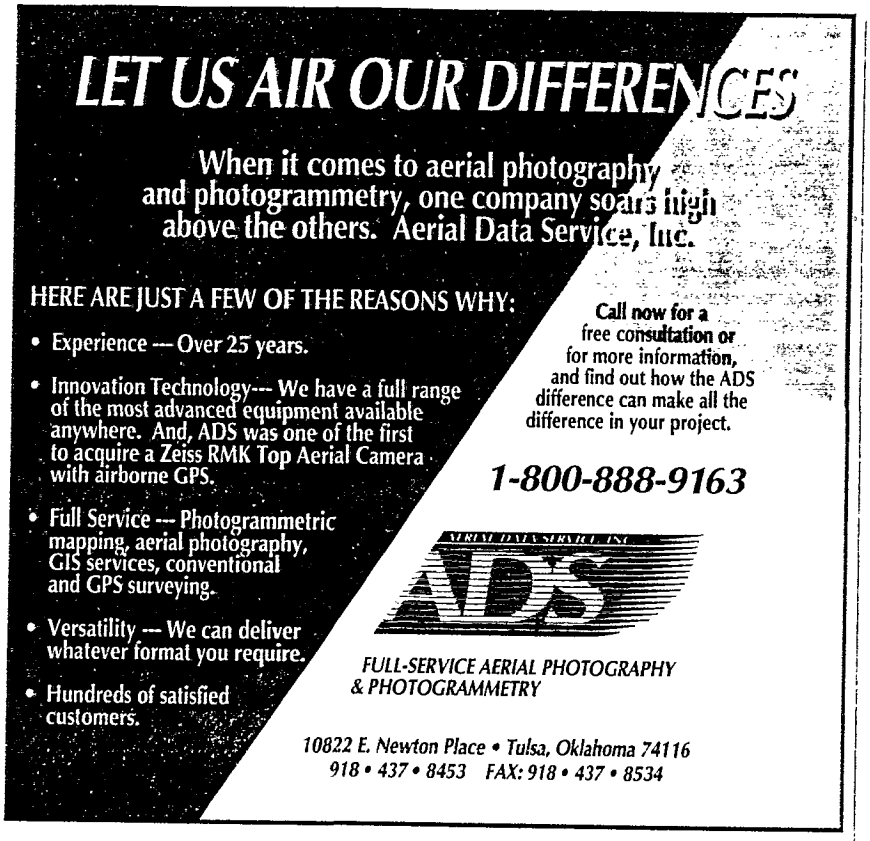

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motorists and bicyclists. Revised standards include narrower widths for lanes, shoulders, and clearances and reduced design speeds.

"Our state is fortunate to possess many roadways that are rich in scenic or historic value. These rules allow counties to design roadways that preserve the natural beauty of the area while still maintaining a safe roadway," said Dennis Carlson, state aid engineer.

To be designated as a Natural Preservation Route, a roadway must possess sensitive or unique scenic, environmental, or historic characteristics. Examples may include roads near historic buildings, along lakes, rivers, and wetlands or through forests or hilly, rocky, or bluff terrain. Individuals who seek to designate a roadway as a Natural Preservation Route must make a written request to the county board having jurisdiction over the route.

Minnesota Department of Transportation News, July 20, 1993.

Other Articles

"Rumble Strips and Pedestrian Safety." A study in Phoenix indicates that advance rumble strips are not a helpful safety device based on speed data and pedestrian accident experience. By Michael J. Cynecki, P.E., traffic engineering supervisor, James W. Sparks, P.E., deputy street transportation director, and Jenny L. Grote, P.E., traffic engineer, Phoenix, Arizona. *ITE Journal*, August 1993, Institute of Transportation Engineers, Washington, D.C.

"America's Premier Scenic Highways." Two magnificent asphalt scenic highways are detailed here: the Blue Ridge Parkway in Virginia and North Carolina and Highway 1 on the California Coast. By H. Fred Waller, Jr., Asphalt Institute regional engineer, Eastern Region; and Roger D. Smith, Asphalt Institute regional engineer, Western Region. *Asphalt*, Summer 1993, the magazine of the Asphalt Institute, Lexington, Kentucky.

• • •

Partnering

(Continued from page 58)

Naugatuck River has 5-ft. wide cantilevered sidewalks on each side. This four-lane structure carried 17,500 ADT at last count.

The scope of activities includes: replacing the original 7-in. reinforced concrete decks with precast concrete deck planks and a waterproof bituminous overlay; cast-in-place median barriers, bridge parapets, and deck joints; repairing fixed bearings and replacing expansion bearings with elastomeric bearings; and upgrading drainage and illumination systems. Greiner, Incorporated (Wallingford, Connecticut) has served as the state's design consultant for the overall project.

The unique design was completed in eight weeks to meet ConnDOT's deadline for advertising the project. Funding for the project derives from an 80/20 percent federal/state split. □□□

R0013746

It's a jungle out there. A concrete and asphalt jungle. And as roots from trees along sidewalks and city streets start to spread, pavement can buckle, crack and fall apart. Not only is this an unsightly problem, but a dangerous one, as well.

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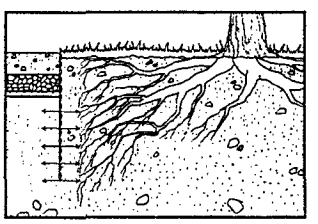

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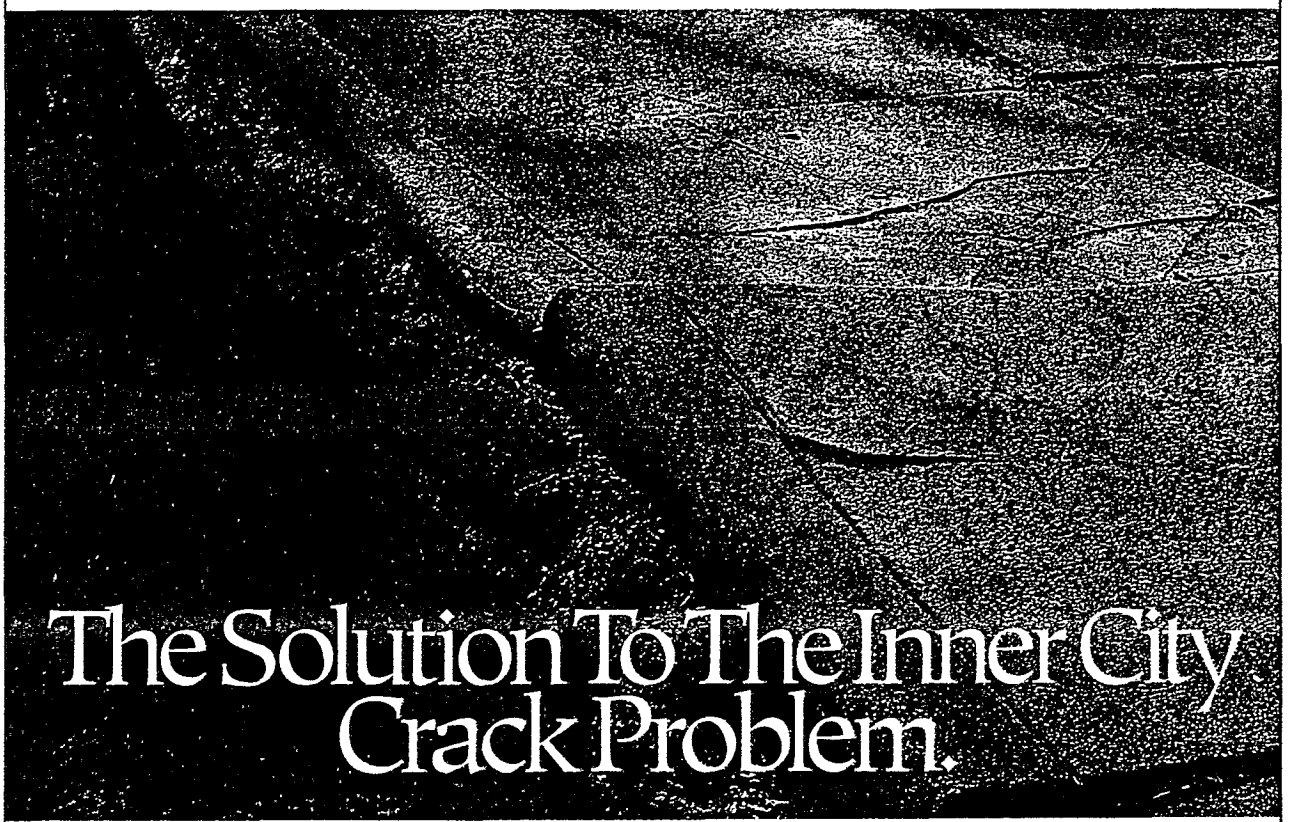
The Biobarrier root control system. It guarantees there's one crack problem you can get rid of in your city, and keep it under control for years to come. For more information about Biobarrier, call 1-800-25-ROOTS.



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Prepared by Clayton H. Billings
Editorial Consultant

Storage Configuration And Water Quality

Several computer models have been developed that can simulate spatial and temporal changes in distribution water quality. An important application of water quality monitoring has been the significance of chlorine residuals. Several models have been developed to simulate the transport and decay of chlorine in water systems. Concentrations of chlorine along with many other water constituents are time-dependent. Thus the average age of water in a distribution system has a significant impact on water quality. In previous modeling efforts, storage reservoirs have been represented as compartmentalized completely-mixed vessels. However, neither the characteristics of mixing in distribution reservoirs nor the effects of reservoir design on mixing behavior have been investigated. From the moment water leaves the treatment plant, its age is increasing and its quality is changing as a result of time-dependent chemical and biochemical reactions. Constituents, such as free chlorine, are relatively unstable, and concentrations decrease with water age. Storage reservoirs can contribute to substantial increases in water age, depending on such factors as geometry, operation, and location. In modeling the effects of reservoirs on water age, complete mixing is usually assumed. The assumption of complete mixing may not be appropriate for all tank configurations. Elevated storage tanks and some ground storage tanks with spherical or elliptical shapes should have better mixing characteristics than standpipes. The potential plug-flow nature of standpipes during mixing and emptying may lead to behavior that can be characterized as "first in, last out." Three storage facilities from the Akron, Ohio distribution system, the Firestone, Crosier, and Tallmadge tanks, were selected for this study. The Tallmadge tank is an elevated, large diameter structure with a diameter-to-height ratio of 3.5:1. In contrast, the Firestone tank is a standpipe with a much smaller diameter-to-height ratio (0.4:1). The Crosier structure is an elevated tank with an intermediate diameter-to-height ratio of 1.4:1. The tanks were monitored for chlorine residual. Chlorine was also measured within the water column of each tank. Although chlorine profiles revealed some stratification in tanks with large diameter-to-height ratios, completely-mixed models were more accurate than plug-flow models in representing the behavior of all three tanks. If all distribution reservoirs behave as completely-mixed reactors as did those in this study, then storage reservoirs should be designed to ensure maximum volume change. Elevated tanks should be utilized rather than standpipes. Overdesign of storage facilities should be avoided because it leads to decreased volumetric change and increased water age. Consideration should also be given to taking storage tanks off line to improve the turnover rate. The use of fluoride as a conservative tracer was not possible in this study, because permission to suspend use of fluoride could not be obtained. The use of chlorine rather than fluoride made the tank mixing studies more difficult to conduct. Chlorine decay rates were deter-

Drinkable Water After Chemical Oxidation Process

A SUPERFUND Innovative Technology Evaluation (SITE) demonstration confirmed that chemical oxidation treatment technology will clean water contaminated by toxic organics. The SITE demonstration at California's Lawrence Livermore National Laboratory was conducted under stringent evaluation standards developed by the EPA for the SITE program.

During the three-week demonstration period a small perox-pure™ system (Peroxidation Systems, Inc., Tucson, Arizona) cleaned about 40,000 gal of groundwater contaminated with trichloroethene (TCE) and tetrachloroethene (PCE), which were present at concentrations of about 1,000 and 100 mg/L, respectively. The chemical oxidation process consistently destroyed the TCE and PCE to levels below detection limits of 0.5 μg/L.

According to Norma Lewis, project manager of the EPA's Risk Reduction Laboratory, once operating conditions were established, the perox-pure unit required little or no attention. "There were no operational problems that affected system performance," she reported. The treated water was drinkable by California standards and met Federal drinking water maximum contaminant levels at the 95 percent confidence level.

The advanced UV/oxidation process destroys the bonds between contaminant atoms and allows the atoms to recombine into simpler, nontoxic compounds, such as carbon dioxide, water, and various salts. During the process, contaminated water is combined with hydrogen peroxide, a chemical oxidant. The mixture is then exposed to ultraviolet light generated by medium pressure mercury vapor lamps. The ensuing photochemical reaction forms hydroxyl radicals, highly reactive molecules that break the chemical bonds of the pollutants. Clean water is the result. The treatment technology produces no air emissions and generates no residue, sludge, or spent media that require further processing, handling, or disposal.

During a second phase of testing, the process effectively destroyed compounds that are more difficult to oxidize and are not usually present in the contaminated water at high concentrations. Influent water containing TCE and PCE was spiked with chloroform, 1,1-dichloroethane (DCA), and 1,1,1-trichloroethane (TCA). The process destroyed over 93.1 percent of the chloroform, 98.3 percent of the DCA, and 81.8 percent of the TCA. Greater destruction efficiencies are achieved with additional oxidation time or larger perox-pure equipment.

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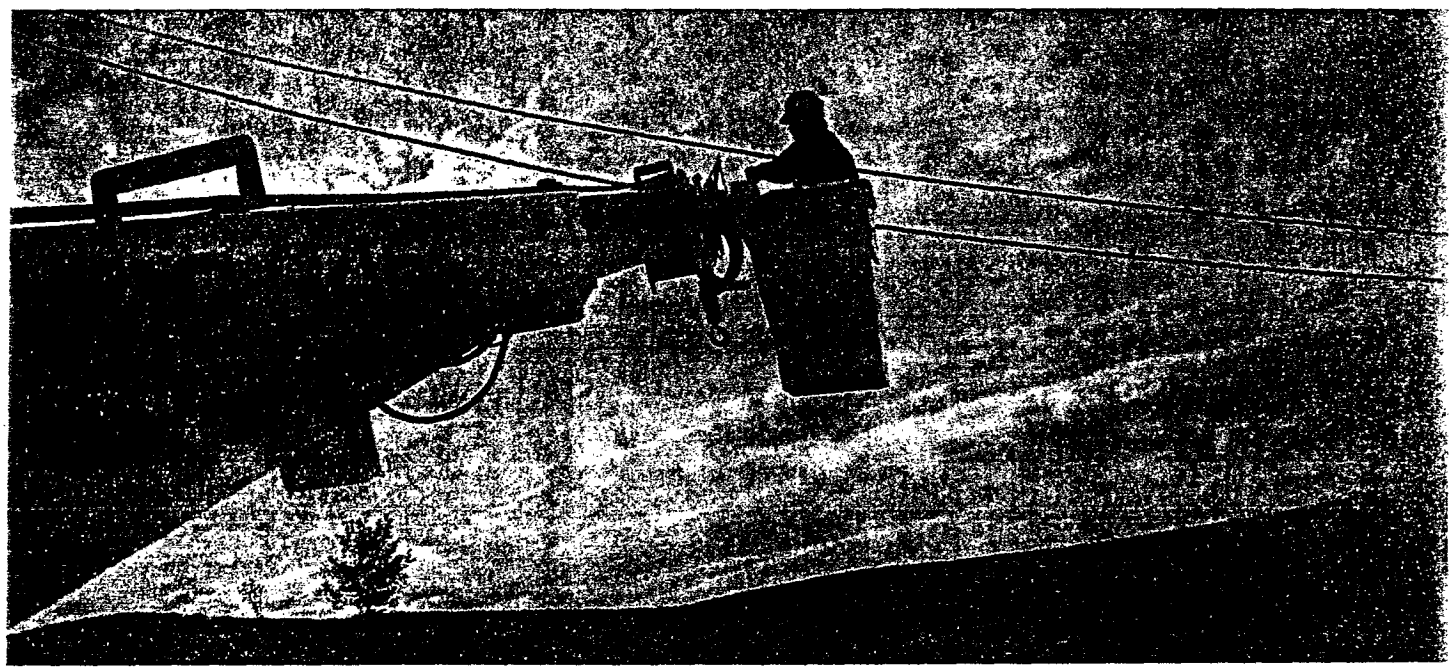

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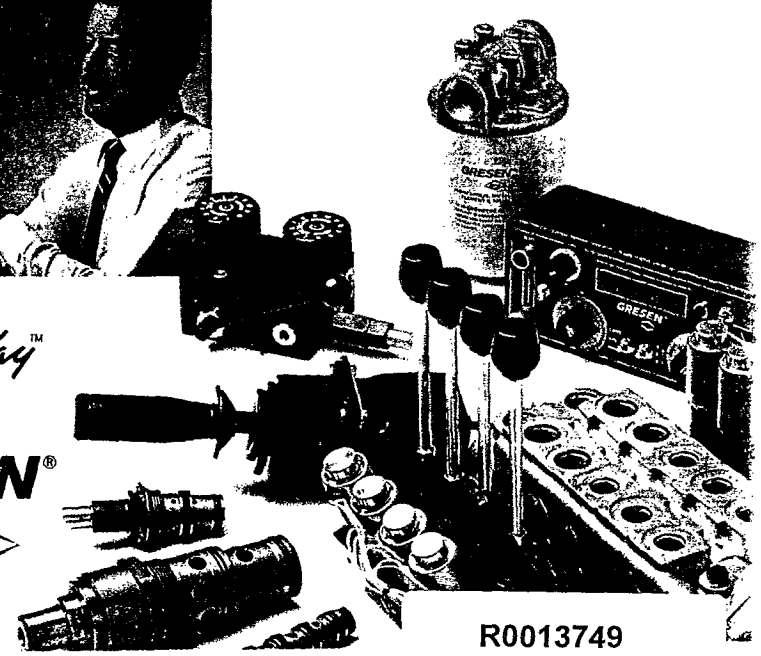

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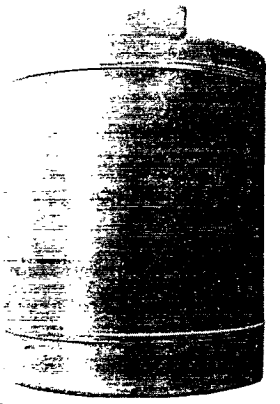

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mined in this study. However, the use of a nonconservative tracer undoubtedly resulted in some tank modeling errors. These errors may have resulted from the assumption of first-order decay and applying lab decay data to storage tanks. The use of fluoride avoids many of the problems associated with chlorine analysis. The benefits of modeling research far outweigh any risk incurred from temporary cessation of fluoridation. State authorities need to be more accommodating in such matters.

"Assessing the Effects of Storage Tank Design on Water Quality." By Mark S. Kennedy, associate professor in civil engineering, South Dakota State University; Scott Moegling, engineer, Burgess & Niple Ltd., Akron, Ohio; Simsek Sarikelle, professor of civil engineering, University of Akron; and Khis Suravallop, engineer designer, Akron Public Utilities Bureau, Akron, Ohio. *Journal AWWA*, July 1993.

Pump Energy Savings

Utilities can save energy in water system operation in only a limited number of ways. By improving the operation of pumps, which are the biggest energy users in water treatment and distribution, utilities can realize significant energy cost savings. This article describes some methods for reducing energy costs and the kinds of tradeoffs that must be considered in making any energy cost savings. It is unlikely that any given pump station, although probably not extremely inefficient, is being operated at its lowest possible energy cost. The best approach to energy cost savings depends on the utility. It may be difficult for a small utility to spend a few thousand dollars studying pump operation or installing telemetry when the total cost of pumping energy is only a few thousand dollars per year. A large utility may be willing and able to spend considerable sums trying to squeeze one or two percent from its electric bill. Any proposed operating policy for a distribution system must be evaluated with regard to its impact on these competing objectives: 1) meeting everyday customer demands; 2) making sure emergency demands are met through proper provision of storage; 3) maintaining water quality; and 4) minimizing capital cost. Because there is no single reason why pumping systems are operated less than optimally, there is no single simple approach to minimizing energy costs. Instead there are myriad reasons why pumping systems operate at a higher-than-optimal cost, including: 1) pumps are incorrectly selected; 2) pumps have worn out or have clearances set incorrectly; 3) capacity in the distribution system is limited; 4) storage capacity is limited; 5) operational pressure tanks, such as hydropneumatic tanks, are inefficient; 6) telemetry equipment is inadequate or inaccurate; 7) pumps and

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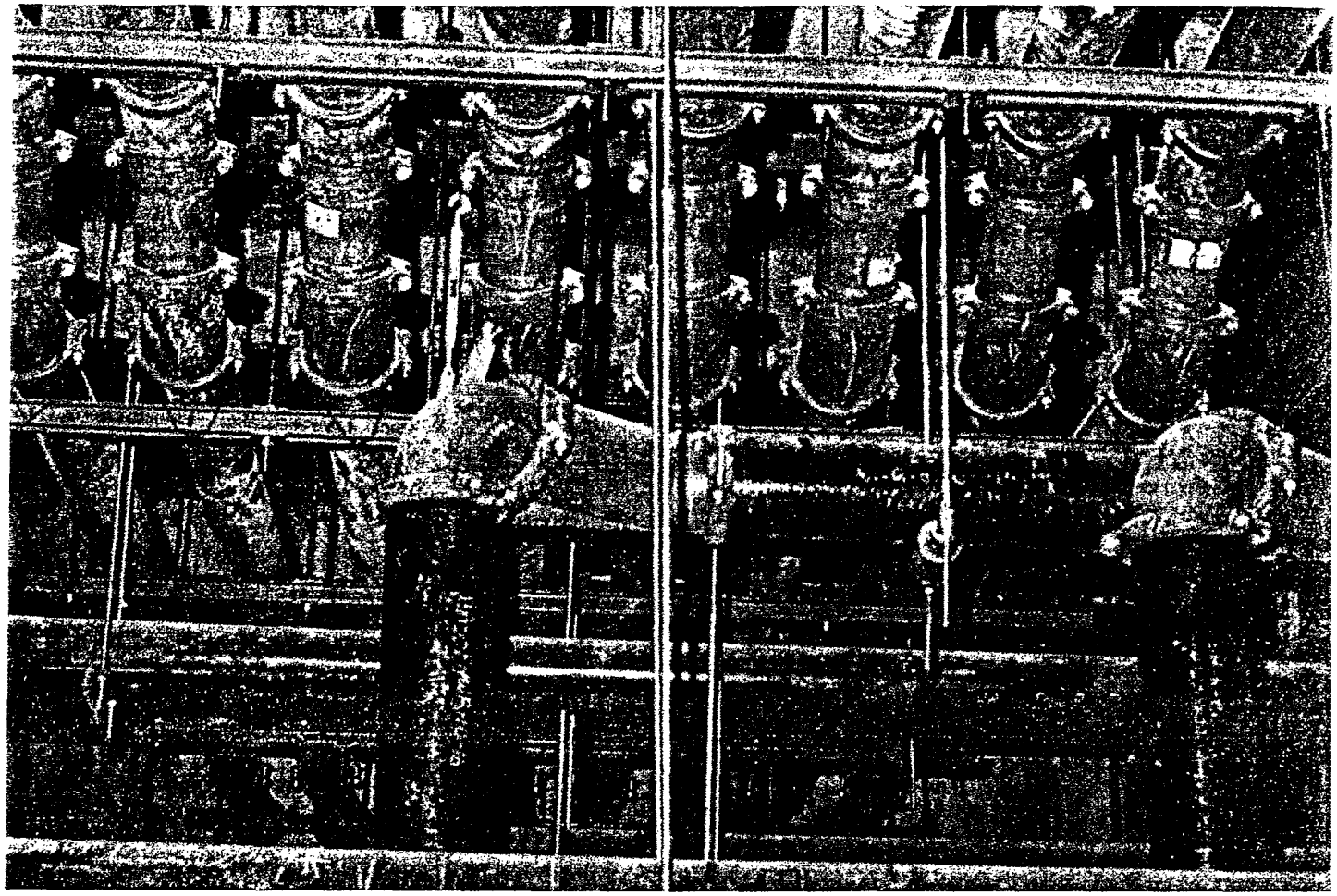

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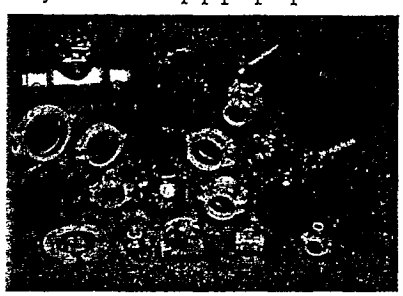

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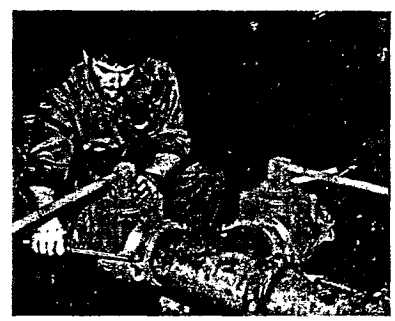

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valves cannot be controlled automatically or remotely; 8) a penalty results from time-of-day or seasonal energy pricing; 9) demand or capacity charges are not understood; 10) operator error occurs; or 11) pump control strategies are less than optimal. Most of these problems will not be noticed unless the utility looks for energy waste. Energy consumption is directly proportional to the discharge and head and inversely proportional to the pumping efficiency. The problem is complicated, however, by the fact that efficiency itself is a function of the discharge. It can be shown mathematically, however, that energy usage can be reduced by reducing the amount of water pumped, the head against which it pumps, or the price of energy, and increasing the efficiency of the pumps. A utility does not have much control over the pumping volume. Water conservation and loss reduction are the only substantial ways to reduce the volume pumped. To the extent that water conservation and loss reduction reduce consumption, they also conserve energy. Where there are multiple pressure zones, savings can be realized by minimizing the amount of water that needs to be pumped to higher zones. Pressure zones can be rearranged so that customers are served from the lowest zone feasible. Reducing the total dynamic head against which the pump must work will reduce energy consumption. The easiest way to accomplish this is to keep distribution tanks less than full and suction storage tanks as full as possible. The heads produced by a pump are those either for lifting water or overcoming friction. If most of the energy goes toward lifting, the system head curve will be very flat. This is usually the case when the suction and discharge reservoirs are close to the pumping station and the pipes are large. Many electric utilities have a constant price for energy usage. Others use time-of-day pricing to discourage use during periods of peak electricity demand. Utilities can take advantage of this price structure by filling storage tanks during off-peak periods. Utilities need to check periodically to ensure that pumps are operating at their best efficiency point regardless of the appearance of satisfactory operation. Utilities are faced with several levels at which they can address improvement in the order of increasing cost. These range from field testing of pumps to an engineering-economic evaluation of energy consumption to the use of computer hardware-software. These costs for a large utility can vary from a few tens of thousands of dollars to millions. There is no substitute for actually measuring water-to-wire efficiency of pumps in the field. It is a standard practice and well-documented. If a utility has not undertaken pump testing in several years, it may be worthwhile. Efforts should be made to test the pumps over as wide a range of flows as feasible. There

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is a limit to what can be accomplished with pump testing and engineering-economic evaluation. For utilities with sufficient energy cost and sound pumps, optimization may assure additional savings. In many cases, the existing rules for operating the system may prevent the utility from optimizing efficiency. Training operators to understand flexible rules can be difficult. At this point it may be necessary to shift to some form of computer-aided operation, in which the operator provides information to the computer to describe the state of the system. The computer would then supply the desired tank levels and which pumps should be running at any particular time. Each system is quite specific, so that there are no simple generic computer programs as there are for pipe networks, to optimize system operation. Enough development work has been done, however, that setting up optimum control is no longer a research effort. A pump optimization study usually consists of the following: 1) preliminary analysis of the system; 2) data collection; 3) optimization pfogramming; 4) verification of new equipment and procedures; and 5) operator training. There is probably not a pump station in existence that could not realize some cost savings. Before investing in sophisticated software or hardware to improve operation, the utility should first conduct pump testing and an overall evaluation of energy costs associated. It would then be possible to determine whether there is much room for improvement. Testing is the only way to determine whether pumps are wasting energy. Reviewing energy bills can give insights into the possibility for savings. Also, if a pump regularly operates to the left of its best efficiency point, the impeller or pump needs to be changed or the distribution capacity needs to be increased. If demand charges are significant, utilities need to determine when charges are effective and to operate during these times. Good communication between pump operators and management is important.

"Tips for Saving Energy in Pumping Operations." By Thomas M. Walski, associate professor of environmental engineering, Wilkes University, and engineer, Wyoming Valley Sanitary Authority, Wilkes-Barre, Pennsylvania. *Journal AWWA*, July 1993.

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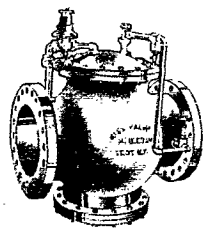

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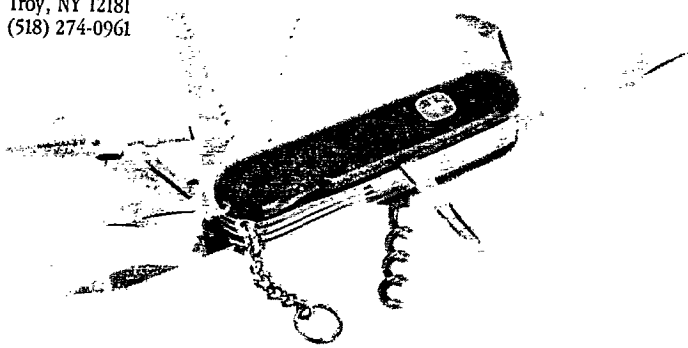

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Reducing Radium By Ion Exchange

U.S. EPA's small system technology initiative was first developed in 1989 with the objective of building public-private partnerships to promote simpler drinking water technologies. The techniques were intended to apply to systems serving fewer than 3300, and designed to seek out and demonstrate cost-effective solutions for complying with federal and state regulations. To date, only systems serving fewer than 500 have been considered as possible demonstration sites. Sites were selected based on a variety of parameters, such as maximum contaminant levels, size, and financial status. Requests for proposals were solicited from water treatment suppliers to provide equipment and operational assistance for individual demonstrations. Demonstrations have been conducted under the supervision of EPA and appropriate regulatory personnel. EPA has completed evaluations and has issued a report on the first small systems technology initiative demonstration site—the Quail Creek water system near Spicewood, Texas. Two other projects are underway: one in Freestone, California, and another in Suffolk, Virginia. Several others are in the development stages. The Quail Creek water system supplies a privately owned mobile home development with about 15 connections and a total of 55 connections available for future expansion. An ion exchange system was provided by Kinetico, Inc. for the removal of radium present in a concentration of 7.5 pCi/L (picocuries per liter). The owner of the property decided to install a water system at a cost of $35,000 in 1983 to help sell tracts. The system consists of a well, storage tank,

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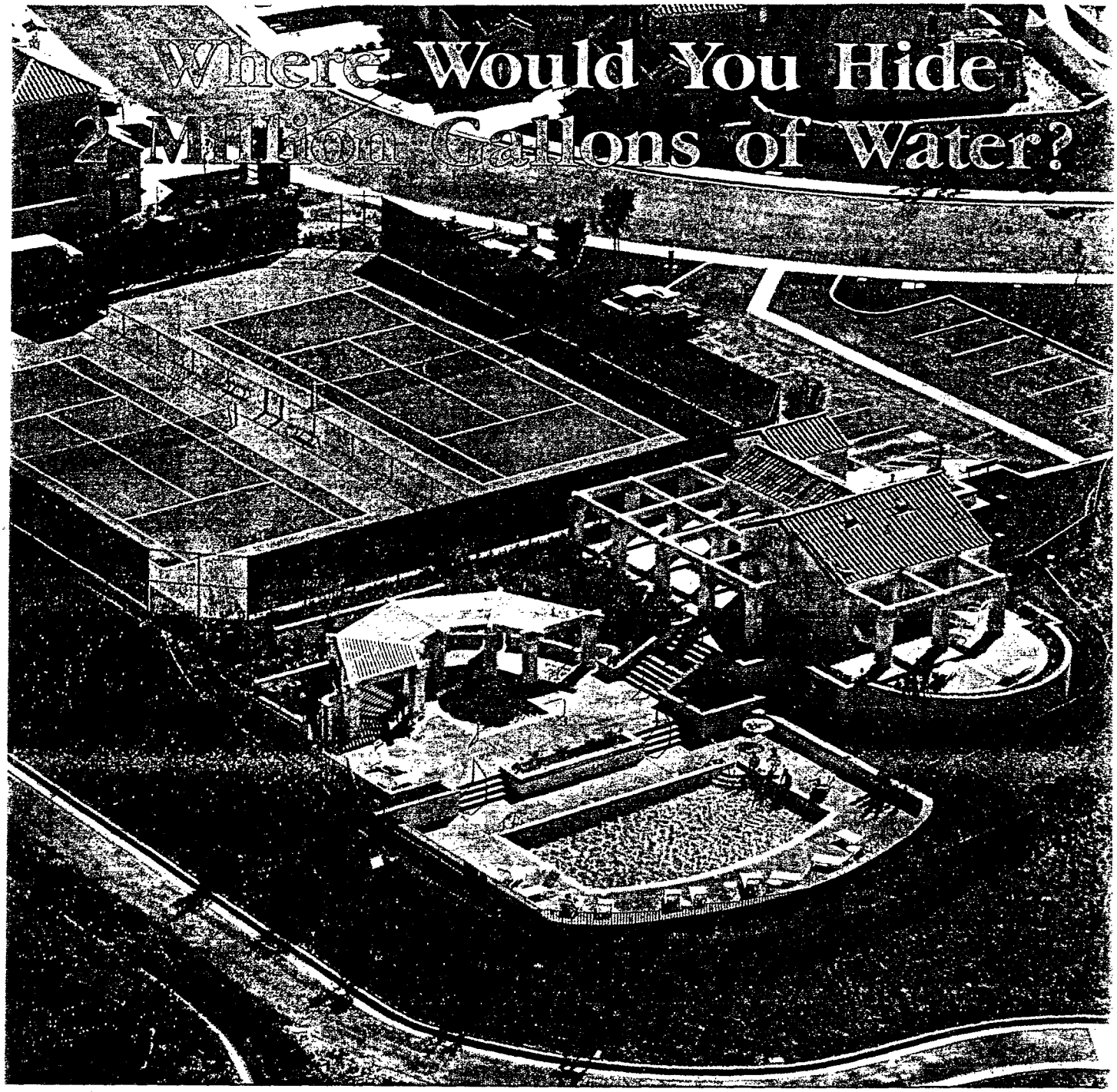

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Engineer: Daniel Boyle Engineering, Inc. Laguna Hills, California

Owners: South Coast County Water District, South Laguna, California
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Storing 2 million gallons of water is one thing. Camouflaging 2 million gallons of water is something else! When the water storage for a new development was being planned, several restrictions were mandated by the water districts, neighbors and the developer. It had to be buried, dependable, maintenance-free, aesthetically pleasing, have a multi-purpose use and enhance the local property values. The obvious choice was a buried, circular, externally machine-wrapped prestressed concrete tank. DYK Prestressed Tanks, Inc., was chosen to install the prestressing because of their impressive and dependable experience that encompasses more than one billion gallons of liquid storage. Galvanized vertical and circumferential prestressing assures a maintenance-free structure. A buried concrete roof, with tennis courts on top, fulfilled the requirement that the structure be aesthetically pleasing and multi-purpose. Whether your storage requirements are for water, sewage, lng, grain, nuclear, oil or if you just want to hide your tank, DYK will be glad to be of assistance.

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pumps, hydropneumatic tank, and distribution piping. It has been recently expanded with ion exchange units, a French drain field, and pressure filters to provide radium removal. An 8 percent sodium chloride solution is furnished for regeneration and chlorine is used for disinfection. In addition to the high radium content, the fluoride level is 2.2 mg/L and total hardness, 471 mg/L as calcium carbonate. Pressure filters are provided to assure that particles capable of plugging an ion exchange resin are removed. The system uses a dual-tank cation softening unit to permit continuous operation. The tanks contain 1.5 cu ft of strong acid cation exchange resin. The system is nonelectric, being hydraulically powered. A water meter on top of the unit initiates the regeneration cycle after 1112 gal of water have been treated. After softening, the water is treated with 1.5 mg/L chlorine and then enters the storage tank for distribution. A French drain field, approved by the Texas Department of Health as part of the treatment plan, was installed for disposal of the brine waste. Because radium is one of the most highly preferred cations in ion exchange, the fundamental principles of cation exchange apply to its removal. Radium replaces sodium in the resin and will continue to do so until the resin becomes saturated. The treatment system was found to perform satisfactorily and was able to reduce radium levels in the Quail Creek water system to acceptable levels. The water system was readily accepted by the community and owner. Even though the costs are low, they still have an impact on a small water system. The current water rate of $17.50 for the first 4000 gal plus $2.50 for each additional 1000 gal provides an annual income for the system of $4500. The current income is approximately equal to the system's annual cost of $4687. By optimizing the resin usage, additional bed volumes can be treated between regenerations, improving cost recovery and reducing salt usage. Waste disposal does not appear to concern the water system owner. Long-term effects, however, could not be determined, and the drain field should continue to be monitored. Using ion exchange to remove radium from water systems appears to be an effective and viable alternative for meeting drinking water requirements.

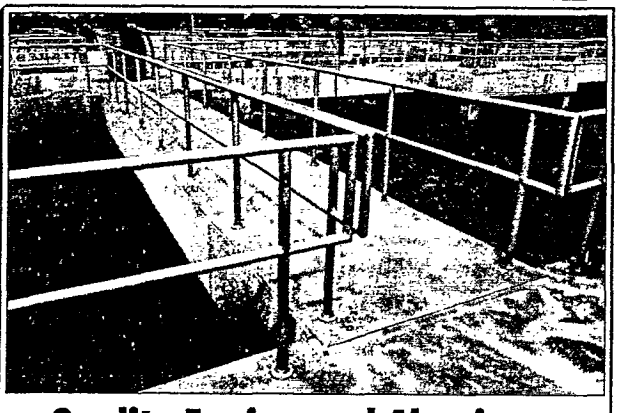
"Ion Exchange: A Cost-effective Alternative for Reducing Radium." By Gregory A. McKelvey, manager, Kenetico, Inc., Community Water Systems Division, Newbury, Ohio; Mark A. Thompson, senior project engineer, Malcolm Pirnie Inc., Newport News, Virginia; and Marc J. Parrotta, environmental engineer, EPA Office of Ground Water and Drinking Water, Washington, DC. *Journal AWWA*, June 1993.

Other Articles

"Computer Operated Systems for Small Utilities." Small water and wastewater utilities should not avoid applying basic computer technology because of unfounded fear of complexity. By Joseph A. Holifield, III, chief electrical engineer, BCM Engineers, Inc., Mobile, Alabama. Public Works, August 1993.

"Computer-generated Pumping Schedules Satisfy Operational Objectives." The authors describe a program to assist engineers, water utility managers, and pump station operators in selecting the optimum combination of pumps over a given time period. By Donald V. Chase, assistant professor of environmental engineering; and Lindell E. Ormsbee, associate professor of civil engineering, Department of Civil Engineering, University of Kentucky. Journal AWWA, July 1993.

"Formation and Removal of Aldehydes in Plants That Use Ozone." Aldehydes apparently are effectively removed by biologically active granular activated carbon filters, but much depends on mode of filtration. By Howard S. Weinberg, research associate; and William H. Glaze, professor and Chair, Department of Environmental Sciences and Engineering, University of North Carolina at Chapel Hill; and Stuart W. Krasner, senior research chemist; and Michael J. Sclimenti, assistant chemist, Metropolitan Water District of Southern California, La Verne, California. Journal AWWA, May 1993.



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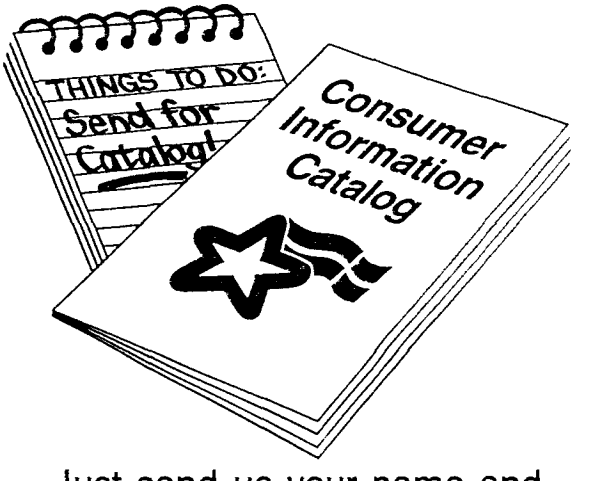

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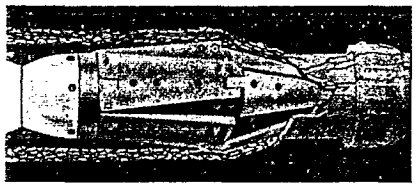

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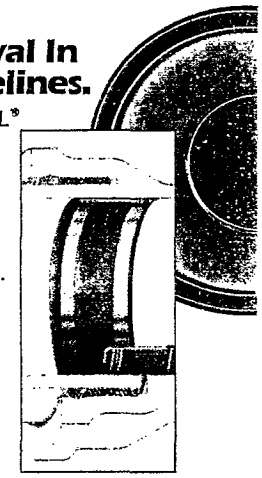

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R0013757

environmental wastes control digest

Prepared by Clayton H. Billings
Editorial Consultant

Laser-Induced Oxidation of Toxics

This report summarizes the results of a two-year bench-scale evaluation of laser-induced photochemical oxidative destruction (LIPOD), a process sponsored by the SITE Emerging Technologies Program. The LIPOD process is based on the photochemical destruction of toxic organic chemicals in dilute aqueous solution. Energy is supplied by an excimer laser and is absorbed by the organic molecule and hydrogen peroxide. This initiates the oxidation of the organic compound by hydrogen peroxide. The advantage of the process is that the narrow band of UV radiation is preferentially absorbed by the organic molecules and hydrogen peroxide. Also, little is absorbed by the surrounding water molecules, and the organic compounds are completely oxidized to inorganics and water. Unsaturated organics, particularly chlorinated ones, are major contaminants in groundwater at or near hazardous wastes sites. These species also rank high on EPA's list of priority pollutants, even at the parts per billion concentrations often found in wastewaters. Removal of the compounds is often difficult and expensive. Carbon adsorption and UV-hydrogen peroxide or ozonation are currently used to detoxify the wastes. The LIPOD process shows promise of excellent performance at a lower cost. The process has been under development for the past seven years, and

Treatment Facility Benefits from Preventive Maintenance

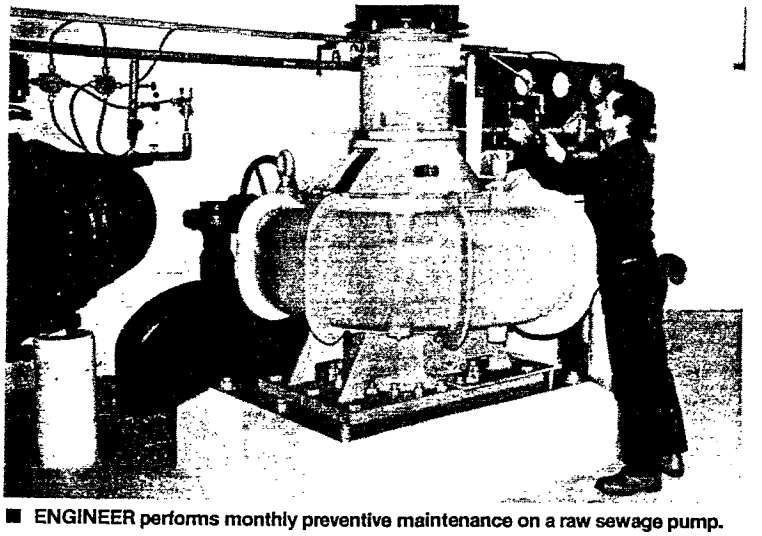
THE primary sewage treatment facility serving three New Brunswick, Canada municipalities known as Greater Moncton, with a combined population of about 85,000, is designed to treat an average of 20 mgd of sewage, with a peak of 45 mgd during heavy rainfall. In addition to operating a primary treatment facility, the Greater Moncton Sewerage Commission (GMSC) is constructing a sludge dewatering facility, an operations center, access tunnels, and a sludge shipping building—a $35-million system spanning 25 acres. An integral part of this new plant, which began operating in 1991, is the Dynastar computerized maintenance management system (DynaStar Systems Group, a division of Decision Dynamics, Inc., Lake Oswego, Oregon).

Roland Boudreau, maintenance coordinator for GMSC, wants to build equipment histories for all pieces of equipment, starting from the time equipment is purchased. Using Dynastar's comprehensive database and decision support capabilities, Boudreau asserts he will have a head start on an effective preventive maintenance program. Such a program will protect the commission's sizeable investment in the facility by assuring full-life expectancy from all equipment, better control of operating costs, and prevention of shut-downs due to equipment failure.

Before the commission implemented the system, the facility used a manual spreadsheet system to track job scheduling and maintenance of some 125 pieces of equipment with an estimated total value of over $10 million. Keeping the data in files was "almost impossible," according to Boudreau. Gathering information was a tremendous job that could take over two hours. Now it takes minutes, and Boudreau has confidence in the data's integrity.

Boudreau is still adding equipment to the history file, which he anticipates will be invaluable in years to come. Decisions about whether to repair or replace equipment will be easier to make. Boudreau said the equipment history module will be important for bringing order to the plant. For example, Boudreau has noticed that work orders are processed more quickly and accurately because records are complete for scheduling both preventive maintenance and corrective maintenance. So far, about 95 percent of the facility's equipment is on the maintenance management system.

The system's parts inventory component also allocates part costs to specific machinery at the end of the year. By looking at parts usage and maintenance hours, the plant's management will be able to thoroughly evaluate labor and work schedules and track costs of operations.



■ **ENGINEER performs monthly preventive maintenance on a raw sewage pump.**

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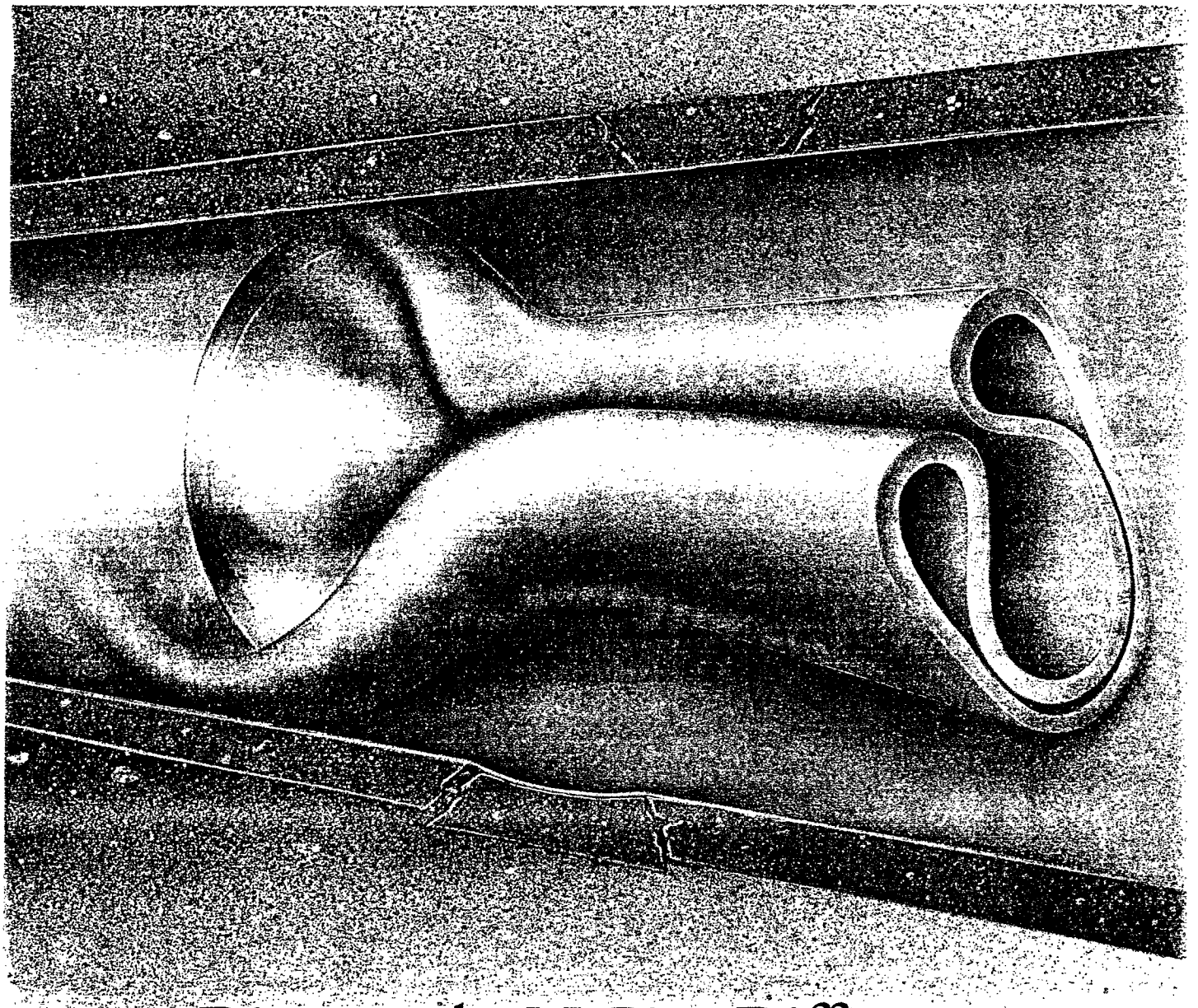

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its efficacy relies on the use of a coherent electromagnetic radiation source in the UV portion of the spectrum to activate an exothermic process in the presence of an oxidant so as to initiate a chain oxidation reaction. The UV source is an excimer laser. The oxidant is hydrogen peroxide. Hydroxyl radicals, which are very powerful oxidants, are produced when the laser beam impacts the hydrogen peroxide, and sufficient oxygen and/or hydroxyl radicals are formed to mineralize the organic compounds completely. The test compounds selected for this project are frequently found in wastewaters and have the ability to absorb the energy from the wavelength chosen for the laser. Laboratory scale testing of the process has shown that the method is capable of destroying 90 percent or more of a variety of toxics. The effects of concentration of the toxic, oxidant concentration, and irradiation dosage have been determined for a series of representative organic compounds. On the basis of these results, the cost of a commercial-scale process has been estimated and found to be very competitive with existing technologies now in use. Costs range from $30 to $70 per thousand gallons treated for the complete conversion of toxics, present initially at the 50 mg/L level. It is recommended that treatability studies using actual water samples from hazardous waste sites be undertaken to establish how the process performs on waste containing a variety of organics and inorganics. Successful completion of these treatability studies would lay the groundwork for commercialization of the process.

"Laser Induced Photochemical Oxidative Destruction of Toxic Organics in Leachates and Groundwaters." By the staff, Energy and Environmental Engineering, Inc., Somerville, Massachusetts. Superfund Innovative Technology Evaluation, EPA, Cincinnati, Ohio. *Emerging Technology Summary. EPA/540/SR-92/080.* February 1993.

EPA's Metals Criteria

EPA's recent publication, *Interim Guidance on Interpretation and Implementation of Aquatic Life Criteria for Metals,* represents a significant advancement in metals regulation. Regulatory policy and science are more aligned. EPA has acknowledged in the interim guidelines that only toxic forms of bioavailable metals are intended to be regulated by EPA criteria. Some critics argue that the interim guidance does not reflect the latest scientific knowledge, and that the regulatory alternatives are overprotective. Since 1980, EPA has published aquatic life criteria for metals pursuant to Section 304(a) of the Clean Water Act. The criteria are not, by themselves, enforceable, but are available to states to assist in the development of water quality standards subject to state enforcement, from which water quality standards EPA or the state calculates the total maximum daily loads for receiving waters as well as the wasteload allocation for each discharge into the receiving waters establishes the permit effluent limitations. Many permit holders are concerned that metals criteria may be based on experiments whose objective was to determine the most toxic impact possible. The conditions under which these impacts occurred in the laboratory rarely, if ever, exist in ambient waters, and therefore the criteria may be unnecessarily stringent. The interim guidance is intended to present recommendations for approaches for implementing aquatic life criteria. A key recommendation is that of the water effect ratio (WER) method—a biological method comparing the bioavailability and toxicity in receiving waters downstream with the bioavailability and toxicity in laboratory test water. The WER provides a site-specific adjustment to the criteria to produce standards toxicologically equivalent to laboratory results. The interim guidance recognizes that, for most ambient waters, the measure of dissolved

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OdorMaster Systems have become the standard against which all are measured by chemically changing, not masking, odorous compounds in contaminated air.

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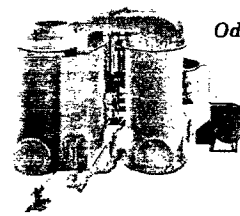
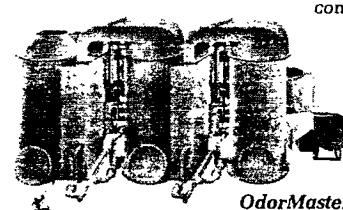


OdorMaster II Systems
Two towers in series. The second dual-compartment type tower provides the additional treatment flexibility needed for more difficult applications, such as composting sites.



OdorMaster III Systems
Three towers in series. Maximum treatment of complex odors, including mixtures of volatile organic and inorganic sulfur compounds, such as odors from thermal sludge conditioning systems.

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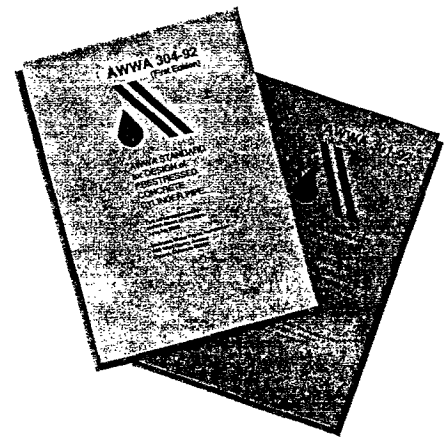
R0013760

NEW AWWA STANDARDS INTRODUCED FOR PCCP DESIGN AND MANUFACTURE

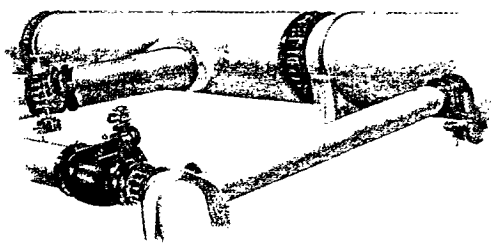
New Generation of Standards for Prestressed Concrete Pipe



Introducing AWWA C301-92 and C304-92

AWWA C301-92 is the new manufacturing standard that squarely addresses the questions raised by owners, engineers and the public about quality and reliability of Prestressed Concrete Cylinder Pipe (PCCP). It mandates stringent testing that had previously been optional and significantly tightens all component material specifications.

AWWA C304-92 is the entirely new design standard based on limit states analysis and advanced computer modeling. Developed over an eight-year period at a cost of over $1 million, C-304 replaces the former C301-84 Appendix A and B design methods. The end result is a new design procedure that is able to provide analysis unsurpassed by other pipe materials. The new design standard provides pipeline owners and engineers the knowledge that Prestressed Concrete Cylinder Pipe is conservatively designed by the most current technology available.



Both new standards were exhaustively reviewed and approved by the AWWA Concrete Pressure Pipe Standards Committee, AWWA Standards Council and AWWA Board of Directors. Those groups include many of the largest users of PCCP and some of the most prominent consulting engineers in the water supply industry.

New standards are just the beginning

As good as these new standards are, they're only a foundation for the future of PCCP. The companies that comprise the ACPPA are committed to continued product improvement and total quality management to ensure that PCCP will continue to provide the best performance record in the water works industry.

We invite you to examine the new AWWA standards in detail. To obtain your copies, please contact the AWWA or call the ACPPA for more information.

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R0013761

metals provides an adequate indicator of toxicity and is a better indicator of toxicity than the measure of total recoverable metals. Although the Guidance states that the dissolved metals approach is a better indicator of bioavailable metals than the total recoverable approach, EPA raises several caveats about its use. The Guidance recommends that states using a dissolved approach reduce the EPA criteria to reflect the percentage of metal in the laboratory that was dissolved. This reduction is generally less than 10 percent and is essentially zero for several metals. The interim guidance states that the criteria and water quality standards refer to acceptable levels of bioavailable metals in ambient waters, which is vitally important to the regulated community. Before the interim guidance was issued, EPA assumed that the metal identified by the total recoverable metals method equated to the biologically available metal in ambient waters. Studies prove that this assumption is false. Updated and scientifically precise standards are essential for ensuring that pollution control resources are expended wisely. Because state agencies do not have resources to conduct independent scientific research, it is important for EPA to provide updated information on pollutant impacts. The interim guidance is a much needed improvement to the regulation of heavy metals. However, the Guidance needs to abandon outdated positions. In addition, the recommendation of the total recoverable method should be replaced by either WERs or the dissolved metals method.

"A Reflection on Metals Criteria." By John C. Hall, counsel, and Ronald L. Raider, associate, Kilpatrick & Cody, Washington, D.C. *Water Environment & Technology,* June 1993.

Great Lakes Pollution Abatement

The Great Lakes Initiative (GLI) is a landmark effort in controlling toxics in the Great Lakes basin. It is also the most far-reaching water quality regulation ever proposed by EPA. It is considered a major success story in both its technical content and its development process, but it is likely that many GLI concepts will be incorporated into future federal and state regulatory initiatives. In fact, Indiana has already adopted a regulation that identifies and controls bioaccumulative chemicals in the same manner as the GLI. The key questions are, is the GLI approach technically sound and fairly applied? Will it accomplish the goal of significantly improving the water quality of the Great Lakes? And finally, is the GLI an appropriate model for future water quality regulation in other parts of the country? The GLI has its roots in the Great Lakes water quality agreement, which was signed by the U.S. and Canada in 1972. When the agreement was updated by the two countries in 1978, language calling for the virtual elimination of the discharge of persistent toxic chemicals was included. In 1986, the governors of Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin signed the Great Lakes Toxics Substances Control Agreement for uniform water quality standards for the Great Lakes. The goal was consistency for both environmental protection and economic competitiveness so that there would be no market-driven incentives to move facilities to a state with less stringent standards. A protocol was added to the Great Lakes Water Quality Agreement in 1987 that called for remedial action plans for 43 toxic hot spots around the lakes. Lakewide management plans were also required. The emphasis is on identifying the major sources of these pollutants and concentrating regulatory efforts where they will have the most impact. The 1987 Clean Water Act established EPA's Great Lakes National Program Office to design and carry out the GLI. Congress also passed the Great Lakes Critical Programs Act in 1990 to convert commitments made by the U.S. in the Great Lakes Water Quality Agreement into domestic law. Three committees were established to develop the GLI: a steering committee, comprised of the water program

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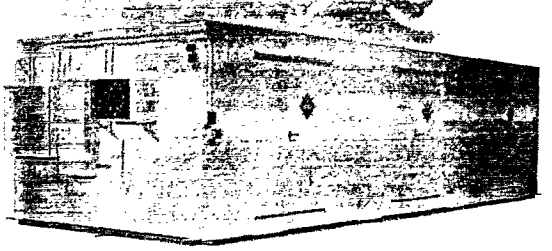

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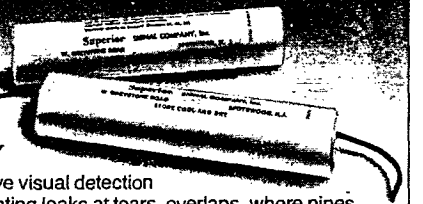

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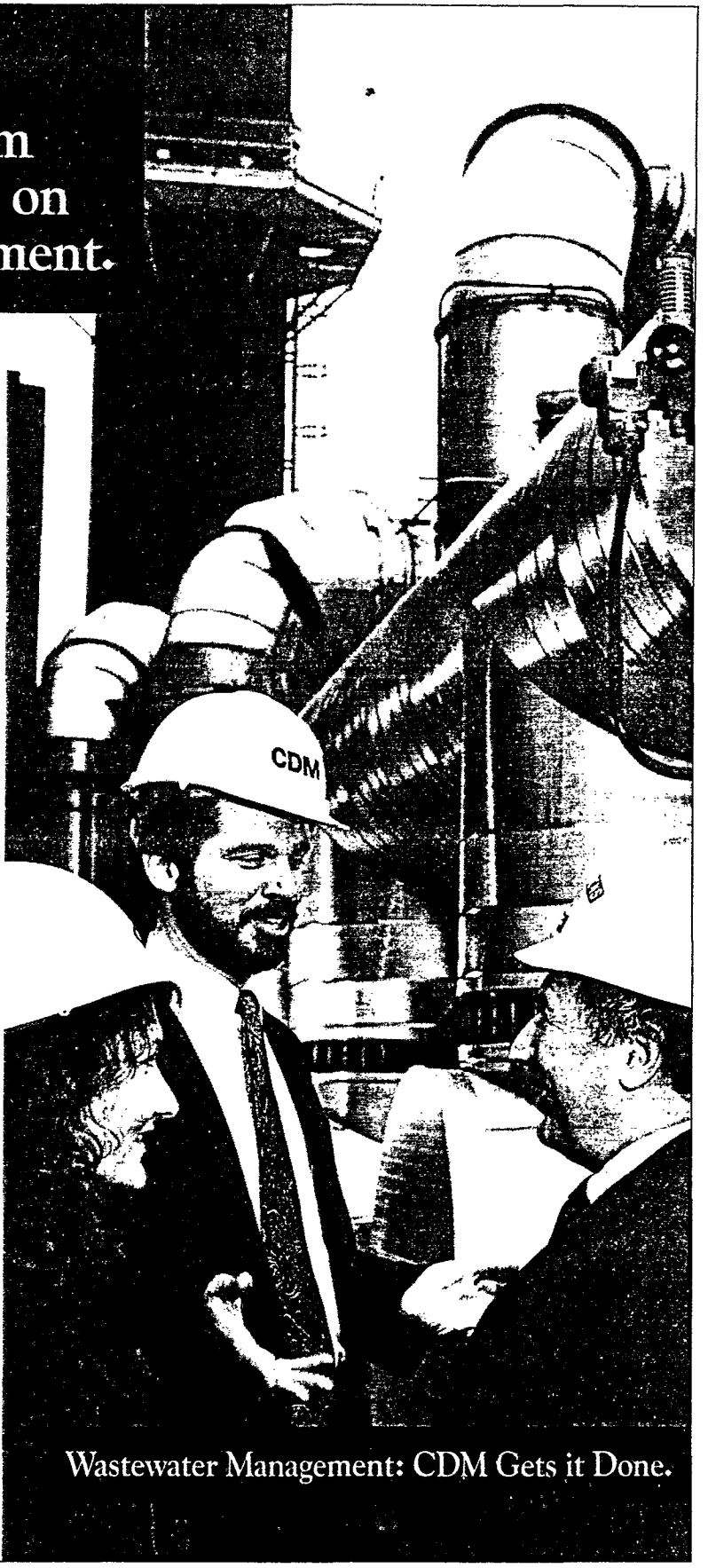

To meet a federally mandated deadline to cease ocean disposal of its sludge, the Passaic Valley Sewerage Commissioners (PVSC) teamed with CDM to develop an interim land-based sludge management strategy for its 330-million-gallons-per-day wastewater treatment plant in Newark, New Jersey. Meeting the ambitious 23-month schedule, CDM turned PVSC's plan into reality by fast-tracking design and construction of the facilities. The innovative design combined existing thermal sludge conditioning with the world's largest lime stabilization system. When it comes to wastewater management, CDM gets it done.

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directors of the eight Great Lakes states, with representatives from EPA Regions II, III, and V; a technical workgroup made up of scientific and technical staff from the Great Lakes states, EPA, and the U.S. Fish and Wildlife Service; and a public participation group, which includes representatives of the regulated community and environmental groups. At the end of 1991, the steering committee voted to approve the Great Lakes Water Quality Guidance drafted by the technical workgroup in 1990. This was done even though resolution had not been reached on many issues. Each of these states must amend its water quality standards to be consistent with the Guidance within two years following the publication, or EPA will promulgate the rule itself. The Guidance document contains detailed procedures for the calculation of water quality criteria for the protection of aquatic life, human health, and wildlife. One of the key concepts is the establishment of Tier 1 and Tier 2 criteria for all three. The procedures for calculating Tier 1, for example, for aquatic life are based on EPA's 1985 Guidelines. The procedures for calculating Tier 2 aquatic life criteria are based on a draft EPA procedure for calculating advisory levels. The procedure for calculating the Tier 2 values for toxicity data must be adopted by the states, however, the values themselves need not be. A total of 34 chemicals have at least one type of criterion. Bioaccumulation factors measure a chemical's potential to accumulate in fish tissue through exposure to both water and food. The emphasis on risk factors for criteria calculation in the guidelines goes beyond the current widespread use of bioconcentration factors, which only consider direct uptake from water. The factors can be measured only in the field on a site-specific basis. Because these are largely lacking, the Guidance depends on the application of controversial food-chain multipliers to convert laboratory-derived concentration factors to accumulation factors. Many of the accumulation factors generated thus far are higher than the concentration factors previously used by EPA and many states in the calculation of water-quality criteria. Many chemicals with high accumulation factors do not yet have criteria. A second issue regarding accumulation factors is the designation of all chemicals with a bioaccumulation factor greater than 1000 as bioaccumulative chemicals of concern to which extremely stringent implementation and antidegradation procedures would apply. Perhaps the topic of greatest debate concerning the GLI is the projected cost of compliance. EPA's preliminary cost estimates for compliance range from $80 million to $500 million. EPA is required to conduct a full impact analysis if the projected annualized costs are estimated to be $100 million or greater than beyond that required by existing regulations. Several groups within the regulated community have conducted their own studies. The American Iron and Steel Institute used site-specific background data for two locations of major existing facilities. The results indicate that for a single facility, the increase in necessary capital and operating expenses up to $102 million beyond that necessary to meet technology-based limits and state regulatory limits would be required to meet limits calculated with the Guidance.

"Launching the Great Lakes Initiative." By James B. Whitaker, manager, Chester Environmental, Towson, Maryland. *Water Environment and Technology,* June 1993.

Virus Monitoring Of Effluents

The current drought in California emphasizes the importance of water reclamation and reuse in Southern California. The County Sanitation Districts of Los Angeles County (CSDLAC) have long been committed to water reclamation and currently operate seven water reclamation plants. This article describes the districts' virus monitoring program and documents

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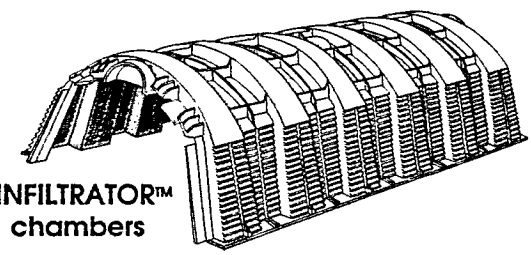

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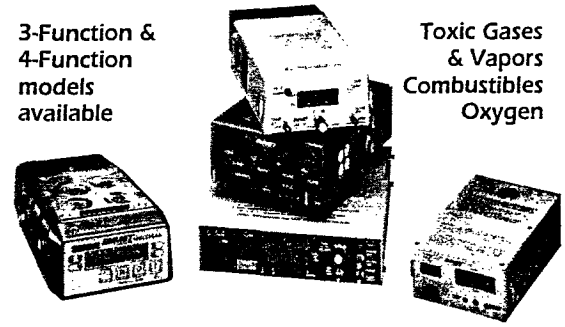

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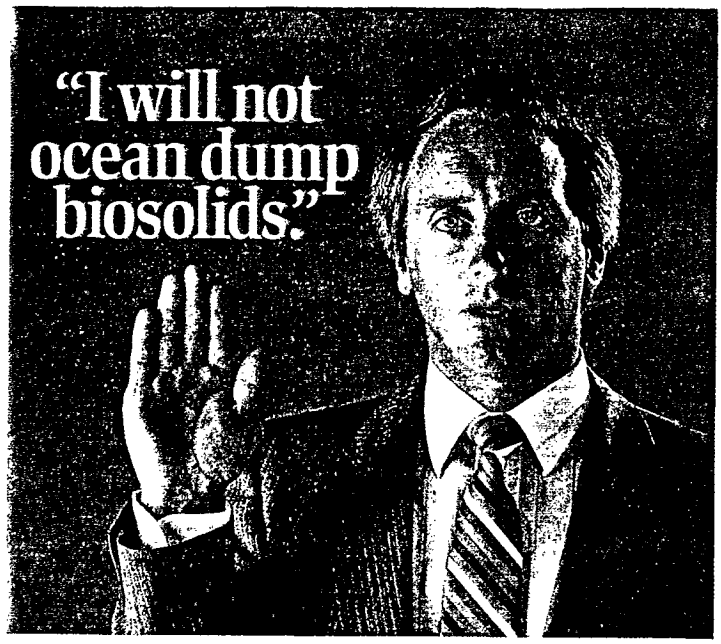



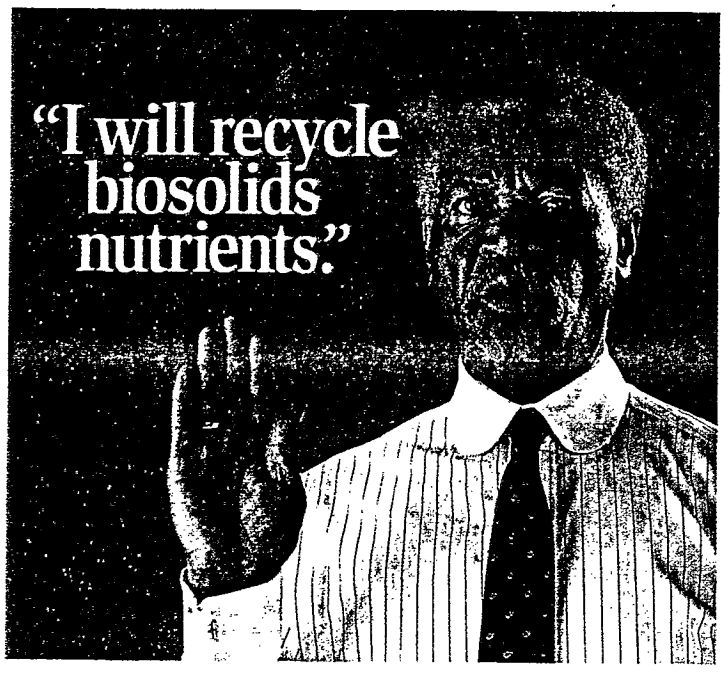



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10 years of virus monitoring experience. One of the early concerns in developing water reuse was the fate of viruses in wastewater. These concerns were addressed in Title 22 of the California Administrative Code, the State Health Department's Wastewater Reclamation Criteria, which required a system consisting of coagulation, flocculation, sedimentation, filtration, and disinfection for recreational reuse. The specified system was costly and served as an incentive for evaluating alternatives. To satisfy that research need, the EPA, the State Water Resources Control Board, and CSDLAC jointly funded the Pomona Virus Study in 1975. This study showed that modified treatment trains, which could be constructed and operated on a less costly basis, achieved virus removal efficiencies equivalent to the full Title 22 requirements. The Pomona Study demonstrated equivalency of virus removal using high doses of vaccine polio viruses. Limited experiments conducted with naturally occurring viruses suggested that seed virus studies may not fully simulate the dynamics of natural virus removal and inactivation. It was still the consensus of the project advisors that the 5-log reduction of seed virus and system equivalency demonstrated during the Pomona Study was an adequate margin of safety for recreation. The Pomona Study also recommended that development of more sensitive virus detection procedures was warranted. As a result of the demonstrated virus removal capabilities of these alternative advance waste treatment trains and other findings of the study, a conservative approach was adopted and the requirements were changed to their present form. Based on the study findings, a construction program expanded the Districts' activated sludge secondary treatment plant to tertiary treatment to meet recreational standards. A health effects study was also proposed in anticipation of increasing the planned groundwater recharge with reclaimed water. Virus sampling of the tertiary treatment plants began in 1979 and continued through most of 1981. It was resumed in mid 1982. Results of that program are presented and discussed in the context of the reliability of the data and the California wastewater reclamation criteria. Six tertiary treatment water reclamation plants were monitored monthly for enteric viruses over a 10-year period. Secondary treatment removed 99.8 percent of detectable viruses. The virus concentrator and assay system detected low levels of native viruses in 74 out of 75 unchlorinated secondary effluent samples. Only one of 590 final effluent samples was positive for enteric viruses. The results have provided evidence that compliance with the California water reuse standard meets the desired objective of producing essentially virus free reclaimed water. This supports the observation that no detectable viral hazard has been found associated with current water reuse programs in California. These data also provide additional evidence that current water reuse programs in California can be expanded with reasonable assurances that viruses will not compromise public health.

"Analysis of 10 Years of Virus Monitoring Data from Los Angeles County Treatment Plants Meeting California Wastewater Reclamation Criteria." By William A. Yanko, laboratory supervisor, microbiology, County Sanitation Districts of Los Angeles County, Whittier, California. *Water Environment Research*, May/June 1993.

Other Articles

"Public Works Surveys Waste-to-Energy Plants—Part One." A market survey conducted in 1992-93 revealed that more than 140 cities, counties, and/or special districts were either operating or planning waste-to-energy facilities. Public Works, August 1993.

"Wetlands for Stormwater Treatment." Wetlands are used to treat urban runoff from a residential site on Lacamus Lake, Washington, and offer protection of lake waters from pollution. By Mark F. Bautista, aquatic ecologist, and N. Stan Geiger, senior ecologist and president, Scientific Resources, Inc., Lake Oswego, Oregon. Water Environment & Technology, July 1993.

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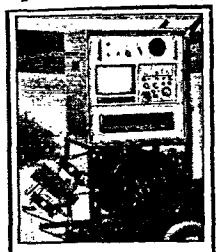

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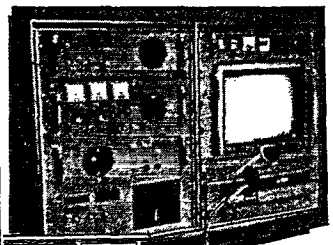

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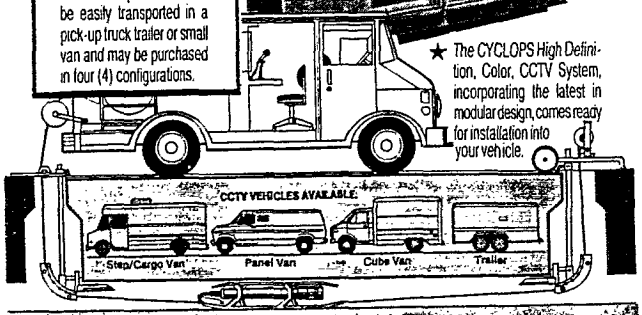

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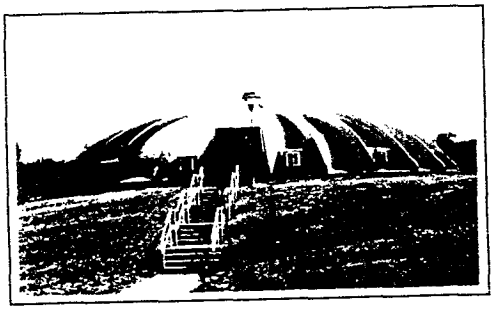

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public works engineering notes

GIS System Planned for Midwest City and County

The Sidwell Company (West Chicago, Illinois) and M. J. Harden Associates, Inc. (Kansas City, Missouri) have joined forces to provide a comprehensive geographic information system (GIS) for Polk County and the city of Des Moines, Iowa. This award follows a successful pilot project designed to provide an accurate cost/benefit analysis for full implementation, which is planned as a four-year project.

Services include conversion of cadastral data (property ownership mapping), sewer mapping of Des Moines, taxing and election district data conversion, boundary mapping (zoning, flood plain, etc.), planimetric compilation, aerial photography and orthophoto production, and other related geographic information services. All digital data will be developed and installed on Intergraph computer graphics equipment in the MGE environment. In addition to the conversion services, training and hardware development are also being provided.

Polk County and the city of Des Moines cover 582 square miles, comprising about 155,000 real estate parcels.

Consultant Awarded Bridge Repair Contract on Massachusetts Turnpike

The Massachusetts Turnpike Authority recently chose Maguire Group, Inc. (Foxborough, Massachusetts) to design the rehabilitation and renovation of ten bridges between exits 8 and 11-A, encompassing over 40 miles. The contract is part of a major project to repair 72 bridges on the turnpike between the New York state line and the terminus in downtown Boston. The rehabilitation designs will include complete deck replacement and other related structural repair on several of the bridges, all of which span the turnpike. Two of the bridges, Bancroft Street and Park Hill Avenue, need immediate repair. An accelerated design schedule has been set to repair these structures, with a design completion date of December 1993. Design work for the remaining bridges is slated for completion by 1996.

Interactive Software is Helping Cities Keep Water Clean

Twenty-four cities in the U.S. and Canada are using computer-based training to certify their wastewater system operators. The latest of three complementary training modules, the software features computer-guided text and high-resolution graphics to create an enjoyable, highly interactive exchange with the operator trainee. Operators are required to respond to questions and activities on environmentally sound wastewater operations. Each lesson ends with a 20-question quiz. Each volume also includes a 100-question certification-caliber examination that gives students a good feel for their test-passing ability. The training materials cross-reference California State University manuals, the generally-accepted standard for training information.

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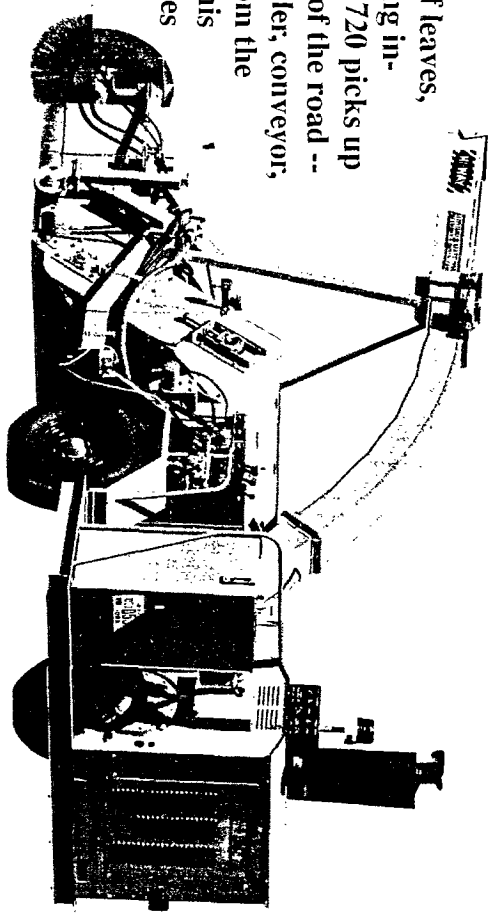

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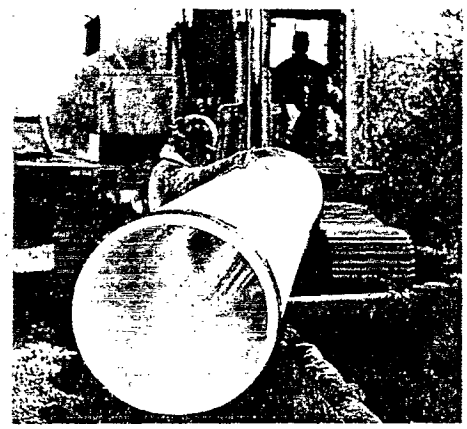

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A-2000™, the reliable, cost effective PVC sanitary sewer pipe you have depended on for years, soon will be available in 4-inch through 30-inch diameters, making it ideal for *storm* sewer applications as well as sanitary sewers.

A-2000 features a smooth interior for superior hydraulics and a corrugated exterior for added stiffness. It should be considered wherever SDR 35 PVC pipe is used. But it's *better* because it's: **Stronger** (nearly 10% stiffer than SDR 35). **Tighter** (the double seal rubber gasket makes tight joints easily). **Less expensive** (lower material cost and lighter weight mean lower installed costs).

For more information, call your local CONTECH® Sales Engineer, or write to CONTECH CONSTRUCTION PRODUCTS INC., Dept. 0204, P.O. Box 800, Middletown, Ohio 45042-0800. Telephone toll-free **1-800-338-1122** (in Ohio, call **1-800-752-8899**).

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course materials presented. The State of Georgia is also considering the software for training credit, says Austin, Texas-based Layton International, supplier of the software. A PC compatible computer with DOS 3.0 or later, hard disk, VGA monitor, and mouse are required to run the software. A demonstration disk is available from the company by calling (512) 251-0074.

King County, Washington Implements County-Wide GIS System

King County, Washington is implementing a county-wide GIS system with ArcCAD software from Environmental Systems Research Institute, Inc., Redlands, California. The road maintenance and surface water divisions of the county's public works department are taking the lead in the project, which will be used to help the county meet the federally-mandated National Pollution Discharge System (NPDES) requirements. In addition to ArcCAD, the county will be using AutoCAD Release 12 and Trimble Navigation's Pathfinder Professional, a portable global positioning system. The system will include a Sun Sparcstation that will function as the server, networked together with high-powered 486-based PCs, linked with high speed dedicated data transmission lines. The GIS will support field investigation of water quality conditions and the artificial drainage network inventory data collection necessary to comply with NPDES permit requirements. The county-wide plan also includes the completion of a survey control densification project to provide a highly accurate control grid to support survey, road design, and capital improvement projects. As part of the NPDES permit requirements,

Major Metropolitan Transportation Commission Contract Awarded

The Metropolitan Transportation Commission, Oakland, California has chosen Colwell-Kirtland International (Sunnyvale, California) to undertake a major study to understand the issues affecting implmentation of automated vehicle location systems (AVLS) in the Bay Area. The study is a forerunner of the TravInfo project, a real-time traveler information system under consideration for the entire area. Colwell-Kirtland's study will include coordinating and interviewing all San Francisco Bay Area Transit organizations to determine each agency's experience with and acceptance of AVLS. The consultant will explore and review the future AVLS requirements of each transit organization to provide the Metropolitan Transportation Commission with a comprehensive analysis of AVLS needs and level of interagency cooperation.

Contract Operator Adds Four New Clients

Kingwood, Texas-based Operations Management International, Inc. (OMI) recently signed operations and maintenance contracts to operate facilities in Colorado, Texas, Hawaii, and Oregon.

- In Boulder, Colorado, OMI personnel have been onsite at the Marshall/Boulder Landfill since early April. The project's scope of services includes treating leachate from a closed landfill designated as a Superfund site. Among the challenges faced by the contract operator's three employees will be meeting strict discharge limitations and Resource Conservation and Recovery Act standards.
- In Lampasa, Texas, ten OMI employees are operating and maintaining the city's water and wastewater systems, including two wastewater treatment plants, five water storage facilities, and the collection and distribution systems. The project's scope of services also includes water and electric meter reading.
- Five OMI employees in Keauhou, Hawaii, are responsible for starting up and providing operations and maintenance services for a sequencing batch reactor wastewater treatment plant, five lift stations, and the collection system. The new facility is expected to come on line shortly and until that occurs, one employee is onsite performing "mothball" maintenance to ensure all equipment is in excellent condition upon startup.

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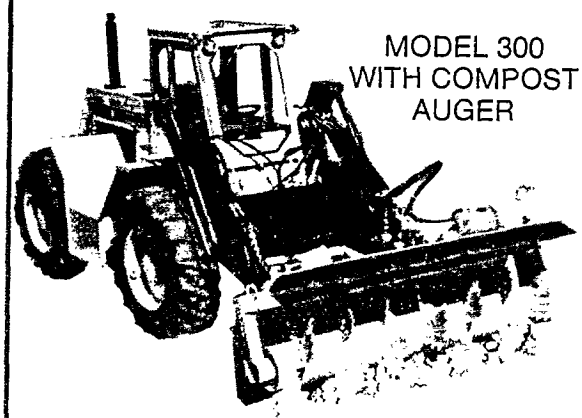

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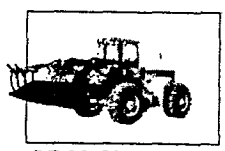
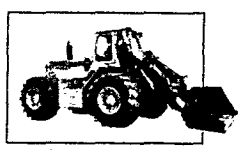
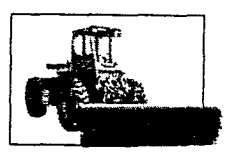


GRAPPLE FORK



BUCKET



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Denise Dolce
Chemical Manager

Q: Since chlorine chemical comes with differing percentages of available chlorine, how can you tell what you are actually paying for the chlorine you use for a wastewater disinfection?

A: To compare accurately, you need to figure your cost per pound of chlorine. This can be achieved by dividing the cost per container by the percentage of available chlorine listed on the label.

Here's an example:

- Brand X Chlorine chemical contains 65% available chlorine (as most chlorine tablets do). For comparative purposes, suppose it costs $190 for a 100 pound drum, or $1.90 per pound.
- Sanuril 115 Chlorine tablets contain 70% minimum available chlorine. Suppose it costs $200 per 100 pound drum, or $2.00 per pound.

Although the Sanuril 115 costs more per pound, the question should be, "which one costs you less per pound of available chlorine?"

Brand X costs about $292 per hundred pounds of available chlorine ($190 ÷ .65).

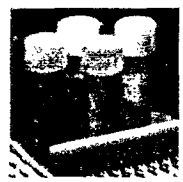
SANURIL, with the higher concentration, would be only $285 per hundred pounds ($200 ÷ .70). In the above example, Brand X, which at first appears to cost less, actually ends up costing you about $7 more per one hundred pounds.

SANURIL 115 also contains two active ingredients for disinfection.

SANURIL provides greater strength, consistent delivery, longer regrowth control and less handling. SANURIL 115 is definitely a better value.

For more information, please call the Chemical Department at (713) 274-8444.





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news of engineers

C. ADAM FISCHER was added to Shafer, Kline & Warren, P.A.'s staff for client development as a member of the market department.

STEVEN L. MARTIN was appointed hydrogeology group manager in Eder Associates Consulting Engineers, P.C.'s Madison, Wisconsin office.

Technomic Publishing Company, Program Division is offering six water quality and wastewater treatment courses November 16 to 18, 1993 in Washington, D.C. For more information write the company at 851 New Holland Avenue, Box 3535, Lancaster, Pennsylvania 17604, tel-(717) 291-5609, fax-(717) 295-4538.

Black & Veatch reorganized its environmental group into five divisions or strategic business units. Heading the groups are LEN RODMAN, managing partner, environmental division; JIM HIPPS, executive partner, environmental enterprises division; DR. JOHN R. STUKENBERG, senior partner, advanced environmental technologies division; ROLF STAMM, executive partner and president of BVI-Environmental, international activities; and PAUL MACROBERTS, executive partner and president of B&V Waste Science and Technology Corp., continues leading this unit.

Montgomery Watson named AGUSTIN E. MARISTANY manager of the firm's Water Resources Technology Center.

The American Society of Mechanical Engineers' Solid Waste Processing Division announced its 1994 scholarship program to encourage engineering students to enter careers in solid waste management. For more information or application forms contact Junius W. Stephenson, ASME Solid Waste Processing Division Scholarship Chairman, 38 Sunset Road, Demarest, New Jersey 07627, tel-(201) 767-1998.

SUSANNE M. BATCHELDER joined the King of Prussia, Pennsylvania office of Greiner, Inc. as a civil engineer. GEORGANNE K. SCOTT joined that office as an environmental specialist.

The Seventh Annual National Conference on Beach Preservation Technology will be held February 9 to 11, 1994 in Tampa, Florida. For information contact David Tait, Beach Technology '94, 864 E. Park Avenue, Tallahassee, Florida 32301; tel-(904) 222-7677, fax-(904) 561-1172.

CHARLES W. BALLINGER has opened the consulting engineering firm of Ballinger Consultants, P.C. The new firm is located at 19207 N. 33rd Drive, Phoenix, Arizona 85027, tel-(602) 516-0798, fax-(602) 516-8294.

WALTER B. SINNOTT was elected chairman of the board of Hazen and Sawyer Environmental Engineers and Scientists. Succeeding him as president is ROBERT E. HAGADORN. JERRY LASTIHENOS, senior vice president, was selected northeast regional manager.

The Engineering Foundation hosts numerous conferences on a variety of engineering subjects. For more information contact the Foundation at 345 East 47th Street, New York, New York 10017, tel-(212) 705-7836, fax-(212) 705-7441.

PETER L. PALMER, a senior engineer and vice president of Geraghty & Miller, Inc., has assumed the new position of vice president of engineering.

At the Wendel company, ANDREW C. REILLY, SCOTT F. SMITH, and TIMOTHY R. WOODBURY were promoted to associate principals.

The H2M Group—Holzmacher, McLendon and Murrell; H2M Associates, Inc.; H2M Labs, Inc.; and H2M Construction Management, Inc.—is celebrating its 60th anniversary this fall.

JOSEPH GLOWITZ, president, announced the formation of Point Services & Engineering, for engineering services, information systems, management consulting, mapping sciences, and geographic information systems. The firm is located at 649 Deer Lane, Point Roberts, Washington 98281, tel/fax-(206) 945-0950.

AWARDS: The Institute for the Advancement of Engineering accorded NICHOLAS L. PRESECAN, senior vice president of Engineering-Science, Inc., its Distinguished Engineering Achievement Award... The American Academy of Environmental Engineers awarded DR. PETER B. LEDERMAN, director, Center for Environmental Engineering & Science, New Jersey Institute of Technology, its Stanley E. Kappe Award; DR. CHARLES A. SORBER, Dean, School of Engineering, University of Pittsburgh, the Gordon Maskew Fair Award; and DUANE L. GEORGESON, assistant general manager, Metropolitan Water District of Southern California, the Edward J. Cleary Award.

The Geographic Resources Analysis Support System developed by the U.S. Army Construction Engineering Research Laboratories, received the 1993 Federal Laboratory Consortium Award for Excellence in Technology Transfer... ROBERT S. O'NEIL, president of Parsons De Leuw, Inc. was presented with the Guy Kelcey Award for career achievement in transportation planning and design from the American Road & Transportation Builders Association.

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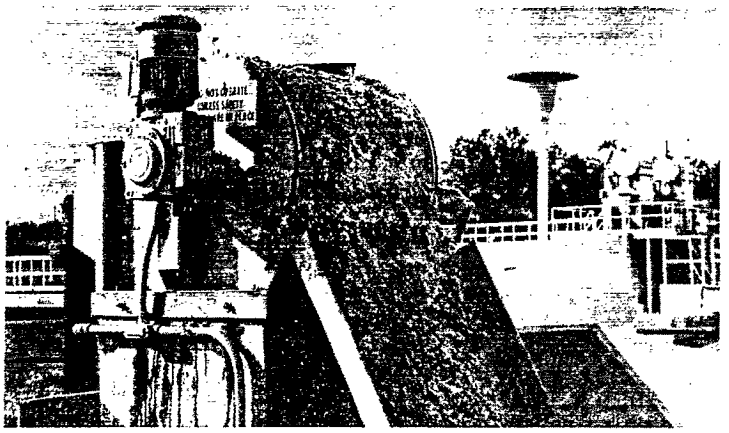

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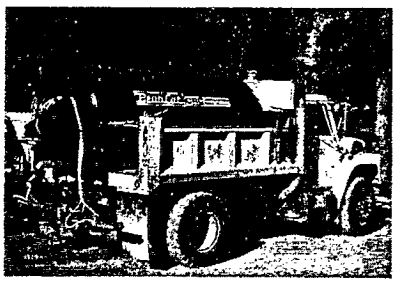
Rotostrainer™ fine screens are designed to remove grease and scum at wastewater treatment plants, whether used before or after the clarifier. The Rotostrainer screen is a compact, automatic rotating wedgewire screen, available in a wide variety of screen openings. The rotating cylinder always presents a clean surface to the flow and prevents binding, even with heavy grease concentration. An automatic doctor blade scrapes the surface clean, and a spray bar cleans the surface when it is not in contact with the incoming flow. Solids and grease are captured on the screen's surface while water and other fine particles return to the process.

Hycor Corp., Lake Bluff, IL.

Circle No. **E-1** on the reply card.



Slip-In Distributor for Ice Control Liquids

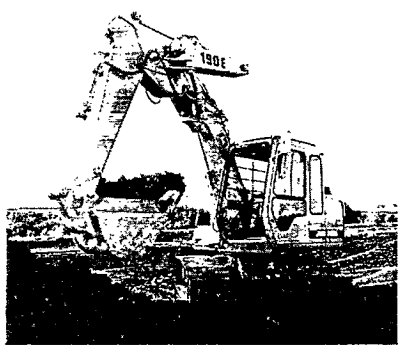
The Bear Cat "De-Icer" distributor for applying ice control liquids slips into a typical 5-cu yd end dump, using the truck's air system to pressurize the 1000-gal tank for spreading. A computerized rate control system regulates flow to maintain the desired spread rate (gallons per lane mile) at any travel speed from 2 to 20 mph. Spreading operations are controlled from the cab.

BearCat™ Mfg., Wickenburg, AZ.

Circle No. **E-2** on the reply card.

E-Series Excavator Line Is Expanded

Two new hydraulic excavators, the 190E and the 892E-LC, have been added to the E-Series excavator line. The 16,300-lb, 55-hp, 190E (pictured) replaces the 70D as the smallest excavator in this company's line. The 67,450-lb, 220-hp 892E-LC is a heavy-duty production excavator. Both feature operator-oriented cabs and Quadtronics, a special microprocessor-based engine and hydraulic control system. Seats are adjustable for operator weight and height, and seat-back inclination. The seat/console arrangement in the E-Series cab allows the operator to move farther forward in the cab, allowing excellent sight lines into trenches when working in close to the machine.

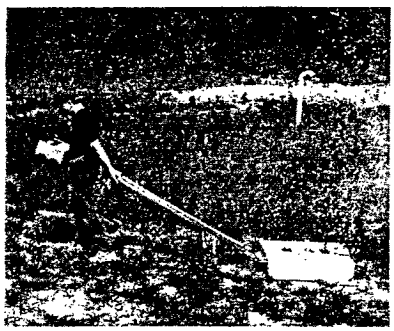


Deere & Co., Moline, IL.

Circle No. **E-3** on the reply card.

Ground-Penetrating Radar System is Portable

The new SIR® System 2 is a high-performance, portable, semi-automatic ground-penetrating radar system that makes subsurface surveys easier and less expensive. The system enables engineers, public works departments, utility crews, and contractors to:



- Pinpoint conduit and wiring within walls when removing buildings.
- Test the integrity of structures ranging from bridges and buildings to buried gas mains and water pipes.
- Locate underground utilities, underground storage tanks, buried hazardous materials, and other subsurface natural phenomena and man-made objects without excavation.

The SIR System-2 can be carried by one person, is powered by a belt-pack battery, and requires less training and experience than previous SIR systems. Its control unit weighs less than 15 lb. Operation is semi-automatic. The operator must only search one parameter: range. The system comes with instructional videotape and a user's manual.

Geophysical Survey Systems, Inc., North Salem, NH.

Circle No. **E-4** on the reply card.

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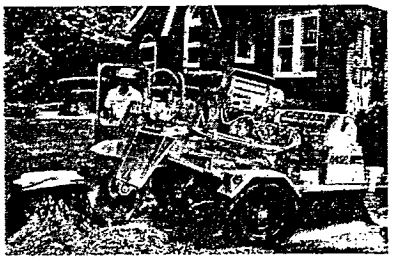


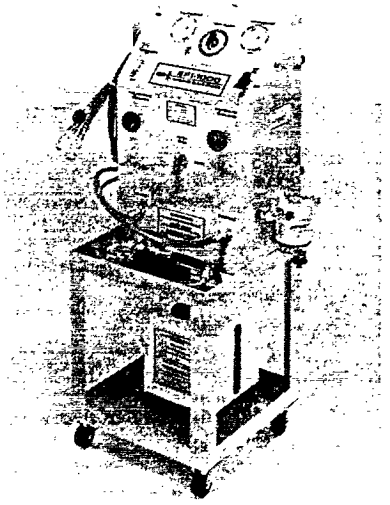
State-of-the-Art Stump Cutter

This stump cutter features a 68-hp diesel engine mounted on shock-absorbing rubber isolator pads for less vibration and a hydrostatic drive system to power the cutter wheel, enabling the operator to increase or decrease the cutting wheel rpm's, depending on soil conditions, independently of the engine rpm's. The RG 1665 AC Diesel stump cutter is compact for maneuvering into tight areas. With a working weight of just over 3000 lb, it tows safely behind a compact size truck.

Rayco® Mfg., Inc., Wooster, OH.

Circle No. E-5 on the reply card.

Powerful Fuel Injector Cleaning System



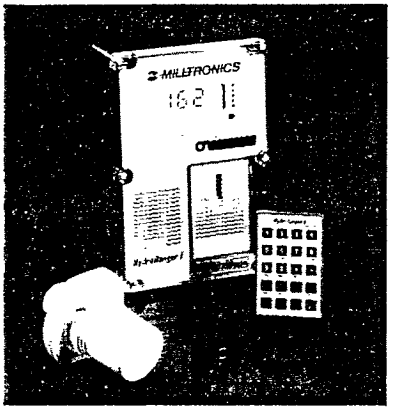
A significant cause of higher exhaust emissions and reduced fuel economy is dirty fuel injectors. The Model EFI-1000 cleaning machine cleans both EFI gasoline and diesel injectors while they are still in the engine by circulating a proprietary cleaning fluid, mixed with gasoline or diesel—as the case may be, through an engine operating at idle conditions for 15 to 25 minutes. The mixture removes carbon, gum, varnish, and other contaminants from the fuel injection system and related combustion surfaces. The system runs on compressed air, with a 12-volt compressor optionally available for use where compressed air is unobtainable.

Injector Clean Systems Inc., Baldwin Park, CA.

Circle No. E-6 on the reply card.

Ultrasonic Level and Flow Measurement System

The new HydroRanger I is a non-contacting, ultrasonic level and flow measurement system designed specifically for the wastewater industry. It is effective on applications from tank level measurement to complete lift station control. The HydroRanger I has an operating range of 30 ft and an accuracy of Ë0.25 percent. Built-in, multiple function relays can control up to five pumps.

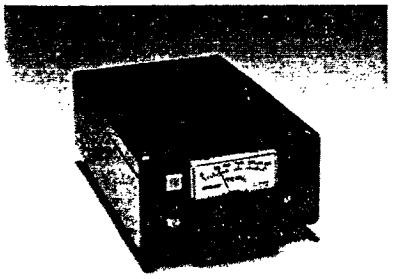


Milltronics Inc., Arlington, TX.

Circle No. E-7 on the reply card.

Portable Carbon Dioxide Detector

The Model CD-1300-P portable carbon dioxide detector uses an infrared sensor specific to CO_2. The instrument includes a built-in pump with detachable hose for remote sampling, dust filter, flow sensor, and 0-1 Vdc output. The analog meter has a standard range of 0 to 5000 ppm and option ranges available of 0 to 10, 0 to 20, and 0 to 100 percent by volume, with user adjustable high/low alarms.

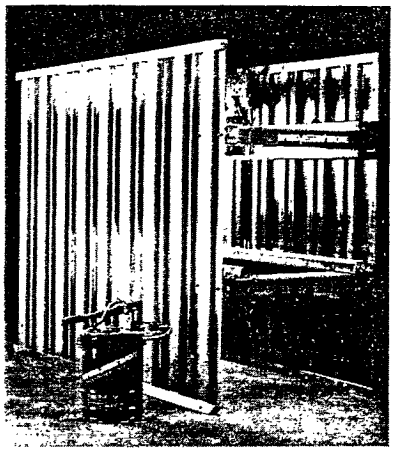


ENMET Analytical Instruments, Ann Arbor, MI.

Circle No. E-8 on the reply card.

Trench Shield Line Gets New Feature

"Speed Struts" have been added to the popular Shoring Shield line. Speed Struts incorporate hydraulic cylinders and return springs within rectangular telescoping steel spreaders to allow for 3- and 4-sided trench support, while providing increased protection to critical components. Quick-connect fittings facilitate speedy hand assembly/disassembly and allow for transport in a light-duty truck. A special hydraulic manifold enables independent strut control to accommodate irregular, non-uniform excavations.



Speed Shore™ Corp., Houston, TX.

Circle No. E-9 on the reply card.

Decanter Centrifuge for Dewatering Sludge



The Noxon centrifuge dewaters municipal or industrial sludge to up to 40 percent dry solids. Its microprocessor-based control system continuously adjusts the differential speed between the bowl and scroll to maximize the dry solids content of the output sludge cake. This precise control is fully automated and minimizes polymer use. The compact system starts and stops automatically according to process requirements and in response to emergency situations.

Purac Engineering, Inc., Wilmington, DE.

Circle No. E-10 on the reply card.

Eccentric Plug Valves for Water/Wastewater Treatment

The 120 Series eccentric plug valves for water and wastewater applications are available in 11/2- to 60-in. diameters in screwed, flanged, and mechanical joint end configurations. The 120 Series features rectangular ports, 90 percent pure nickel raised seat, stainless steel bearings, and adjustable V-ring packing. A variety of actuators are offered.

Homestead® Valve Co., Allentown, PA.

Circle No. E-11 on the reply card.

R0013778

Redesigned Wheel Loader, Integrated Toolcarrier

The improved 910F wheel loader (pictured) and the IT12F integrated toolcarrier replace the 910E wheel loader and the IT12B toolcarrier, respectively. Both machines are powered by a fuel injected, turbocharged 80-hp diesel engine. The transmission is electronically controlled with four forward and three reverse speeds and on-the-go shifting for greater operating efficiency and productivity. Autoshift transmission control with kickdown switch is offered on both machines. The units' oil-disc brakes are adjustment free, fully enclosed, and sealed from contaminants.

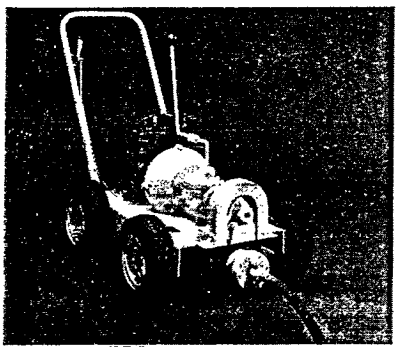


Caterpillar® Inc., Peoria, IL.

Circle No. E-12 on the reply card.

Sewer Cleaning Machine Only Needs Crew of One

The Model 325 sewer and industrial pipeline cleaner is engineered to thoroughly clean 4 to 14 in. diameter pipelines for distances up to 500 ft. It can be operated by one person and requires no handling of the rotating, heavy-duty dual cable. Features include 5-hp, 4-cycle gasoline engine; 3-speed forward and reverse transmission; and an automotive clutch to assure smooth and efficient transfer of power from the engine to the transmission. A trailer with tool box, loading ramps, and cable reel is optional.

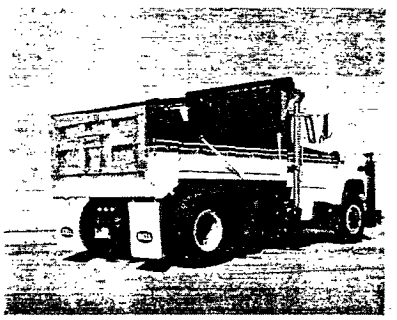


Electric Eel Mfg. Co., Inc., Springfield, OH.

Circle No. E-13 on the reply card.

New Dump Body Design Called Revolutionary

Described as a revolution in dump body design, the Sidewinder™ provides highly functional delivery at only 78 in. above the chassis frame in the side dump position. This allows the driver to spread or dump a wide variety of materials without having to pause for low-clearance obstacles such as bridges, trees, or power lines. Features include Cor-Ten® steel, heavy-duty box-braced tailgate, and continuous, 100 percent welding on the body. With the standard side-mount spinner, the Sidewinder throws sand, salt, etc., up to 25 ft with continuous feed from the dump body.



Heil® Co., Chattanooga, TN.

Circle No. E-14 on the reply card.

NGC

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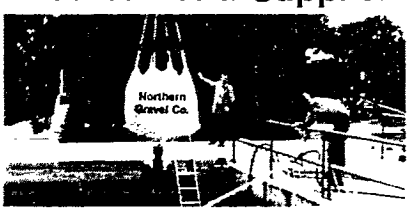

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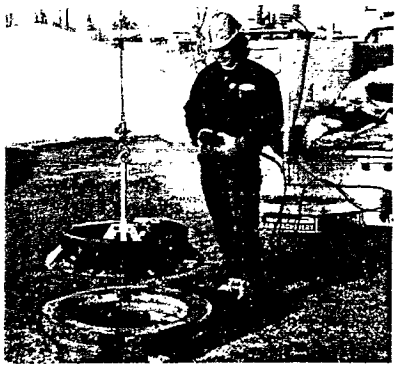
R0013779

Manhole Lifting Device Promotes Back Safety



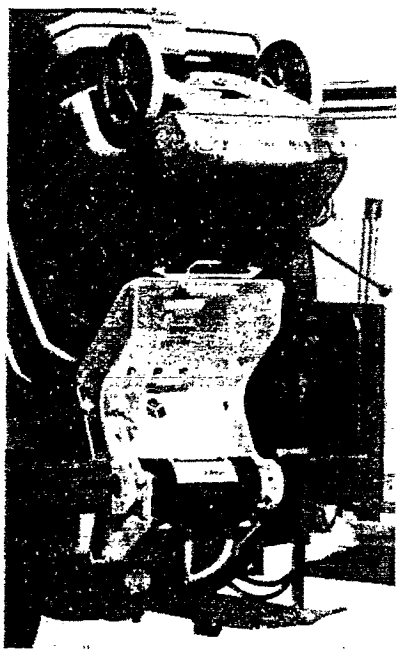
These casting pullers are back saving devices for removing or setting castings in place for new construction and structural maintenance. Lightweight and portable, they feature all-steel construction and tough powder coating in OSHA-approved safety yellow. They attach to backhoes, loaders, or truck cranes. Three models available to fit all circular and square castings.

Grappler™ Specialty Products, Eden Prairie, MN.

Circle No. E-15 on the reply card.

Rotary TuckAway Refuse Cart Lifter

The rotary-action TuckAway cart lifter boasts a trim, vehicle-hugging design, fits most types of carts, and lifts them higher for better dumping efficiency. And with fewer moving parts, it is smoother and more reliable. This company also makes the Tipper Bar rotary cart lifter, plus a full line to fit every cart.

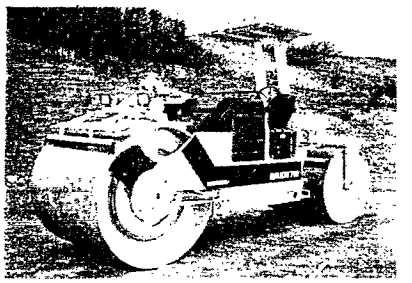


Perkins Mfg. Co., Chicago, IL.

Circle No. E-16 on the reply card.

New Static Rollers Offer Innovative Design

The 700-Series line of static tandem rollers consists of the Model 708 (5 to 8 ton), Model 710 (8 to 10.5 ton), the Model 712 (8 to 12 ton), and the Model 714 (10 to 14 ton). The special design of these rollers gives the operator excellent visibility to the rolls from either side, allowing the operator to clearly see the position of the roll, especially when working near curbs or obstructions. The 700-Series machines also offer excellent visibility to the top of both rolls, including the spray nozzles. Because these rollers were designed with minimum frame overhang and smooth streamlined sides, they can work very close to walls or obstructions, reducing the need for hand tamping. Other features include 180-gal polyethylene water tank with automatic flow control, all-brass spray bars with quick-disconnect brass spray nozzles, and externally-mounted water pump for easy servicing.



Galion Div., Komatsu Dresser Co., Galion, OH.

Circle No. E-17 on the reply card.

Interesting New Program For Water Utilities

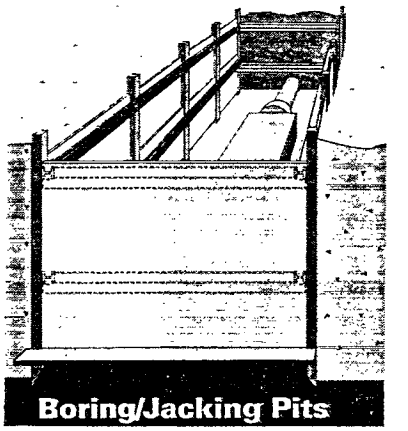
Schlumberger Industries announces the Direct Utility Licensee Program, which offers the utility unlimited rights to acquire third-party reading equipment to read Schlumberger ARB® V and ProRead™ ARB® encoder meters. The company says it recognizes and supports the utility's need to have multiple vendor options for reading systems. The license is issued to requesting utilities at no cost. Technical information or assistance is available for a fee to utility designated vendors. The company says its product development strategy ensures that its systems are open and flexible. For more information on the Direct Utility Licensee Program contact Tim Jeffcoat at 1-800-633-8754 or circle the appropriate reply number on the reader service card.

Schlumberger Industries, Tallassee, AL.

Circle No. E-18 on the reply card.

Shoring System Boasts Double Slide Rails

The SBH double slide rail system is a close lining system in which the lining plates are driven by force. The system is installed by the excavator during the excavation work



using the cut and lower method. This means that excavation and support are one operation, the excavator will be fully utilized, and time and labor needs will be reduced. The SBH double slide rail system offers the advantage of greater safe working loads together with ease of installation.

Shoring Int'l.™, Oakland, NJ.

Circle No. E-19 on the reply card.

Protective Coating for Treatment Plants

Interthane 990 H.S. is a polyurethane, low VOC, high-solids protective coating for use in aggressive environments such as water treatment plants and storage tank exteriors. It exhibits excellent single-coat hiding and appearance in most colors. Other characteristics of high-gloss Interthane 990 H.S. include high abrasion and impact resistance and strong adhesion. Application by brush, roller, or spray.

Porter Int'l., Louisville, KY.

Circle No. E-20 on the reply card.

Transportable Valve Box Clean Out Systems

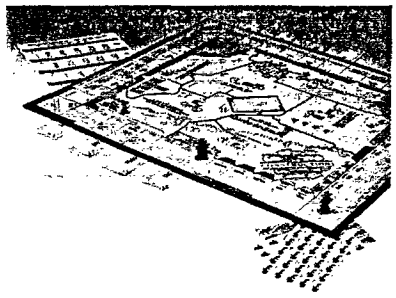


The new self-contained Trav-L-Vac transportable vacuum excavation and valve box clean out systems are designed for the following utility applications when a "no dig" approach is desired: leak repair, pipe and cable location, removal of directional boring debris, curb box and valve box clean out, service installations and terminations, and anode installation through "pot holes" and "key holes." Five different trailer- or skid-mounted, gas engine driven, Trav-L-Vac systems are offered.

E.H. Wachs Co., Wheeling, IL.

Circle No. E-21 on the reply card.

R0013780



Fun Board Game for Construction Crews

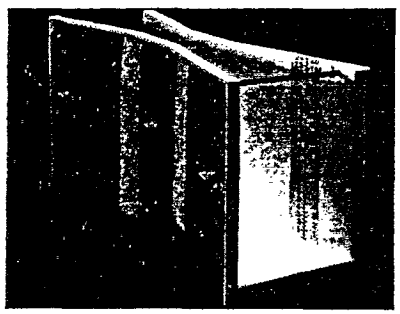
Participate in the fun, frustration, and financial free-for-all that is "The Construction Game." It is an easy way to teach associates, friends, and family the gut-wrenching risks and rewards of the business. Grow your company slowly or try and borrow your way into the big time. Buy a sand and gravel operation, trucks, or paving plant. Invest in earthwork equipment and gamble on jobs. Game includes high quality, durable components: colorful board and box; dice; plastic earthwork equipment and contractors; contingency cards; property title deeds; money; debt notes; and illustrated rules.

Earthcalc, Inc., Kent, WA.

Circle No. E-22 on the reply card.

Flumes for Open Channel Flow Systems

A complete line of flumes for use where primary flow devices are required is available here. This company manufactures industry-standard Palmer-Bowlus and Parshall flumes for measuring flows in treatment plants and sewers. Included in the line is the Palmer-Bowlus PBF-Q, the Quick Insert Portable Flume designed for easy installation. This special flume allows the user to do inexpensive and accurate short-term flow studies.



TN Technologies, an Enviro Co., Round Rock, TX.

Circle No. E-23 on the reply card.

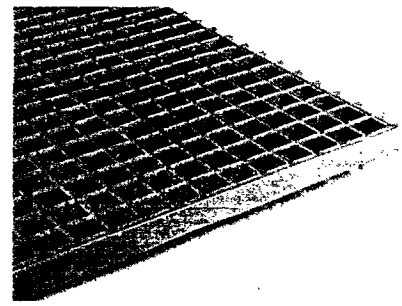
Lease-Purchase Plan For Street Sweepers

With today's tight budgets and cash flow demands, municipalities everywhere are looking for creative and more flexible ways to acquire needed capital equipment. One way is this firm's flexible lease-purchase plan, which allows participants to acquire efficient new street sweeping equipment on convenient payment terms. This arrangement combines the debt-free financing benefits of leasing with an innovative lease-to-own concept. As with a lease, the needed new street sweeping equipment is acquired with little or no money down. Payments are structured monthly, quarterly, semi-annually, or annually to best suit cash flow schedules. Unlike a lease, however, equity is accumulated with each payment. Customers own the equipment free and clear upon final payment with no buy-back or other special requirements.

Elgin Sweeper Co., Elgin, IL.

Circle No. E-24 on the reply card.

Fiberglass Grating for Treatment Facilities



The Corvex line of economical fiberglass grating is especially suited for water and wastewater treatment facilities. Durable and corrosion resistant to both acids and caustics, Corvex provides a slip-free surface, low flame spread, and non-conductivity for worker safety. It is available in various panel sizes and thicknesses.

Fibergrate Corp., Dallas, TX.

Circle No. E-25 on the reply card.

High Performance Notebook PC

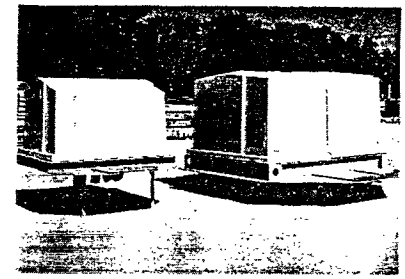
The NP933 Notebook PC provides long battery life and various plug-in options such as Fax/modem, scanner pack, Ethernet pack, IBM 3270 emulation pack, extra serial port, voice-mail pack, SCSI interface pack, and 12-volt car battery adapter. Optional packs are added by removing one of the dual battery packs, and operating off a single battery. The high-contrast 10-in. black-on-white LCD screen has a 640 x 480 pixel resolution and can display 64 levels of gray scale. System RAM is expandable to either 4, 6, or 8 megabytes using ZIP memory modules. In addition to the 1.44-MB 3 /12-in. floppy disk drive and the standard 80-MB hard disk, an optional 120-MB hard disk drive is offered. Special ports are included for an external VGA monitor and an external floppy disk drive.



Micro Express, Santa Ana, CA.

Circle No. E-26 on the reply card.

New Wet Well Mounted Pump Station



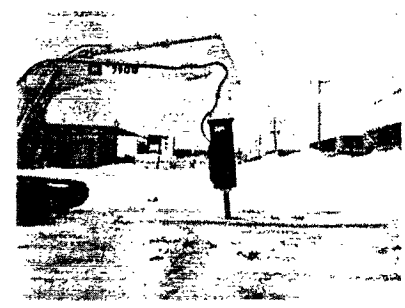
The wet well mounted pump station shown on the right is the new Model 8D4D, and doubles the flow capacity of the standard model pictured on the left. With an 8-in. pump, the Model 8D4D can accommodate over 2400 gpm. The station successfully pumps wastewater by drawing liquid up through a suction pipe to a centrifugal pump, pumping out through the discharge pipe, check valve, and plug valve into the force main. The new model's main distinctions are its special ability to double past flow rate capacities without affecting its high efficiency and low horsepower requirements.

Smith & Loveless, Inc., Lenexa, KS.

Circle No. E-27 on the reply card.

Large Size Range of Hydraulic Mounted Breakers

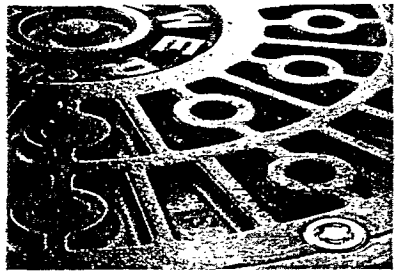
These ten models of hydraulic breakers range from 125 ft lb class for compact excavators through 8000 ft lb for large excavators with other models to match any skid steer or wheel loader backhoe size. Ready-to-mount brackets and skid steer mounting plates are also available. Major features include long stroke, smooth operating piston design, and elimination of gas-filled accumulators plus simplified maintenance due to only two moving parts.



Hanix America Inc., Bensenville, IL.

Circle No. E-28 on the reply card.

R0013781



Prevent Unauthorized Manhole Access

Intimidator® manhole cover locks are made from a through-hardened special alloy steel with triple nickel chrome plating for lasting durability, are easy to install, and have no moving parts that can jam, freeze, or corrode. The special locking pattern makes them virtually impossible to remove except with the specially coded keys, which are registered under computer control so only authorized personnel have access to them. Black plastic threaded caps are added for extra protection and low maintenance.

McGard, Special Products Div., Orchard Park, NY.

Circle No. E-29 on the reply card.

Solar-Powered Venting For Park Restrooms

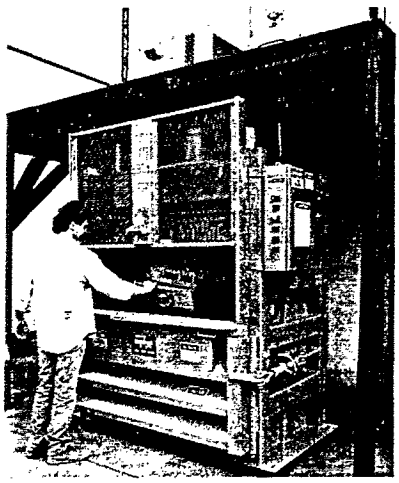
Many park facilities have experienced an odor problem with poorly vented restrooms and vault toilets. This firm offers four models of solar-powered fan kits to solve restroom odor problems. Features include easy installation, no maintenance, and quiet performance.

Solar Electric Systems of Kansas City, Inc., Kansas City, MO.

Circle No. E-30 on the reply card.

Extra Low Profile Baler

The 95-in. high V-6042 XLP extra low profile baler is designed for installation under 8-ft ceilings, yet produces a corrugated bale exceeding 800 lb. It features a guided ram, front tie-off system with bolt-on rear wire guides for space-saving corner installation capability, hinged teeth, "bale made" light, and a hydraulic power unit.



Marathon Equpt. Co., Vernon, AL.

Circle No. E-31 on the reply card.

Tool for All-Around Weed Cutting Work

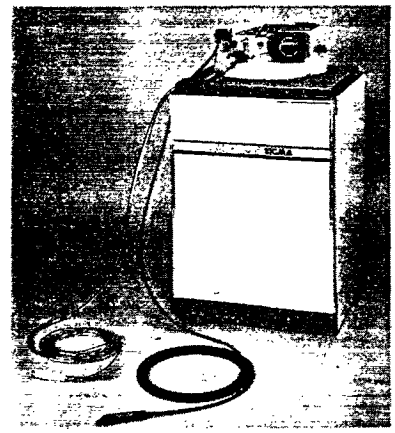
The hand-held Bow-Knife is a strong, perfectly balanced tool designed for all-around weed cutting. It offers rugged performance, yet weighs only 32 ounces.



The Jimsin Co., Centerville, LA.

Circle No. E-32 on the reply card.

Sampler Assures No Sample Degradation



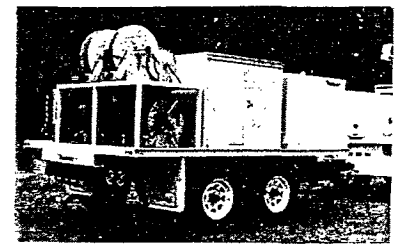
The 800SL refrigerated liquid sampler is designed for conventional or priority pollutants. It maintains a constant temperature of 39.2°F, and features a highly efficient compressor/condenser assembly, wrap-around evaporator, and rigid foam insulation to assure sample integrity. The refrigerator body is steel with a protective laminate over-coating. All components and copper plumbing are treated with a phenolic resin coating to protect against corrosion. The 800SL offers ten bottle options.

American Sigma, Medina, NY.

Circle No. E-33 on the reply card.

Versatile Lube Skid/Trailer

This lube skid can be used either on a chassis equipped with a hook-lift system or mounted on a trailer. The lube/skid trailer is self-contained and comes with a gas engine driven air compressor to operate the product pumps. With four product tanks and one evac tank, this unit will be a welcome addition to users desiring lubrication capabilities, but not needing a separate vehicle.



Maintainer Corp. of Iowa, Inc., Sheldon, IA.

Circle No. E-34 on the reply card.

New Low Oil Sensor For Engines

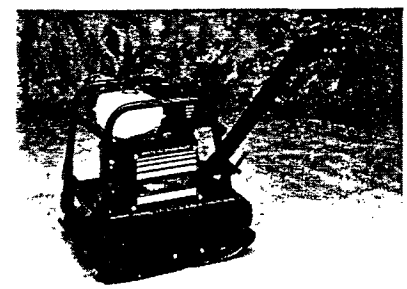
The ED0505 oil level sensor accurately measures lube oil levels in engine crankcases. It can be used both on main power units and auxiliary equipment engines such as heater, compressor, or refrigeration engines. Used as standard equipment by some truck and bus manufacturers, it can be retrofitted to most engines. The sensor has a built-in 0.5-amp switch that can trigger a warning light or alarm. It can also be used as an ignition lockout in the event of low oil level before engine start-up. Sensors with variable output to indicate level range are available for use with gauges, monitors, or computer control systems.

Power Plus Corp., San Marcos, CA.

Circle No. E-35 on the reply card.

Highly Maneuverable Reversible Plate Compactors

Models RP650G and RP650D reversible plate compactors are designed for medium-size granular and mixed soil compaction jobs. Infinite hydraulic forward and reverse travel and on-the-spot vibration provide high maneuverability and performance. Their low center of gravity and 20-in. working width enable optimum compaction in confined areas. Model RP650G is powered by an 8-hp Honda engine and has an operating weight of 418 lb. Model RP650D is powered by a Hatz Supra engine, with a working weight of 462 lb. Both models deliver 6520 lb of centrifugal force.

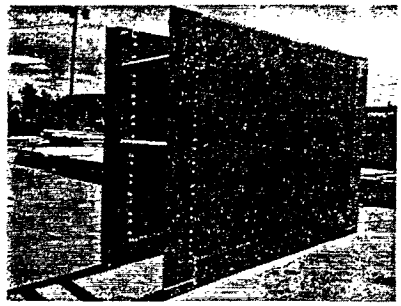


Stone Construction Equpt., Inc., Honeoye, NY.

Circle No. E-36 on the reply card.

R0013782

Versatile Trench Box

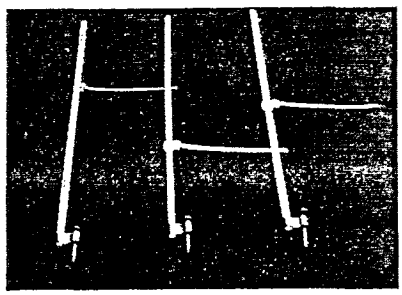


The Shorlite Shield is designed with an ultra narrow 2½-in. wall trench shield made of durable steel with the lightness and flexibility of aluminum. It is designed to work as a system box that can be stacked, hooked in-tandem, and leap frogged. The Shorlite Shield's center is made up of aluminum panels while the outside is wrapped in a steel barrier to give it durability. All-steel end tubes are part of the barrier, giving extra strong support to the ends of the box, where most of the driving force will be applied.

Kundel Industries, Warren, OH.

Circle No. E-37 on the reply card.

Stake Saves on Road Construction Costs



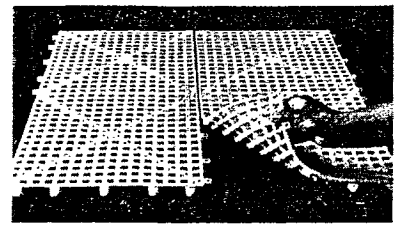
The Flexeon staking system was developed for accurate placing of base rock and treated base materials. When the stake is used it prevents costly overruns during the placement of base rock in confined areas such as streets and parking lots. It eliminates constant grade checking and digging for hubs. When placed on the subgrade hub, the stake has a neon horizontal marker that marks the finished rock grade without survey crews setting new grades. It is also used to mark utility access covers when placing base rock. The highly visible, durable, and reusable Flexeon stake springs back to original position when hit by a blade or other equipment. Three neon colors are offered: red, green, or orange. Standard length is 16 in. with other sizes available.

Paving Innovations Co., Eugene, OR.

Circle No. E-38 on the reply card.

FREE Samples Available of Compartment Floor System

This firm is now providing free samples of its Dri-Dek interlocking compartment floor system for trucks. The 4 x 4 in. samples are designed to show the flexibility, safety characteristics, and interlocking features of the system. Dri-Dek provides a dry, shock-absorbing cushion for tools and sensitive equipment while shielding compartments from nicks, scrapes, cuts, and scratches. Offered in 12 x 12 in. tiles, Dri-Dek also comes in custom made Redi-Paks containing ready-to-use sections of Dri-Dek pre-cut to fit each compartment of your truck body. Dri-Dek comes in 11 colors, with custom colors available.

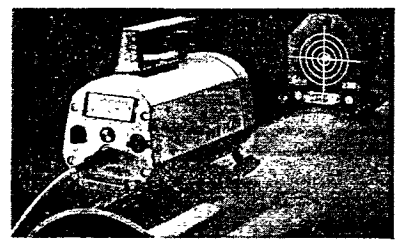


Dri-Dek Corp., Naples, FL.

Circle No. E-39 on the reply card.

High Performance Pipe Laser

The compact Wild PLA10 laser system is especially suited for laying pipes quickly and accurately on the construction site. The Wild PLA10 pipeline laser, together with its range of accessories—including target plates, remote control system, and power supply cable—comes in a padded, visible bright orange container.



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This firm will manufacture a truck-mounted paint striper to meet your specifications: 120- to 1200-gal paint capacity, spraying 1 to 5 lines with glass beads simultaneously on each side. Airless spray equipment with stainless steel components is used. Many options are available.

E-Z Liner Industries, Orange City, IA.

Circle No. E-41 on the reply card.

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POSITIONS AVAILABLE

Director of Public Works

The City of Liberal, Kansas is seeking qualified applicants for the position of Director of Public Works. Responsibilities include planning, organizing, supervising, and directing the following activities: water production and distribution, wastewater treatment and collection systems, street maintenance and repair, recycling operations, solid waste management, engineering, and airport maintenance. Requires a Bachelor's degree in Civil Engineering or a closely related field and at least five years progressively responsible engineering and public works experience. Experience in local government with extensive supervisory experience desired. Must possess a current registration as Professional Engineer in the State of Kansas or become registered within one year of employment. Salary is negotiable, depending on qualifications. (Current range is $40,000 to $48,000).

Submit resume, salary history/requirements, and at least five work related references to:

Personnel Director, City of Liberal, P.O. Box 2199, Liberal, KS 67905-2199.

EOE

Senior Project Manager

Municipal & Public Works Engineering

Excellent opportunity with well-established civil engineering firm in South Florida for Senior Project Manager with strong design, project management and business development experience. Must interact well with clients and have excellent abilities in communication and leadership. Florida P.E. registration will be required. All replies confidential.

Send resume and salary history to:

Mock, Roos & Associates, Inc., Engineers * Surveyors * Planners, 5720 Corporate Way, West Palm Beach, FL 33407. Phone (407)683-3113. Equal Opportunity Employer.

R0013783

St. Lucie County

UTILITIES SERVICES DIRECTOR

This is a management and technical position responsible for planning, organizing, directing, budgeting, and coordinating water and wastewater activities. Duties include the coordination of water and wastewater projects and activities with other utilities functions and the public.

Minimum Qualifications: A Bachelor's Degree in Civil or Sanitary Engineering or Business Administration. Ten (10) years of progressive administrative experience, of which at least five (5) years of supervisory experience, including responsibility in the engineering field with part of it in the wastewater and water treatment field.

Send resume or apply in person to:

St. Lucie County Personnel Coordinator, 2300 Virginia Avenue, Ft. Pierce, FL 34982. EOE.

Director of Water Supply

The Town of North Kingstown, Rhode Island located on scenic Narragansett Bay (population 25,000) is seeking qualified applicants for the position of Director of Water Supply. The water system is composed of ten artesian wells (250 to 2,100 GPM) located in 3 aquifers, five storage facilities and approximately 126 miles of distribution system. The system services approximately 8,000 customers. Responsibilities include planning, implementing and administering all activities of the Department of Water Supply engaged in the operation of a 2.5 to 8.5 MGD municipal water supply system.

Position requires a Bachelor's Degree in mechanical or civil engineering or related field with a minimum of 5 years of experience. Must also possess superior knowledge and experience relating to complete operation of a municipal water system, personnel and office management, Safe Drinking Water Act, budgeting and future planning. Must be able to obtain Rhode Island Operators Certification when required. Salary range $40,000 to $50,000 commensurate with experience.

Resume with cover letter should be directed to:

Richard Kerbel, Town Manager, 80 Boston Neck Road, North Kingstown, Rhode Island 02852 prior to October 10, 1993.

AN EQUAL OPPORTUNITY EMPLOYER (M/F)

Director of Public Works/ City Engineer

CEDAR HILL (pop. 23,500). $43,263 to $57,980 annually & benefits. Suburb of City of Dallas. Administration and operation of 32 public works employees. Responsibilities include: street & drainage, water & wastewater and engineering. Requires progressive public works managerial experience with preference for a Texas Registered Civil Engineer.

Send to:

Bill Lindley, Assistant City Manager, Post Office Box 96, Cedar Hill, Texas 75104.

Solid Waste Manager

Our Public Works Department is seeking an experienced individual to head up their Solid Waste Division. The Manager directs the development and implementation of solid waste recovery, reduction, and diversion programs. and the planning of new processing facilities. The Manager also oversees the Transfer Station and landfill operations. Salary $4,355-$5,317/mo. + xlnt. benefits. Recr #93-7076-01. Apply by: 11/15/93.

For more information and Application/Supplemental Questionnaire forms, contact:

Santa Barbara County, Personnel, 1226 Anacapa Street, Suite 1, Santa Barbara, CA 93101, 805/568-2800 V/TDD FAX 805/568-2833.

Utilities Manager

Ormond Beach, Florida (31,000)

Utilities Manager, Salary range $41,303 - $57,823 (starting DOQ). Requires Bachelor's Degree in Civil Engineering with a major in Environmental or Sanitary Engineering. Completion of college level courses in Water & Wastewater Treatment Plant operations and seven (7) years relevant experience, two (2) years of which must have been administrative and technical management experience in a municipal water and/or wastewater utility. Responsibilities include management and administrative work directing and coordinating the Water & Wastewater Utility functions of the City.

Send resume to:

Utilities Manager Application, c/o The Human Resources Department, P.O. Box 277, Ormond Beach, FL 32175-0277. Open until filled. E.O.E. M/F/Handicapped/Veteran Preference.

Public Works Director

The City of Des Plaines, a northwest suburban Chicago community of 53,414, is seeking a person to manage the department responsible for street maintenance, sewer system, water distribution system, forestry and beautification; mechanics, water meter repair/installation, and buildings and grounds. Will administer department expenditures, make recommendations for equipment purchase, and coordinate department activities with related City departments. High School degree required; college degree preferred. Five years of supervisory experience in public works or construction, four of which at least at superintendent level; ability to plan, schedule, estimate, and supervise several diverse functions; ability to analyze public works services and develop cost effective programs to meet community's needs; ability to lead and motivate large, diverse workforce. Salary dependent on qualifications.

Submit resume, including salary requirements by October 22, 1993 in confidence to:

Human Resources and Services Department, City of Des Plaines, 1420 Miner Street, Des Plaines, IL 60016.

EEOE/MF

Chief Water & Gas Engineer

CITY OF DANVILLE

Chief Water & Gas Engineer to plan, design and engineer the present and long range programs for rehabilitation and/or extensions to the City's water and gas distribution system. Duties include staff supervision, overseeing of project cost estimates, plans and specifications for $3 million capital improvement programs; preparing budget recommendations and insure compliance with government regulations. Education and experience equivalent to graduation from an accredited college or university with major work in engineering and minimum of ten years experience in the water and/or gas distribution field. Valid drivers license required. Possession of or ability to obtain valid registration as a Professional Engineer in the State of Virginia within six months of employment. Salary range $37,773 - $56,639 per year.

Submit resume or apply at:

City of Danville Personnel Department, City Hall - Third Floor (Room 300), Danville, VA 24543 or any local office of the Virginia Employment Commission by November 5, 1993.

EQUAL OPPORTUNITY EMPLOYER

Wanted—Manager

The Kalamazoo Lake Sewer and Water Authority is seeking a full-time manager. This is a salaried position (35-45K), requiring experience with City, Village, and Township Councils. The ideal candidate will also possess Michigan "B" Wastewater and S-2/D-2 Water Certification. The Authority operates and maintains water and sewer in the Saugatuck/Douglas Community on the west shore of Lake Michigan.

Interested applicants should request a summary sheet and job description by writing:

Kalamazoo Lake Sewer and Water Authority, PO Box 789, Saugatuck, MI 49453-0789.

Or Fax your request to 1-616-857-1565. No walk-ins or phone calls accepted. REQUEST DEADLINE IS OCT. 15, 1993.

Director, Department of Public Works

County of San Diego

Seeking a registered civil engineer and top-level executive to direct public works and civil engineering operations. Staff of 900 and budget of $262 million. Services include those of County engineer, surveyor and road commissioner; sanitation and flood control, solid waste management, public transportation and airfield maintenance. $75,000 - $100,000. Executive benefit package includes automobile and relocation allowance. Apply by October 29, 1993.

For resume submittal form and recruitment brochure detailing the application process, position and benefits, please contact:

County of San Diego, Department of Human Resources, 1600 Pacific Highway, Room 207, San Diego, CA 92101, (619) 236-2191 or 531-5139.

R0013784

Manager of Engineering Services

City of Sterling Heights, pop. 117,810 (suburban Detroit). Salary $50,737 - $58,348 DOQ, plus excellent benefits package. Under direction of City Engineer, supervises engineering staff in plan review, design and contract administration. Acts as City Engineer in his absence. Union represented position. Requires BS in Civil Engineering, 8 years of progressive experience including strong computer and plan review background. Must be registered PE in Michigan, or in other state that meets Michigan requirements. Residency required in Macomb County within 6 months.

Send resume to:

Personnel Director, City of Sterling Heights, P.O. Box 8009, Sterling Hts, MI 48311-8009. Deadline: 10/29/93. EOE M/F/H.

Public Works/Utilities Engineer

The City of The Dalles, Oregon, Population served 15,000 and Gateway to the beautiful Columbia River Gorge National Scenic area, has an opening for the position of Public Works/Utilities Engineer. The position serves under the general supervision of the Director of Public Works and is responsible to oversee water distribution and wastewater collection operations, maintenance and capital improvements. This position provides professional engineering services and design to water and wastewater utilities systems, street and stormwater collection systems and provides engineering advice to all city departments and divisions. An Oregon Professional Engineers Registration, or the ability to obtain one within eighteen (18) months of employment is required. Oregon certification as Water Distribution Operator II and Oregon Wastewater Collection Operator III is desirable.

Annual salary range is $35,496 to $46,716 with excellent fringe benefit package.

For a copy of the Job Description and an application contact:

Joanet Gray, Personnel Director, City of The Dallas, 313 Court Street, The Dalles, Oregon 97058, Telephone 503-296-5481. Deadline to receive applications is 5:00 p.m. October 29, 1993. The City of The Dalles is an Equal Opportunity Employer.

Director of Public Works/Engineer

Town of Rockingham/Village of Bellow Falls, Vermont (pop. 5500) seeks experienced public management professional to supervise the Department of Public Works which includes streets, highways, drainage, water, wastewater, cemeteries, all buildings, grounds maintenance, and provide related engineering. Strong technical (especially computer skills), administrative leadership, interpersonal and public/employee related skills essential. This is a new position. Candidates must have a BSCE or related field and 5 years professional experience. Salary $34,000-38,000, DOQ.

Resumes to:

Rockingham/Bellows Falls Manager, P.O. Box 370, Bellows Falls, Vermont 05101 by October 18, 1993.

Marketing/Advertising Pro Available

Expertise and excellent track record in identifying marketplace needs. Strong background in sales promotion, print advertising, public relations, exhibits, and customer research.

Write or phone for resume:

Box 10-1, c/o PUBLIC WORKS, Box 688, Ridgewood, NJ 07451 or phone direct (402) 483-6215.

Treatment Plant Shift Supervisor

$12.22 (Class A); $11.64 (Class B). High school diploma/GED; State of Florida Class "A" or "B" Wastewater Treatment Plant Operator's License. This position is a working first-line supervisor; previous supervisory experience desirable. Duties: Supervisory and operational duties on a rotating shift of an advanced wastewater treatment facility.

Apply Monday, Wednesday, Friday only at:

City of Largo, Human Resources Department, 225 First Avenue S.W., Largo or send resume for Job 63, City of Largo, Human Resources Department, P.O. Box 296, Largo, FL 34649-0296 by 10/29/93.

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Board of County Commissioners

Bay County, Florida
Request for Qualifications
For Contract Operations, Management and Maintenance of Water
And Wastewater Treatment Systems for Bay County

The Board of County Commissioners of Bay County, Florida is soliciting Request for Qualifications for Contract Operations, Management and Maintenance of Water and Wastewater Treatment Systems.

A copy of the Request for Qualifications may be obtained at the Bay County Public Utilities Department, 3400 Transmitter Road, Panama City, Florida 32404, telephone (904) 872-4785.

BID NO. 048-93

Office of the County Manager, 310 West 6th Street, Panama City, Florida 32401 (904) 784-4029

Interested Parties should submit six (6) copies of qualifications to the above address on or before November 1, 1993, at 10:00 a.m., marked "RFQ for Contract Operations, Management and Maintenance of Water and Wastewater Treatment Systems for Bay County - Bid No. 048-93".

Bay County reserves the right to waive informalities in the selection process, to accept or reject any or all qualifications statements in part or in whole, or to solicit for additional qualifications if appropriate.

Bay County is an Equal Opportunity Employer.

This notice dated this 27th day of August, 1993.

Submitted by: Mary L. Dayton, Budget Officer

FOR SALE

For Sale

The City of Fairfield, California is selling its 10 MGD diatomaceous earth water treatment plant equipment. Some items "for sale" are: Pneumatic Control Equipment, DE Filters, Instrument Control Panels, Pumps, Hydropneumatic Tanks, Air Compressors, etc.

For more information, contact:

Mark Forbes at (707) 428-7487. Bidding closes 11/4/93.

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David Prinzhorn at Engineering-Science, Inc., Phoenix, Arizona (602) 956-2286.

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legal aspects of public works

Thomas P. Vest, Esq.
Attorney at Law

Court Construes Bid Bond Guarantee Provision

In 1989, the city of North Las Vegas, Nevada solicited bids for a public works project involving the city jail. The city required all bidders to post a bond in the amount of 5 percent of their bid price and further, upon delivery of the executed contract with the city, to furnish performance, payment and guarantee bonds.

The bid provision also provided that the contractor would forfeit the bid guarantee deposit if it did not enter into a contract within 10 days after notice of acceptance of the bid. The plaintiff duly tendered a deposit of 5 percent of its bid in 1989, but refused to pay for the performance bond, and therefore the city refused to execute a written contract. The city then retained the plaintiff's bid bond and awarded the contract to the next lowest bidder.

The plaintiff brought an action for breach of contract and restitution of its bid bond. The city counterclaimed for breach of contract and requested damages of an amount between the appellant's bid and the next lowest bid. The trial court awarded the city the damages requested, offset by the amount of the bid bond that it had retained. The appellate court was forced to construe the bid deposit provisions of the contract to determine whether the provisions should be construed as a liquidated damages provision, or a penalty provision, which would have allowed the city to obtain the additional damages it requested.

The court at *American Fire vs. City of North Las Vegas*, 849 P.2d. 352 (1993) ruled partially in favor of both parties. The court held that the contract provision was ambiguous as to whether it was intended as liquidated damages, or a penal bond. The court reviewed legislation and case law in other jurisdictions, which were not consistent in their characterization.

However, the court felt that the provision, being ambiguous, would need to be construed against the city, since it had drafted the agreement. The court also noted that the legislature had not expressly characterized bid bonds one way or the other. Therefore, the court construed the provision against the city, and held it was restricted to 5 percent as liquidated damages, and could not recover the additional penalty.

Statutory Waiver of Immunity Section Construed

Próperty owners in Albuquerque, New Mexico filed a complaint alleging property damage and personal injury caused by flooding on their property by water that came from a city arroyo. The city moved for summary judgment at the trial level on the ground that it was immune from liability under the New Mexico Tort Claims Act, NMSA 1978 § 41-4-1 through 41-4-29. The appellate court was forced to construe a very complex statute to decide whether the storm drainage system was a part of a "water utility" for purposes of statutory immunity, and whether the intent of the statute was to encompass water runoff as opposed to toxic waste water.

The court at *Espander vs. city of Albuquerque*, 849 P.2d 384 (1993), initially decided that several sections of the statute did not intend to waive statutory immunity. One section of the statute, § 41-4-6, dealt with negligence of public employees on certain public property such as public parks and public buildings. The court ruled that this section did not waive statutory immunity.

Secondly, the court decided that a subsequent section, § 41-4-8, which dealt with the discharge or release of substances such as toxic liquids or gases and waste materials, was also not meant to apply to normal water runoff, as opposed to toxic water discharge. Further, another section dealing with waiver of immunity for damages arising out of operation or maintenance of works used for diversion or storage of water, did not apply for the same reason.

However, the court found liability under a prior case in the State of New Mexico that held that water runoff was a form of liquid waste and that works for the collection and diversion of runoff water were part of a public utility or service within the ambit of § 41-4-8(a), supra. Therefore, the court remanded the case back to the trial court for disposition.

Court Declares Set-Aside Programs Unconstitutional

A Washington D.C. construction company brought an action seeking a declaration that certain minority and disadvantaged business set-aside programs enacted by the District of Columbia were unconstitutional. The District of Columbia had enacted the District Minority Contracting Act in March 1977, to set goals for the participation of minority business enterprises in the awarding of public construction contracts (D.C. Code § 1-1141). The plaintiff claimed that this program violated 42 U.S.C. § 1981 and 1983. The act provided that each agency and department of the district should allocate construction contracts in order to reach a goal of 35 percent of dollar volume of such contracts to be let to local disadvantaged business enterprises.

The district claimed that it was required to comply with certain federal statutes as a condition of receiving federal funding on state highway construction projects. Further, the district argued that a prior federal statute required each recipient of federal aid to make reasonable efforts to award at least 10 percent of those funds to certain economically and socially disadvantaged individuals. Various codes of federal regulations sections required that the governmental unit set goals for such contractor participation in public works contracts. The District of Columbia enacted the Department of Public Works Disadvantaged Business Program (DBE) in 1988 to implement such regulations. The DPW had set an overall goal of awarding 37 percent of federally funded contracts to qualified DBEs.

The court at *O'Donnell Construction Company vs. District of Columbia*, 815 F.Supp. 473 (D.C.C. 1992) ruled that the District of Columbia Minority Contracting Act was unconstitutional as it sought to implement the federal statutes. The court considered the act invalid because it relied on general allegations of discrimination in the construction industry, and contained geographic limitations that were overbroad and not sufficiently limited in duration. The court found the record devoid of evidence that any agencies had disfavored minority contractors over white contractors, or that the bid process was rigged to have any such effect.

It ruled that the district failed to show a prima facie case of overt racial discrimination in the industry and that the statute that was not sufficiently narrowly tailored to achieve specific ends. The court felt that this statute did not pass constitutional muster in this regard. The court was concerned that the ratio of minority participation was much higher than the standards set by Congress under the 1987 statute and was itself a form of reverse discrimination.

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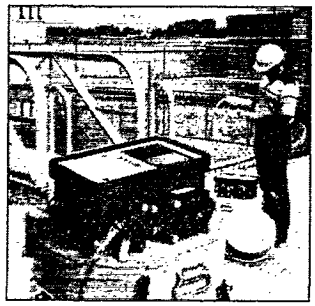

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worth telling

♦ Novalab Ltd. of Montreal, Quebec and Mann Testing Laboratories Ltd. of Mississauga, Ontario have merged their laboratories to develop a national laboratory network.

♦ The solid waste management equipment company of McClain Industries, Inc. is celebrating its 25th anniversary.

♦ Mitsubishi Fuso Truck of America, Inc. is building a new 53,000 square foot parts warehouse facility connected to its corporate headquarters in Bridgeport, New Jersey. The expansion will nearly double its inventory capacity.

♦ Environmental Systems Research Institute, Inc. and GTCO Corporation have entered into a marketing and technical support agreement to facilitate support for their respective geographical information system software and digitizer systems.

♦ JPS Elastomerics Corp. promoted **Bruce Wilby** to company president.

♦ EOSAT (Earth Observation Satellite Company) and ERDAS,® Inc. have joined forces to analyze and interpret Landsat satellite data of the Midwest for the U.S. Army Corps of Engineers and the Federal Emergency Management Administration to set priorities for post-flood clean-up and flood prevention management.

♦ At Insituform Technologies, Inc. **George Peak** was named director of corporate communications and government relations; **Scott Triplett** was promoted to strategic business unit manager for NuPipe, Laterals, and UltraCure Manhole Systems; **Phillip Sorrell** was named strategic business unit manager for industrial markets; and **Tom DiBernardo** assumed the newly created position of national sales manager.

♦ Kraiburg of America, Inc. opened a new manufacturing plant at 100 Kraiburg Boulevard, Lisbon, Iowa.

♦ Poly-Pak Industries Inc. of Melville, New York, with the help of Yellow Freightway Systems, shipped 450,000 plastic sandbags within a few days to United Service of Greater Kansas City, Missouri to reinforce existing levees and build new ones in the flood-ravaged Midwest.

♦ The Composites Institute will hold its 49th Annual Conference and EXPO '94 trade show February 7 to 10, 1994 in Cincinnati, Ohio. For information contact the Institute at 355 Lexington Avenue, New York, NY 10017, tel-(212) 351-5410, fax-(212) 370-1731.

♦ United Dominion Industries completed its previously announced acquisition of The Marley Company.

♦ **Morten Smedstad** was appointed president of Nederman, Inc.

♦ Shred Pax Corporation's 200-hp shredders are being used by the Illinois Department of Transportation and by St. Louis County, Missouri to help cleanup flood-scarred Mississippi River towns.

♦ **Michel Guerry** was appointed to head the Motorola/Schlumberger Industries Joint Venture A.M.R.T.

♦ Smith & Loveless promoted **Chuck Miller** to municipal sales manager, **Stuart Marschall** to president of the international division, and **Bob J. Rebori** to vice president of international operations.

♦ The National Asphalt Pavement Association is holding its 39th Annual Convention and Trade Show February 12 to 17, 1994 in Palm Desert, California under the theme, "The Foundation of Our Future—Research, Education & Quality." For information contact LaDonna Burton, Meetings Registrar (convention registration and program), or Arden M. Sell, Executive Director (trade show) at the Association, NAPA Building, 5100 Forbes Boulevard, Lanham, Maryland 20706, tel-(301) 731-4748, fax-(301) 731-4621.

♦ The Galion Division of Komatsu Dresser Company has reintroduced the "Galion" trade name and a new paint scheme to help the division and its products establish a strong identity in the construction equipment market place.

♦ Navistar International Transportation Corp. of Chicago and Culligan International Company of Northbrook, Illinois worked together to deliver more than 50,000 one-gallon jugs of packaged drinking water to Des Moines, Iowa when the city's water plant was put out of service during the Midwestern floods. Two International trucks and trailers were provided.

♦ Parents who want to encourage their teen-age children to use seat belts should follow one simple rule—use seat belts themselves!

R0013788

How to mow 10,000 acres

It's good to get an early start—say, around 6:30 a.m. And it doesn't hurt to have plenty of technical skill, or the kind of honest, polite demeanor that motivates a work crew. A commitment to quality, customer satisfaction and environmentalism is also a plus. But even with all of this going for her, Wanda Davis—vegetation team leader for Hillsborough County, Florida—still needs help to maintain her 10,000 acres of roadside right-of-way.

Part of the challenge is Hillsborough's subtropical climate. Vegetation has a field day. Some species grow as much as ten feet a year. And the weeds—smutgrass, paragrass, ragweed, broomsedge—look even worse than they sound.

Then there's Tampa's suburban sprawl to worry about: new subdivisions, 2,272 miles of roads, 2,200 miles of drainage ditches. Mile after mile of municipal rights-of-way are constantly being added to the district. What's more, Hillsborough is a major tourist area; millions of sightseers visit every year. The roadways not only have to be attractive, they must also provide good visibility.

So where does Wanda turn for help to solve all these problems? Roundup® herbicide, from Monsanto. "Given what we have to accomplish, the growth rates we have down here, we could mow year-round and never get the job done. Herbicides make our roadside vegetation management program possible."

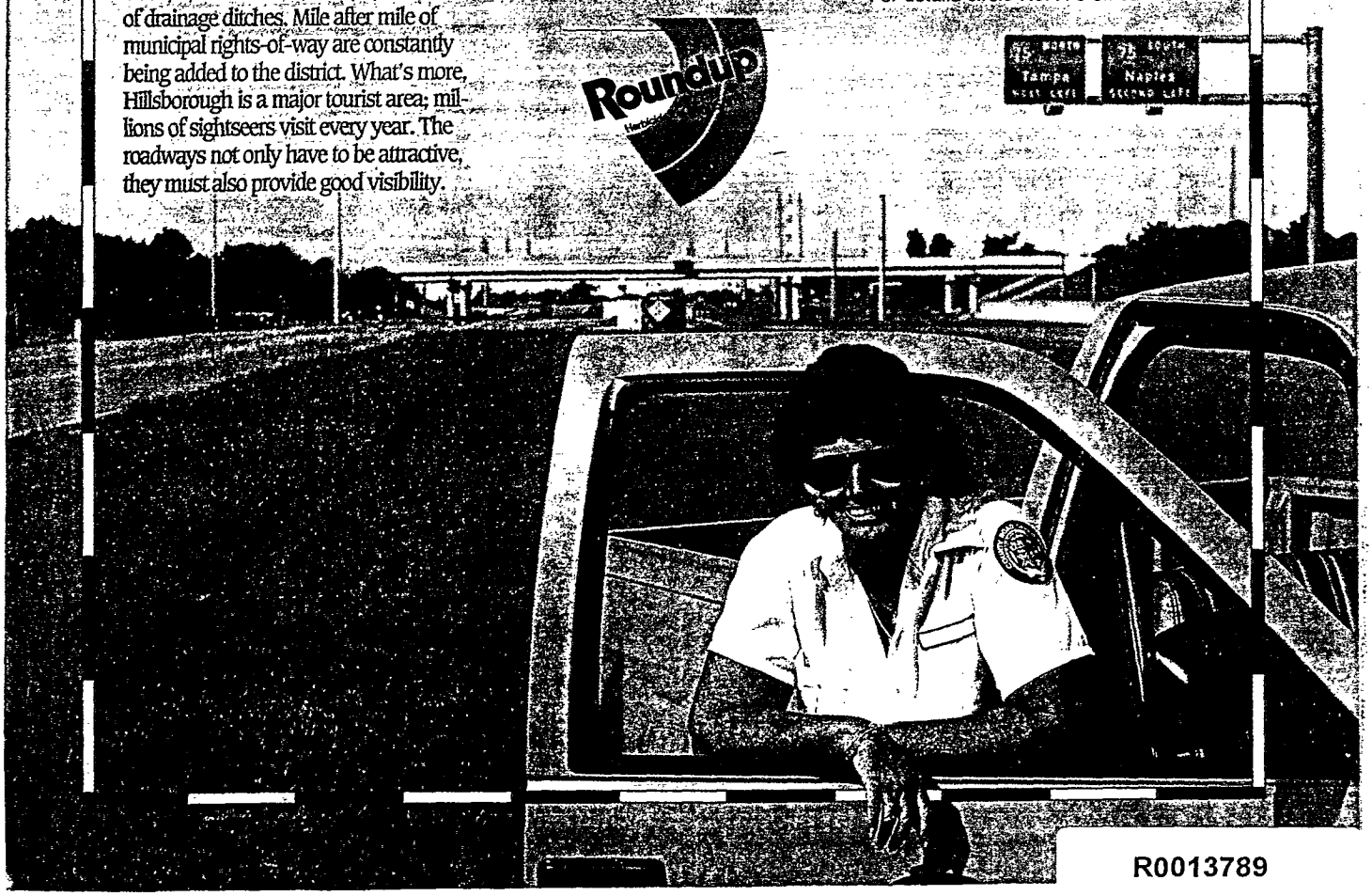
Her crews spray Roundup to control the large weeds and brush that invade road shoulders. They also use it to dust the nastier grasses, as well as to control brush and trim around guardrails, signs and mailboxes. Wanda says these treatments significantly speed up mowing. "We can run our mowers in third gear once we get the brush and trimming out of the way. And by mowing faster, we save fuel and man-hours."

So Roundup helps Wanda cut material and labor costs. (Material costs were further reduced when the price of Roundup itself was lowered.) And it has the same active ingredient as the herbicides homeowners use on their own lawns. In fact, in many ways, Roundup is actually better for the environment than mowing. Wanda notes that mowing is particularly hard on the wildlife that hides in vegetation.

The many benefits of Roundup are appreciated by the road maintenance crews, Wanda's supervisors—and the public, Wanda says. "When you let the public know what you're doing, why you're doing it, what you're accomplishing, you won't have problems with public opinion. We've taken a proactive approach with folks, and they've responded by supporting our program."

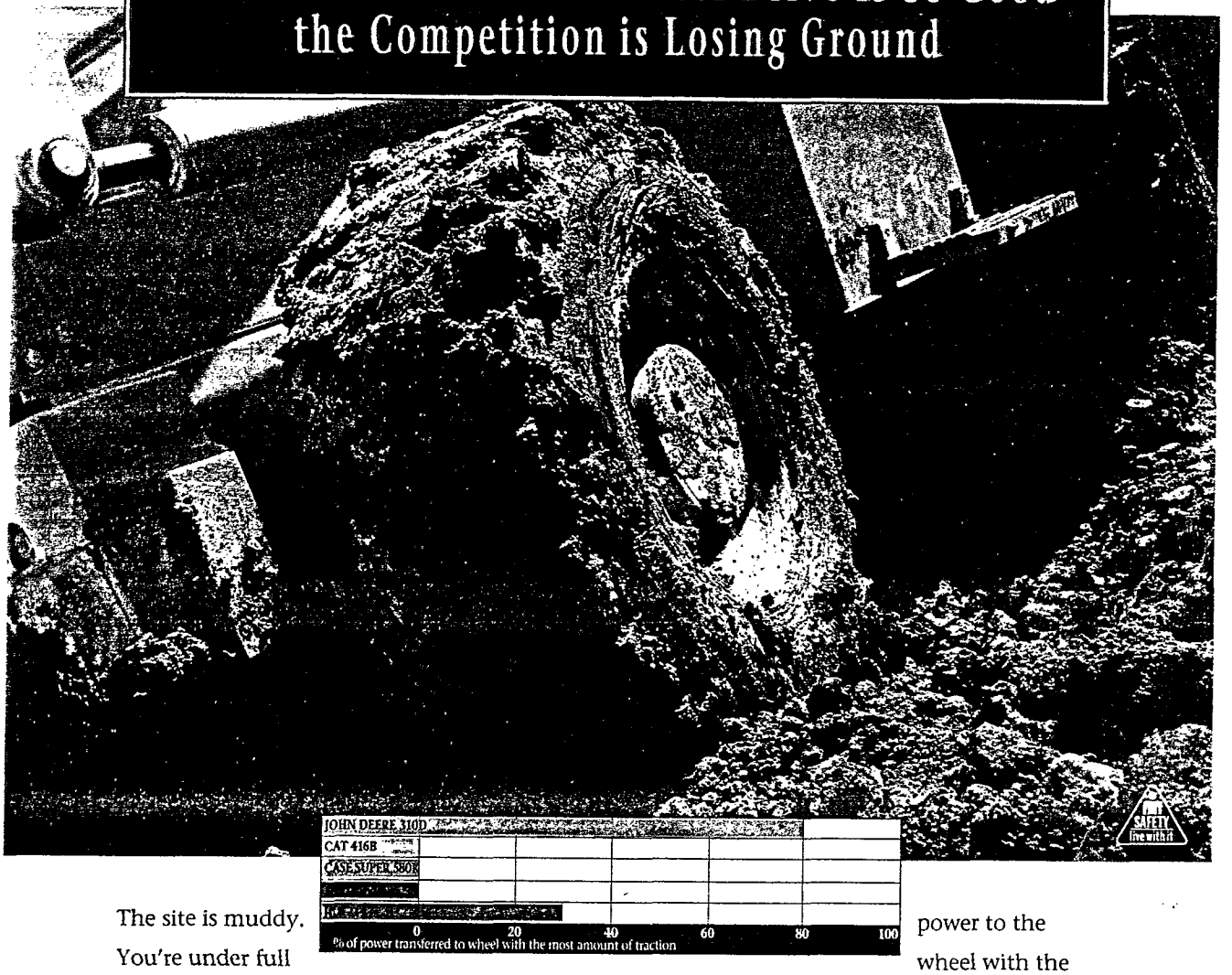
Thanks to a combination of the right people, equipment, materials—and Wanda—Hillsborough has an effective vegetation management program. Roundup is a key part of that program.

For details circle No. A-3 on card



R0013789

Our Mechanical Front-Wheel Drive is So Good the Competition is Losing Ground



The site is muddy. You're under full load. And a front wheel is spinning. So much for your mechanical front-wheel drive!

The Slipping Competition

According to a recent study, when mechanical front-wheel drive is engaged on most backhoes, power is transferred equally to each front wheel. If one wheel has no traction, all of the power goes to that spinning wheel. And you're stuck.

The True 4-Wheel-Drive Machine

Mechanical front-wheel drive is worthless if the wheel that is spinning-out gets all of the power. That's why John Deere uses mechanical front-wheel drive with a limited slip differential.

It automatically transfers 80 percent of the machine's power to the wheel with the most traction. This pulls you through the muddiest spots.

Tired of your machine slipping on the job? Get on firm footing. Order your John Deere D-Series Backhoe Loader with mechanical front-wheel-drive and get the benefits of four-wheel-drive performance. Call your dealer for a free limited slip differential demonstration today.

JOHN DEERE

RUN WITH THE BEST™

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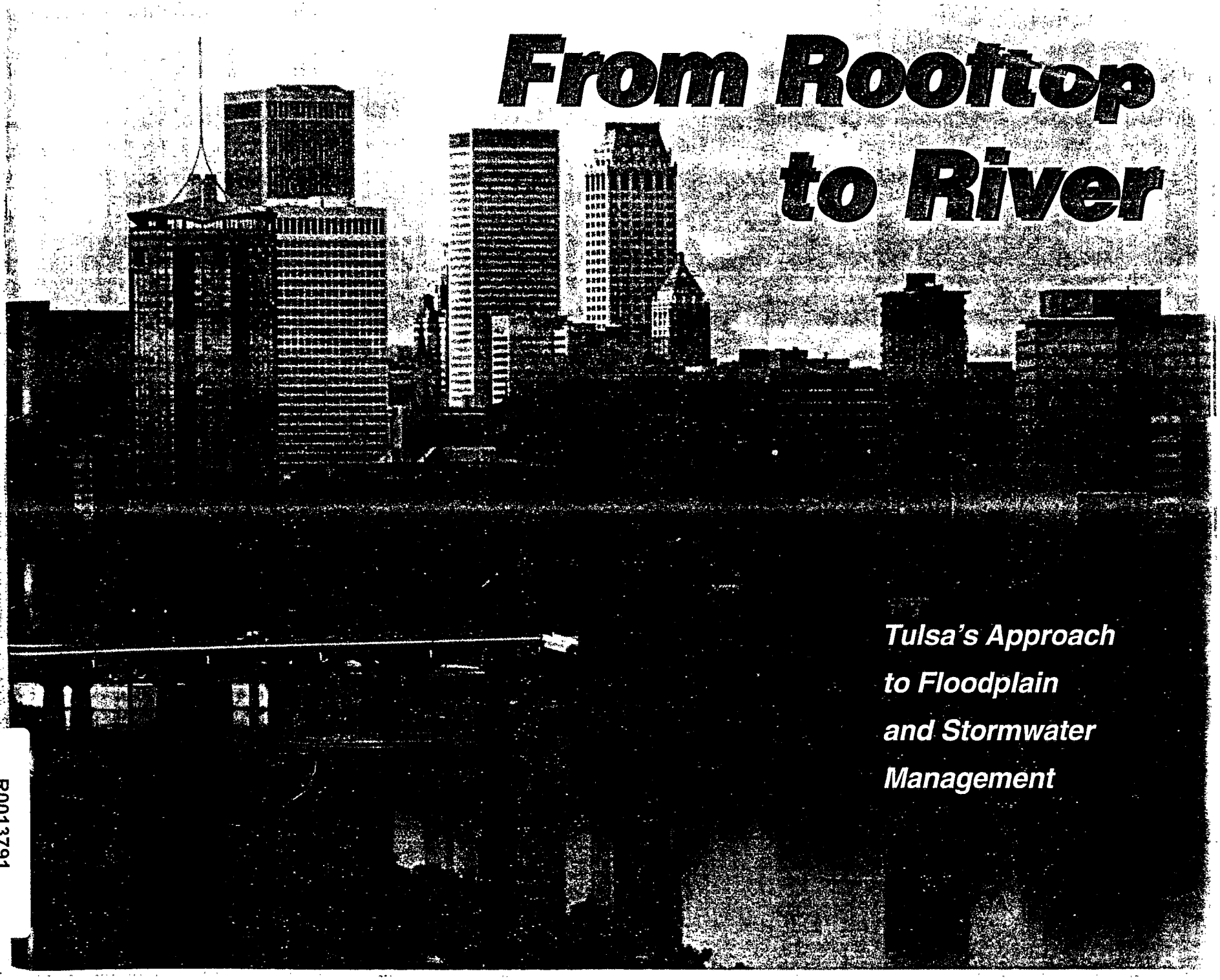

From Rooftop to River

Tulsa's Approach to Floodplain and Stormwater Management

R0013791

"In recent years, Tulsa has become one of the most progressive and far-sighted cities in the nation by promoting the protection of lives and property through the application of exemplary floodplain and stormwater management principles...

"This success is a direct result of the collective efforts and commitment of local government staff, elected officials, private sector organizations, and the citizens of Tulsa...."

– Federal Emergency Management Agency, 1992

M. Susan Savage, Mayor

This booklet was prepared under the auspices of the City of Tulsa Stormwater Drainage Advisory Board and Public Works Department, Charles L. Hardt, Director.

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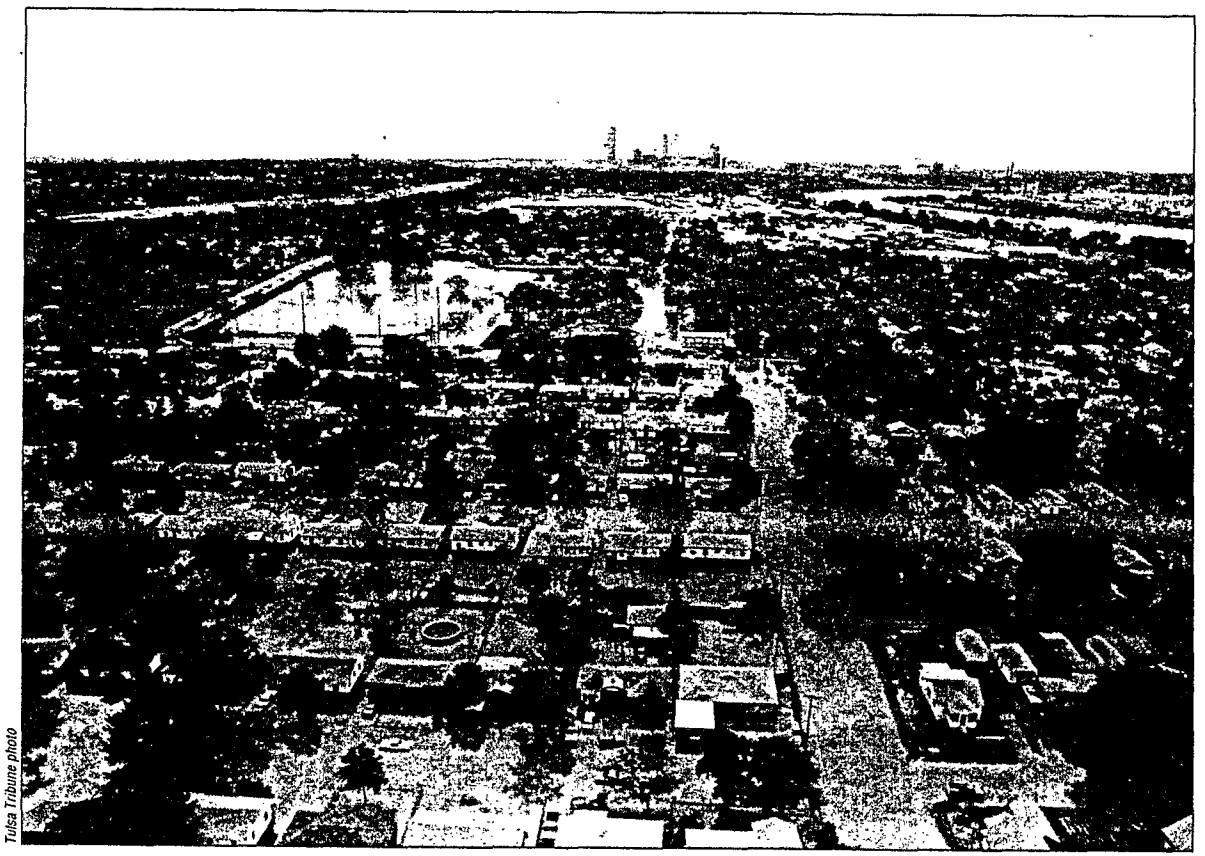

Tulsa Tribune photo

▲ Looking east toward downtown: Tulsa's 1984 flood damaged nearly 7,000 buildings.

Cover: Tulsa's heart is on a high bank of the Arkansas River. *Bob McCormack photo.*

From Rooftop to River

Tulsa's Approach to Floodplain and Stormwater Management

May 1994

R0013793

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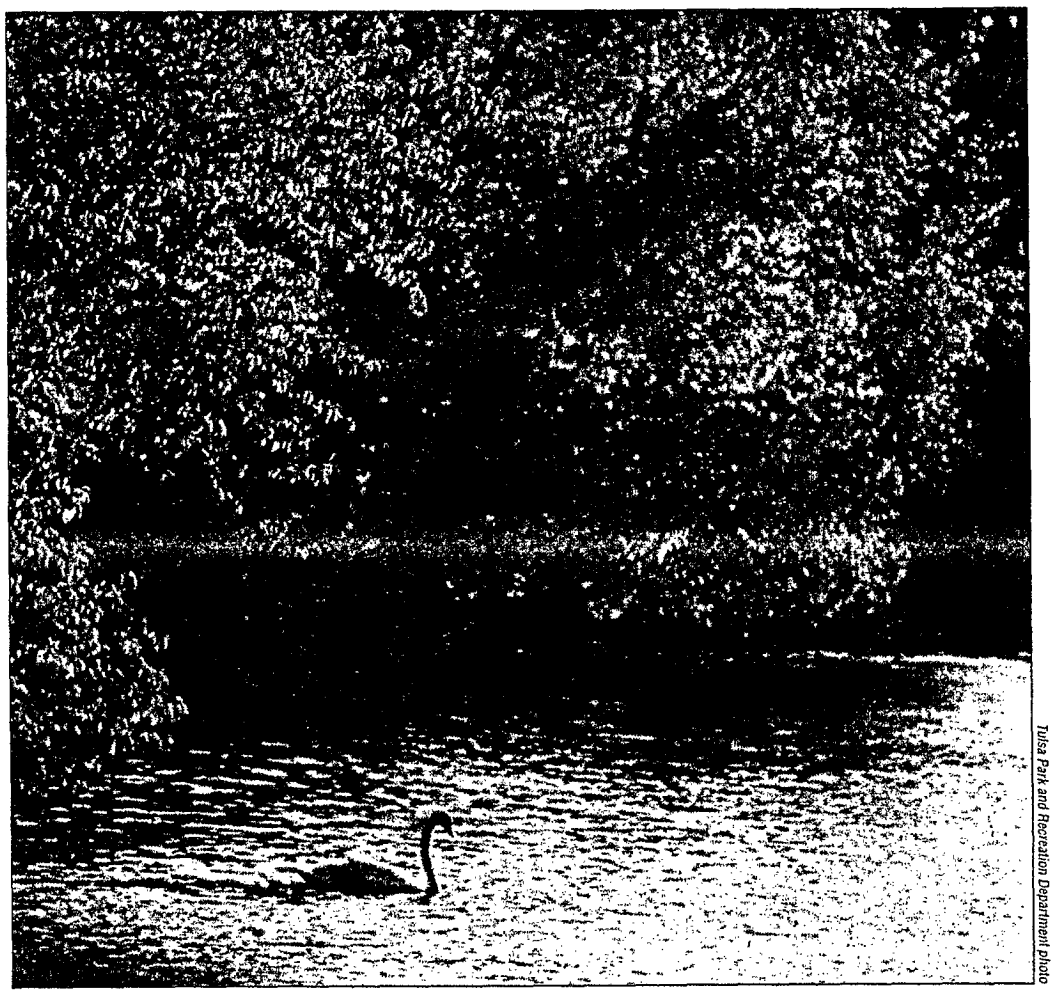

Tulsa Park and Recreation Department photo

▲ The water's edge holds promise.

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Foreword: *Becoming Floodsafe*

Tulsa, Oklahoma, has been called America's most American city, because the age, race, income, and attitudes of our citizens reflect the United States as a whole. We're a test market for new products; if it works in Tulsa, it has a good chance of working elsewhere.

Tulsa's flooding problems also mirror many other towns. Our community was founded a hundred years ago on a major river and has a long history of floods, compounded by post-war growth, floodplain development, and frequent rainstorms.

By the 1980s, Tulsa's flooding had reached singular proportions. The federal government had declared Tulsa County a flood disaster area nine times in 15 years, more than any other community in the nation. Each flood was worse than the one before.

The most devastating flood in our history hit in the mid-night hours of Memorial Day 1984. Our City responded to the shock of this killer flash flood with community-wide commitment to end our recurring disasters. Determined leaders crafted a unified program to curb flood losses.

Today, Tulsa's floodplain and stormwater program is based on respect for the natural systems. It includes comprehensive watershed management, dedicated funds for maintenance and operation, a prototype alert system, and a $200 million capital improvements program.

This program is more than flood control. We're building parks in the floodplains, sports fields in stormwater detention basins, and greenway trails on creekbanks.

We are forging strong partnerships with federal and state agencies.

And we've stopped creating new problems. Since the City adopted comprehensive drainage regulations 15 years ago, we have no record of flooding in any structure built in accord with those regulations.

Because the federal government gave our program its highest ranking, Tulsans enjoy the lowest flood insurance rates in the country. We are reaping benefits from national awards and favorable publicity.

We're still building our program, and we're still learning. We know our location in "tornado alley" guarantees that Tulsa will flood again, and we're working to prepare for that inevitability. But, without question, we've come a long way. Tulsa's progress has been called an example of what can happen when a community fully commits to solving urban problems.

Like many other U.S. communities, our experience didn't come easily. This booklet has been prepared in the hope that others may benefit from Tulsa's costly lessons on our long and continuing journey toward becoming floodsafe.



M. Susan Savage
Mayor, City of Tulsa

May 1994

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Dedication: *Leadership and Courage*

This report is dedicated to two gifted leaders in the field of floodplain and stormwater management — one national and one local. Both helped Tulsa develop its program. Both epitomize the many pioneers whose contributions leave the city and the nation immeasurably enriched.



Gilbert Fowler White is the father of modern floodplain management. Mentor to many, Dr. White exemplifies the many national experts who have generously shared their vision, wisdom, and support with Tulsa. Gilbert White's sphere is global; but for 20 years, he has also been Tulsa's friend.



Joseph Davis Metcalfe led Tulsa's program during its formative years after the 1984 flood. A professional engineer and industrialist, J.D. Metcalfe has spearheaded community-improvement coalitions for decades and served as the city's elected street commissioner between 1984 and 1990. He is a patron for progress.

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Preface: *Lessons Learned*

As Tulsa's stormwater and floodplain management program evolved over many years, we learned from others, from our mistakes, and from our successes. The following are a few of the many lessons we have learned:



- Strong partnerships are essential; but local communities must accept responsibility and not expect the state or federal governments to solve all their flooding problems.
- Watersheds and drainage systems are interconnected units. Effective management demands drainage basins to be planned as integral units.
- The National Flood Insurance Program was instrumental in leading our community into floodplain management. But NFIP regulations do not take into account future watershed urbanization and the resulting increase in flood depths. Tulsa's program is based on total basin urbanization.
- In an urban area such as Tulsa, stormwater and flood programs should include multiple objectives, including recreation and environmental quality, and multiple techniques, including structural and nonstructural projects.
- Mitigation and flood-loss reduction should become the central focus of flood recovery efforts. Re-establishment of the pre-flood status quo only sets the stage for future disasters and losses.
- Pre-flood contingency and mitigation planning is the next local, state, and federal priority. We must plan in advance for our actions during and after the next floods – and there will be future floods, in Tulsa and elsewhere.

If this booklet helps us share our experiences with others, and if our lessons prove useful, it will have served its purpose well.

Charles L. Hardt, P.E.
City of Tulsa Public Works Director
and Chief Operations Officer



▲ Charles L. Hardt, center, leads a river sandbag crew, 1993.

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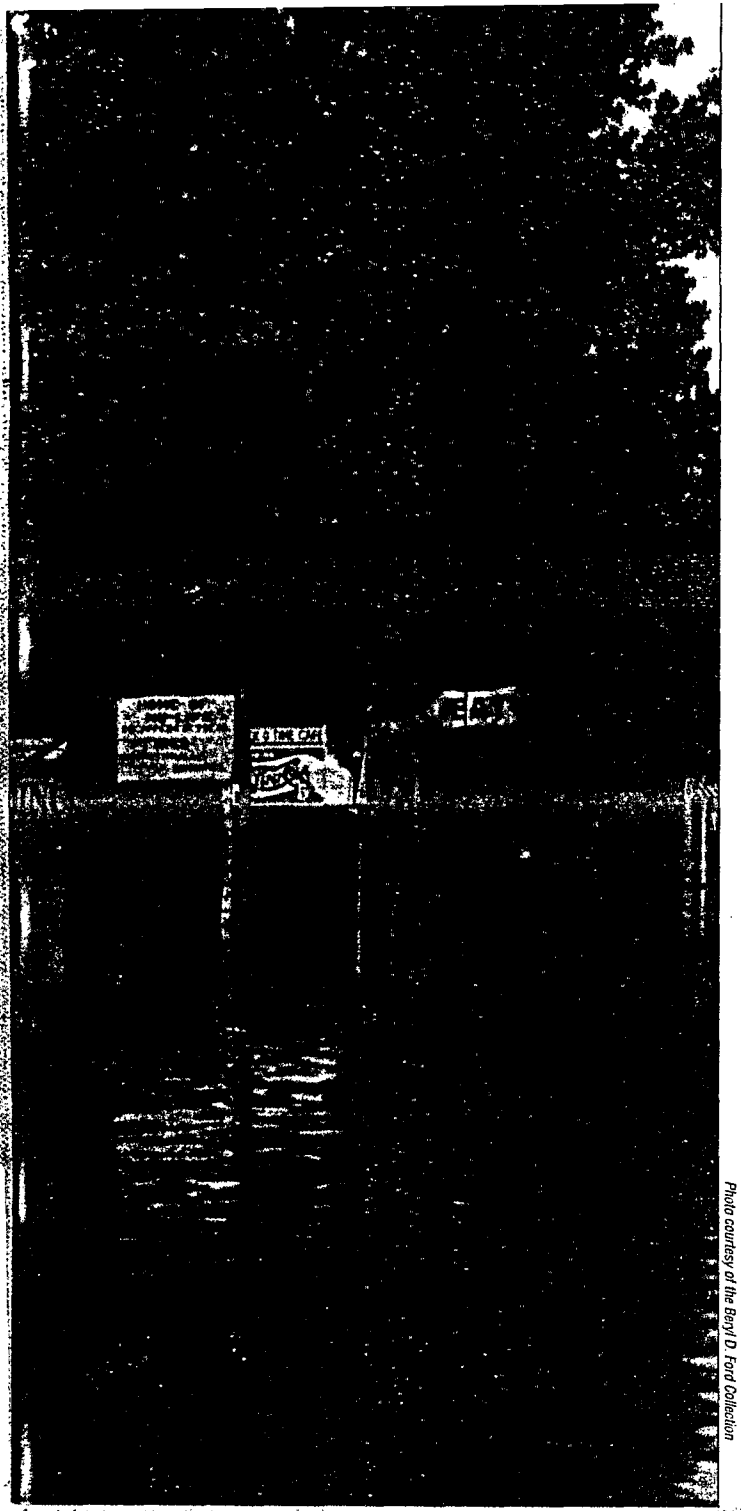


Photo courtesy of the Beryl D. Ford Collection

◀ Floods haunt Tulsa history. Left: circa 1943.

Setting and History

Learning the Hard Way

Tulsa is a crossroads Midwest community with a long history of flooding that mirrors, in many respects, the nation as a whole.

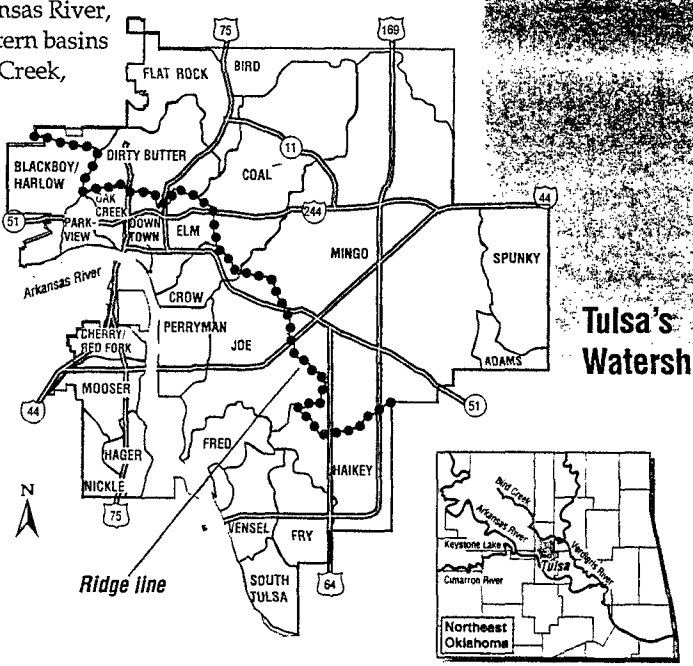
The city has 375,000 people and extends across 200 square miles of gently rolling terrain in northeastern Oklahoma's Osage Hills. The area is one of transition between the Ozark mountains to the east and the Great Plains to the west.

Tulsa is set on the Arkansas River, which rises in the Rocky Mountains and gathers across the Great Plains of Colorado, Kansas, and Oklahoma, thence to the Mississippi.

A ridge line divides the city. Southwestern creeks flow into the Arkansas River, and northeastern basins drain to Bird Creek, then to the Verdigris River east of Tulsa.

The fundamental lesson that nature teaches and will repeat patiently for the slow learner, is that the rivers and creeks own the floodplains.

—Jim Sellars



Tulsa's Watersheds

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When a cool front meanders south to break a warm weather pattern, the results can be awesome. Occasionally, a cool front slows to a near-halt during a hot afternoon, and the moisture piled high above the city condenses into pounding thunderstorms. Creeks and streams swell rapidly as stormwater seeks out its natural course. Floods soon follow.

WEATHER: Tornado Alley

Tulsa's geographical crossroad is also a weather junction, an interchange amidst the hot, arid zone to the west, the temperate climate to the north, and the hot, humid zone to the south.

Warm, moist air from the Gulf of Mexico is pulled north by high-pressure systems and collides with cool northern fronts making their way south. This wide swath of convergence is known as tornado alley. When cool fronts clash with warm fronts, towering thunderheads can soar eight miles high and pack enormous energy and moisture.

The converging weather systems meet over Tulsa most often in the spring and fall, sometimes causing violent storms. Normal annual rainfall averages about 36 inches, but successive waves of thunderstorms occasionally can dump nearly half that in a few hours, with little warning.

EARLY HISTORY: Indians and Oil

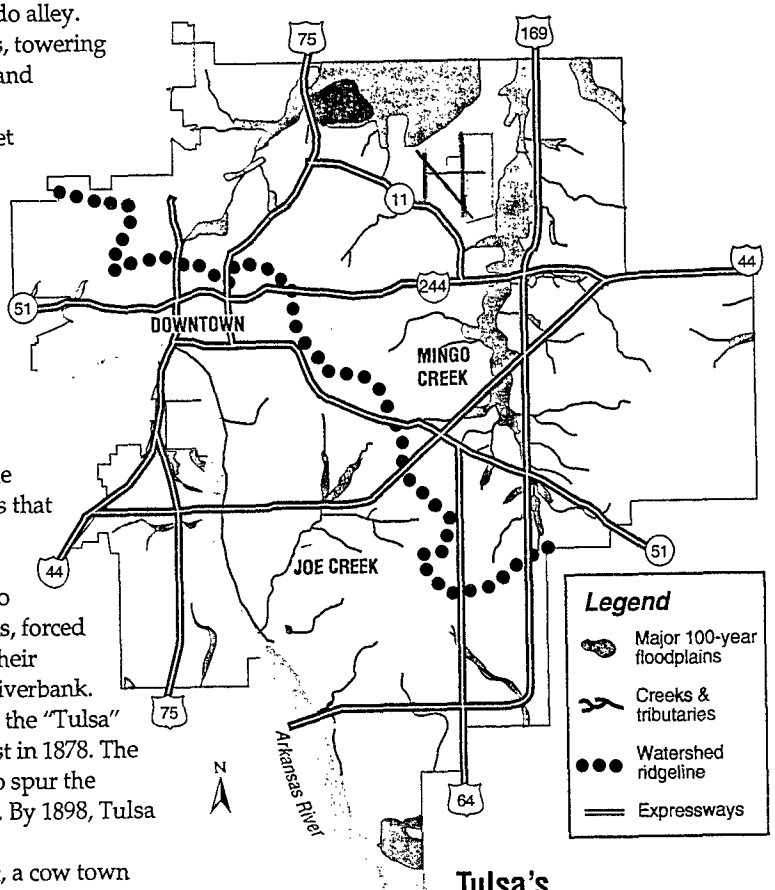
In search of water for transport and survival, early settlers were drawn to the Arkansas River in the low timbered hills that would become Indian Territory and, later, Oklahoma.

Tulsa can trace its beginnings back to the early 1800s, when Lockapoka Creeks, forced from their Southern homes, rekindled their council fires beneath an oak on a high riverbank.

A Creek Indian rancher established the "Tulsa" post office at the Perryman Trading Post in 1878. The Frisco Railroad came through in 1882 to spur the shipping of Texas herds to Kansas City. By 1898, Tulsa had incorporated as a town.

What was, in more than one respect, a cow town changed dramatically in 1901. Oil was discovered on the west side of the Arkansas River at Red Fork. The boom began in earnest in 1905, when the Glenn Pool, then called the world's largest oil field, was discovered south of Tulsa. Indian Territory became the center of oil exploration and speculation.

In the wake of Oklahoma statehood in 1907, Tulsa's population grew 100 percent a year. The city gained worldwide prominence as a petroleum center and dubbed itself the "Oil Capital of the World."



Tulsa's Major Creeks

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FLOODING HISTORY: Pathways to Progress

Tulsa has grown up with flooding. Many of the causes are locational: The city is based on a wide river, in a zone of violent storms, and on a frontier where a man had a right to do as he wished with his land.

Flood records are sparse before 1900. In 1908, only a year after statehood, Arkansas River flooding at Tulsa caused $250,000 in damages ($13.15 million in 1994 dollars).

By 1920, the town had outgrown its raw, boom-town image. As riches mounted and investors and speculators poured in, Tulsa grew to a wealthy city of 72,000. Development edged closer and closer toward the river.

On June 13, 1923, the river flooded Tulsa's waterworks, caused $500,000 in damages ($11.94 million in 1994 dollars), and left 4,000 homeless. City fathers responded with Tulsa's first land-use plan, which envisioned upland boulevards and housing. In the lowlands, such as Mingo Creek east of town, would be generous parks and recreational trails.

The waterworks moved to higher ground, near a band of Bird Creek bottoms that became one of the nation's largest city parks. That far-sighted preservation of Tulsa's 2,800-acre Mohawk Park was destined to save the city innumerable future flood losses.

The Structural Era of Flood Control

Meanwhile, around the nation, the 1920s ushered in what has been called the Structural Era of Flood Control, generally 1928 to 1968.

In response to the Great Mississippi River Flood of 1927, Congress in 1928 passed the Lower Mississippi Flood Control Act, authorizing the U.S. Army Corps of Engineers to construct dams and levees to control flooding.

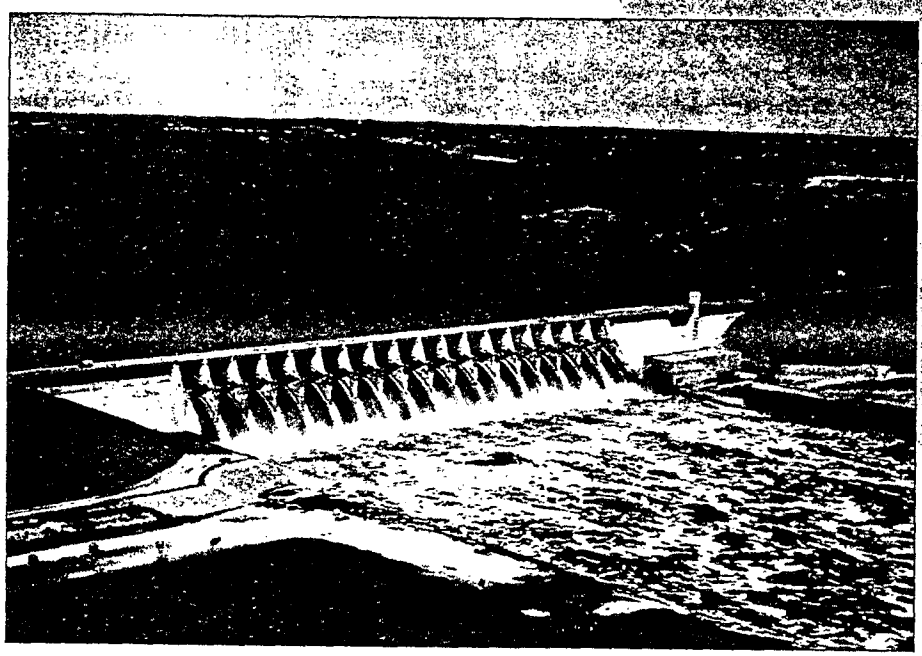
The major impact first came to Tulsa during World War II. As an emergency national defense project, and in response to 1943 flooding, the Corps built levees around Tulsa's oil refineries along the Arkansas River.

By 1950, in the post-war building boom, housing was fanning out, onto the floodplains to the south and east. Land that had periodically flooded with little harm now was awash in wave after wave of urban flooding.

By the late 1950s, flooding of newly developed subdivisions along the river spurred calls for flood control. In 1964, the Corps completed Keystone Dam 15 miles upstream from Tulsa. For years to come, Tulsans would believe that the Arkansas River was forever tamed.

Tulsa enjoyed another boom in the 1960s, when the city's population grew 25 percent. Tulsa's rapid growth required pastures and meadows to be piped and paved, as new buildings continued to spill into the lowlands of the the creeks and streams that etch the area. The rapidly urbanizing Mingo watershed was annexed to the city in 1966.

Early settlers took to the high ground, following the paths of Native Americans who honored natural laws.



▲ Keystone Dam was built upstream from Tulsa in 1964.

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▼ Firemen rig a rescue line off Little Joe Creek, 1968.



The argument that floodplain dwellers should have known better stood exposed for what it was: cynical disregard for community welfare. City-wide responsibility for flood problems would eventually become conventional wisdom.

Floods struck every two to four years during the 1960s and early 1970s. The response was classic: emergency response and recovery, reconstruction as quickly as possible, and denial of the possibility that floods could reoccur.

Victims petitioned for neighborhood flood control, with limited success.

The Regulatory Era of Floodplain Management

Nationally, flood losses continued to rise despite billions of dollars in federal flood-control projects. The dilemma prompted a decade of actions that could be called the Regulatory Era of Floodplain Management, generally from 1968 to 1978.

Flood control structures offered spot protection but sometimes caused offsite problems. They also could produce a false sense of security that lured more development into floodplains, flirting with catastrophe. To compound this problem, the value of the induced growth was counted as a benefit in project evaluations.

In the 1960s, this problem was illuminated in the landmark House Document 465, *A Unified National Program for Managing Flood Losses*. In response, the late 1960s brought Presidential Executive Order 11296 espousing floodplain management and the National Flood Insurance Act of 1968, which made federally subsidized flood insurance available to communities that agreed to adopt minimum floodplain regulations to stem future losses.

The Mother's Day flood of 1970 in Tulsa caused $163,000 in damages ($340,000 in 1994 dollars) on rapidly developing Mingo and Joe creeks.

The City responded by joining the National Flood Insurance Program's "emergency program" and promising to adopt federal floodplain regulations. In August 1971, the NFIP issued its block rate maps. A month later, Labor Day floods hit Flat Rock, Bird and Haikey creeks, and many suburban communities. In December, Bird Creek flooded again. Tulsa joined the NFIP's "regular" program, adopted a new 100-year flood standard, and promised to regulate floodplain land use.

The Year of the Floods, 1974, brought April and May floods that left $744,000 in damages ($2.11 million in 1994 dollars) on Bird Creek. Violent storms June 8 caused widespread flooding on Joe, Fry, Haikey and Mingo creeks, with more than $18 million in damages ($40.24 million in 1994 dollars). On September 19, Mingo Creek flooded again; for some citizens, it was the third flood in a year.

Angry, drenched victims waded out of the floods to demand help. They contended the city wasn't enforcing NFIP regulations. They tried to halt development, to avoid deeper flooding until existing problems could be solved. Developers objected strenuously.

Thus began a community debate over floodplain management, locally called "Tulsa's great drainage war," destined to last years.

The city responded with a plan to widen part of Mingo Creek, including clearance of 33 houses in the

R0013802

right of way. The houses were removed just before the next flood.

The 1976 Memorial Day flood marked a milestone in Tulsa's search for flood solutions. A three-hour, 10-inch deluge was centered over the headwaters of Mingo, Joe and Haikey creeks. The resulting flood killed three and caused $40 million in damages ($75 million in 1994 dollars) to more than 3,000 buildings.

By this time, the victims were becoming skilled lobbyists and gathering sympathizers city-wide. They stormed City Hall.

Newly elected city commissioners responded with a wave of actions. They enacted a floodplain building moratorium; hired the city's first full-time hydrologist; developed comprehensive floodplain management policies, regulations and drainage criteria; enacted stormwater detention regulations for new developments; instituted a fledgling alert and warning system; and began master drainage planning for major creeks.

In 1978, an earth change ordinance was also adopted, giving the city control over alterations to Tulsa's landscape, including floodplains and stream channels.

The Nonstructural Era of Stormwater Management

The Nonstructural Era, a third major phase of stormwater management, began with the President's 1978 Water Policy Initiative. It recognized the need to place nonstructural techniques on a par with flood-control structures and to preserve the natural values of floodplains and wetlands.

To curb continuing losses, in the early 1980s the federal government developed the Federal Interagency Hazard Mitigation process. In the days after disasters, federal teams were dispatched to identify hazard mitigation opportunities – basically ways to make the response to each disaster reduce the scope of the next one. The mitigation concept focused on correcting the *causes* of losses, including removing, raising, or floodproofing the most vulnerable of the damaged buildings.

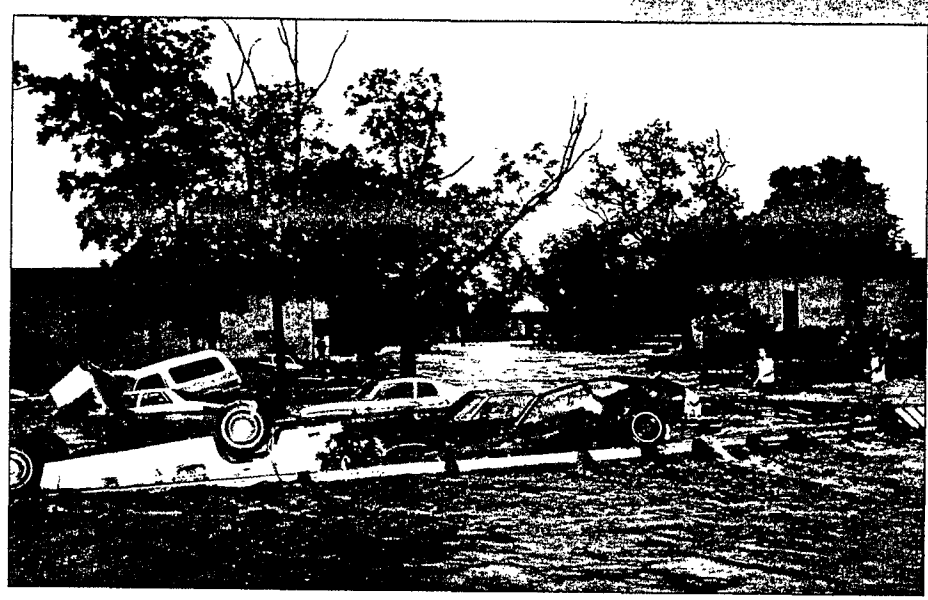
Tulsans worked with the Federal Emergency Management Agency to develop the process. Tulsa's early exposure to the new FEMA mitigation program was to have a significant impact on the city's response to future floods.

The 1984 Memorial Day Flood, the worst in the city's history, was Tulsa's watershed point.

After a muggy Sunday afternoon, a stalled cool front produced some 15 inches of mid-night rain, centered over Mingo Creek but also extending across most of the city. The results were disastrous.

The 1984 Memorial Day Flood killed 14, injured 288, damaged or destroyed nearly 7,000 buildings, and left $180 million in damages ($257 million in 1994 dollars). Mingo Creek alone accounted for $125 million of the damages.

Tulsa's 1984 flood response focused on mitigation and flood loss reduction, rather than re-establishment of the pre-flood status quo.



© Jim Wolf

▲ The 1984 flood routed thousands, killed 14, injured 288, and caused $180 million in damages to nearly 7,000 buildings.

The newly elected mayor and street commissioner had been in office for only 19 days, but both knew the issues well. In the darkest hours of the city's worst disaster, they pledged to make their response reduce the likelihood that such a disaster would ever be repeated.

R0013803

By the 1990s, Tulsa's stormwater program was institutionalized and broadly accepted.

Before daylight, they had assembled the city's first Flood Hazard Mitigation Team to develop the city's strategy.

Within days, a new approach to Tulsa flood response and recovery was born.

As ultimately completed, the program included relocation of 300 flooded homes and a 228-pad mobile home park, $10.5 million in flood control works, and $2.1 million for master drainage plans. The total capital program topped $30 million, mostly from local capital sources, flood insurance claim checks, and federal funds.

It was only the beginning.



Tulsa Tribune photo

▲ Volunteers sandbag on the Arkansas River, 1986 flood.

A Unified Program was created after the 1984 flood.

The work didn't end with the initial flood response and recovery. In fact, it was only the first step in a long and continuing journey to make Tulsa floodsafe.

The 1984 flood also persuaded Tulsans that a coordinated, comprehensive stormwater management program was needed – from the rooftop to the river.

The Department of Stormwater Management in 1985 centralized responsibility for all city flood, drainage, and stormwater programs.

A stormwater utility fee was established by ordinance in 1986 to operate the program. The utility fee ensures stable funds for maintenance and management, independent of fickle political winds. The ordinance allots the entire fee exclusively for floodplain and stormwater management activities.

The 1986 Arkansas River Flood was a first test of the new stormwater management program. It also served as a reminder of the finite protection of Keystone Dam.

Between September and October 1986, Keystone Reservoir filled to capacity, forcing the Corps to release water at the rate of 310,000 cubic feet per second. Downstream flooding was inevitable.

At Tulsa, a private westbank levee failed, causing $1.3 million in damages to 64 buildings. The city fielded its hazard-mitigation team and cleared 13 substantially damaged structures.

Institutionalization and acceptance came in the 1990s, after Tulsans approved a change in city government from the mayor-commission to the mayor-council form.

A new Department of Public Works consolidated all public works services. Stormwater management was reintegrated and finally institutionalized into the city structure.

Today, storm drainage management is generally an accepted part of the city's services.

Tulsa's system has not been tested by a catastrophic rainfall since 1986, but the system has handled smaller rains well. Leaders believe improved maintenance, continuing capital projects, stringent regulations, and aggressive citizen awareness programs will reduce – but cannot entirely eliminate – future flood losses.

The greatest testimony to the program is that, since comprehensive regulations were adopted in 1977, the city has no record of flood damages to any building that complies with those regulations.

In the early 1990s, FEMA ranked Tulsa first in the

R0013804

nation for its floodplain management program, allowing Tulsans to enjoy the nation's lowest flood insurance rates. The program was also honored with FEMA's 1992 Outstanding Public Service Award; and the Assocation of State Floodplain Managers has twice given Tulsa its Local Award for Excellence.

Leaders consider the Tulsa program still in progress. They know that much remains to be done, and that there is an inevitable next flood ahead. The program continues to evolve.

The Watershed Era of Comprehensive Management

The Great Midwest Floods on the Mississippi and other heartland rivers in 1993 caused more than $10 billion in damages to 72,000 structures and, in some cases, entire communities.

The 1993 Midwest floods spurred national leaders to re-examine their programs. Although Tulsa was not directly affected, local leaders also took advantage of the lessons that the nation was learning.

The 1993 floods served as a catalyst to launch a fourth era in the nation's attempts to stem disaster losses, according to Dr. Gilbert F. White, a leader in national floodplain management for the past 50 years, and Larry Larson, Executive Director of the Assocation of State Floodplain Managers.

That new era looks above and beyond the floodplains, beyond response to a specific disaster, and takes a longer and broader view.

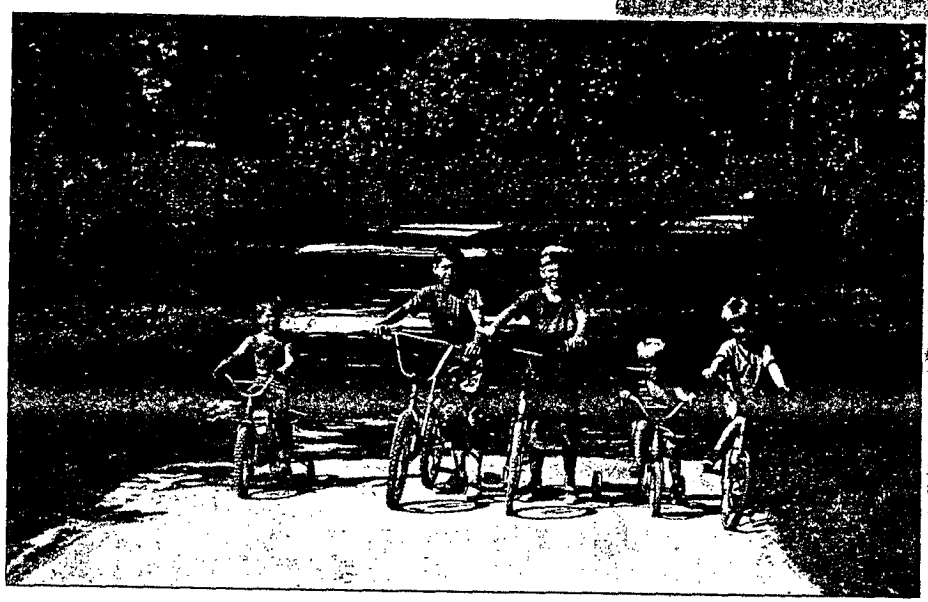
"It examines in an integrated fashion the whole regional floodplain environment," White says. "It is a program which takes into account the human values, the local resource decisions, the whole pattern of local community management as it is related to flood-hazard and the floodplain."

"Until this year," says Larson, "the government mostly helped people rebuild at risk of the next flood. A monumental change has occurred in federal attitudes and programs that assist people and communities in flood recovery. That change will result in relocation of structures out of flood hazard areas or elevation above flood levels with government assistance."

This new direction – a comprehensive, regional approach to long-term solutions, based on collaborative partnerships – mirrors the best of Tulsa's local goals and priorities.

The long journey and hard lessons continue. In the words of a former Tulsa mayor, "We're all learning – together."

The newest national era of floodplain management mirrors the best of Tulsa's local goals and priorities.



▲ Creekbank maintenance trails make excellent playgrounds.

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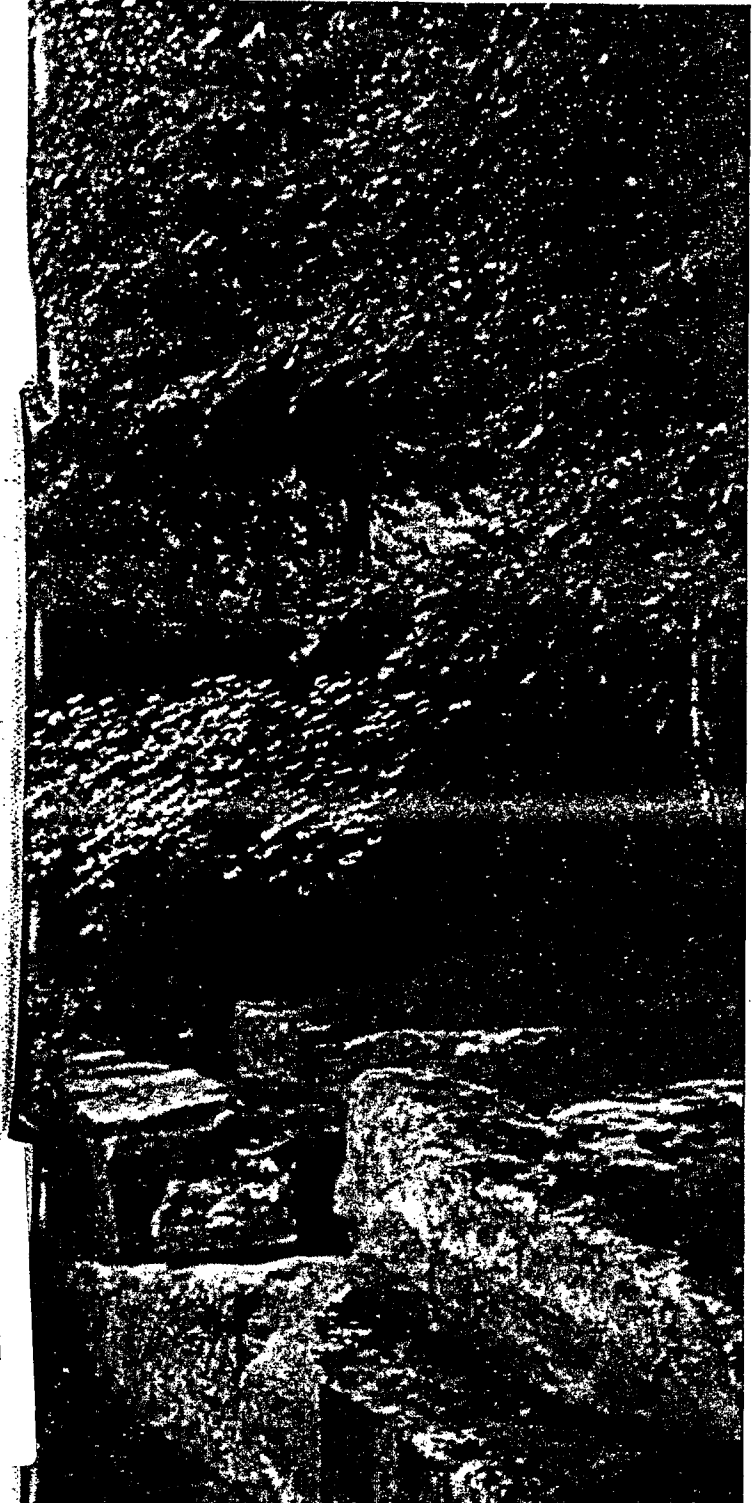


◀ Tulsa policies encourage use of stormwater as an amenity, as in this private project at Warren Place.

Policy Framework

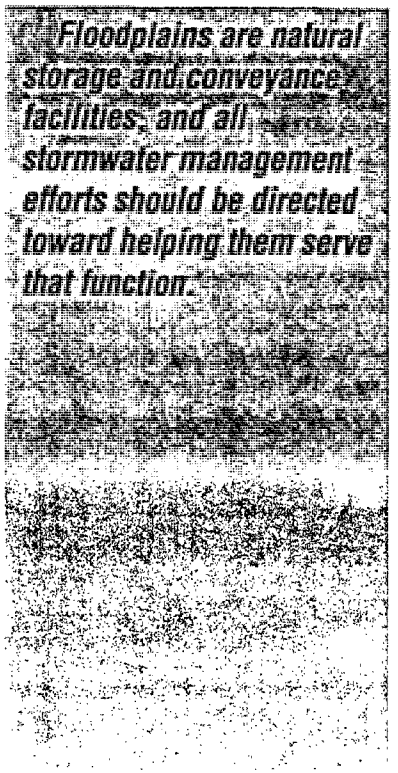
Watershed Management

Tulsa's program works because it is based on a unified, logical philosophy.

The philosophy evolved as Tulsa realized that management systems must take into account two key factors: the timing of flood peaks and the availability of flood storage. This awareness led Tulsa to its watershed-wide management approach to time and space allocation of stormwater.*

It is the foundation on which the program rests.

This section highlights excerpts from Tulsa's floodplain and stormwater management philosophy and policy framework.



PRINCIPLES

- **The urban environment and each watershed within it form a single, interacting system. Actions have consequences.**
- **Floodplain and stormwater management is a matter of time and space allocation. Water requires space and must be stored and conveyed, in either appropriate or inappropriate places.**
- **Floodplains and stormwater are resources. If they can become recreation or beautification assets, so much the better.**
- **Floodplain and stormwater management programs should include multiple purposes and multiple means.**
- **Changes in the natural balance require compensations. Nature bats last.**

*Tulsa's policies were gleaned from the work of many others, including the National Flood Insurance Program, Gilbert F. White, Jim Goddard, Jon Kusler, Rutherford Platt, Jack Sheaffer, Ken Wright, and FEMA's *Unified National Program for Floodplain Management*.

R0013807

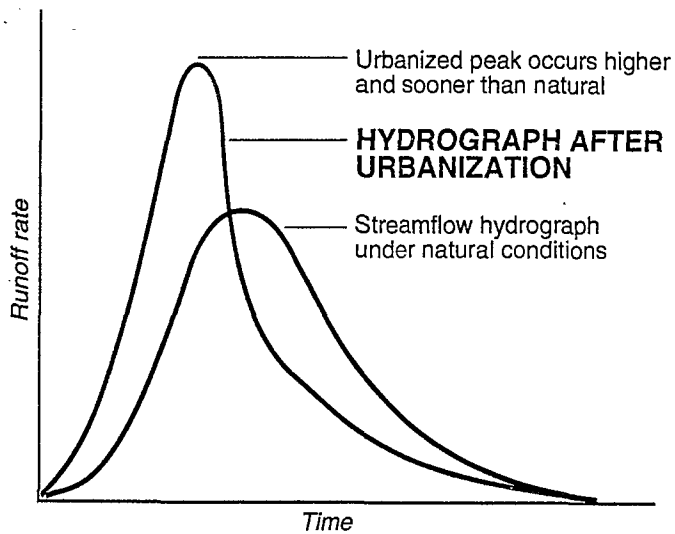
Structural and non-structural approaches are both weapons in the arsenal of flood management when appropriately applied in accordance with a basin-wide plan.

CORRECTIVE POLICIES

- **Flood control works include channel modifications and stormwater detention storage.**

  Under certain circumstances, structural projects are necessary to correct past mistakes and provide spot protection. But they must be used with care, because they tend to transfer problems elsewhere, create a false sense of security, and encourage unwise use of the floodplain.

  Flood control projects should consider the entire watershed, based on master drainage plans.



Stormwater Runoff Rates Compared

Urbanization can significantly increase runoff because buildings, parking lots, and other impervious areas reduce groundwater infiltration and natural surface storage.

Peak rates of flow increase as vegetation is removed and the natural landscape is altered, replacing slowly draining wetlands, depressions, meanders, and gullies with rapidly draining urban curbs, gutters, pipes, and straight channels.

The increased speed decreases the time for runoff to peak at a given location – more water reaches a given point faster.



▲ Detention storage, such as this Mingo basin, can include amenities.

Proper, routine maintenance is essential to keep the stormwater systems working.

- **Acquisition and relocation should be used to reduce, over time, the occupancy and value of exposed property in flood-hazard areas.**

  Any proposal for corrective actions should include a careful analysis of acquisition and relocation alternatives. The value of floodplain lands for urbanization should not be used to *justify* structural projects. The value of floodplain land for park, recreation and open-space purposes and other natural values should be used to evaluate nonstructural alternatives.

  Relocation may be more cost-effective after a flood. Post-flood acquisition should be evaluated and, if possible, pre-planned.

- **Other essential corrective measures include flood insurance and floodproofing.**

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PREVENTIVE POLICIES

- **Public park, recreation, and open space use of the floodplain is the best policy.**
- **Regulatory systems are based on the "100-year flood" under fully urbanized watershed conditions.**
- **Floodplain alterations should be avoided unless they are based on a basin master drainage plan and it can be shown that they will not cause off-site problems.**
- **Regulation of floodplain uses is based on the recognition that:**

  Flooding is a public threat.

  Floodplain uses should be compatible with the natural functions of conveyance and storage.

  Floodplain uses should not reduce, restrict, or impede channel conveyance capacity, or increase downstream velocities.

  No changes can take place in the floodplain that decrease or reduce storage. If filling is allowed, compensatory storage must be provided in the floodplain.

  Development should be directed to areas free from flooding.

  All development within the regulatory floodplain requires a permit.

- **Stormwater runoff control is necessary because development on higher ground can increase flooding, siltation, and erosion.**

  Excess stormwater runoff caused by new development should be detained and released at a rate that will not increase peak discharges above that which occurred before development. Generally, regional detention basins are more effective than on-site facilities, unless a specific problem is being addressed.

- **Public facilities located in the floodplain require special attention.**
- **Other preventive actions include:**

  Public acquisition of floodplain lands.

  Disclosure of flood-hazard information to purchasers and renters.

  Flood alert, warning and emergency management systems.

  Public information, education and awareness programs.

  Development of a post-flood recovery plan, including acquisition of frequently damaged properties; relocation of occupants from floodprone areas; and preservation of floodplain lands for park, recreation and open-space purposes.

Waterways can be channeled, concrete-lined, or even buried. But the floodplain carved over centuries is the gathering point for runoff from higher lands. Regardless of our schemes, water will continue, from time to time, to reclaim its routes.



Tulsa World photo

▲ Neighbors now stroll where homes once flooded.

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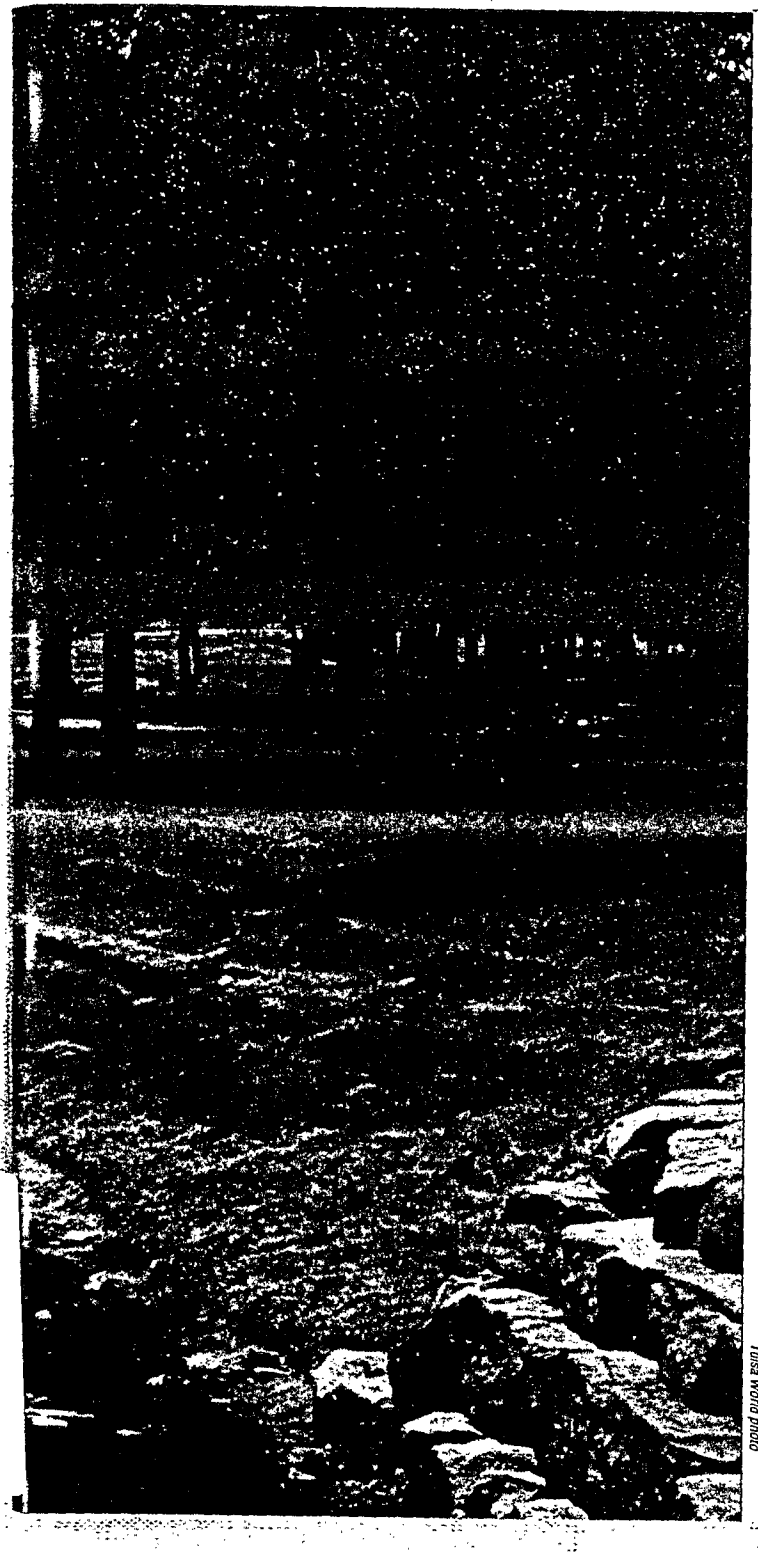


Tulsa World photo

◀ Before (inset) and after flood channels and detention storage were added to McClure Park.

Rooftop to River

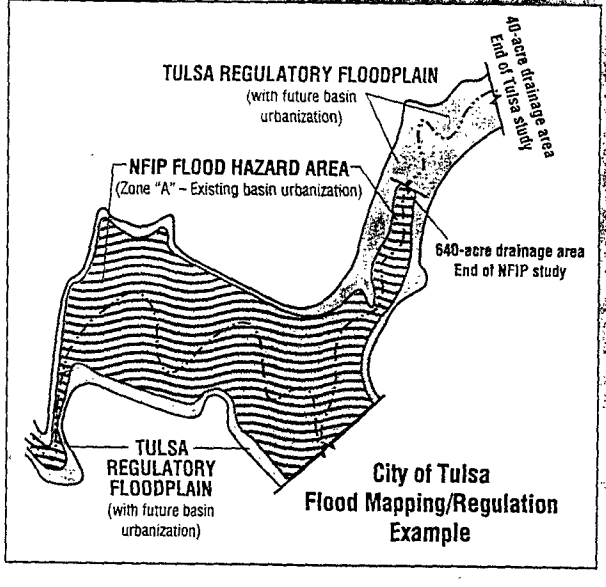
The Tulsa Program

Tulsa's floodplain and stormwater program includes three key goals:

- Prevent new problems.
- Correct existing problems.
- Enhance the community's safety, environment, and quality of life.

This section highlights major program elements used to achieve those goals.

A city can overcome its flood hazards while still encouraging responsible growth.



REGULATION

In general, Tulsa growth is welcomed – so long as it will not flood or cause flooding elsewhere.

Beyond the 100-year standard*

Experience showed that the National Flood Insurance Program's minimum standard is insufficient for Tulsa. Therefore, the city's regulations exceed NFIP's standard in several important ways, highlighted below.

*Two terms need to be defined.

Base flood: The National Flood Insurance Program is based on the so-called "100-year flood," which has a 1 percent chance of occurring or being exceeded in any given year. This standard is also called the "base flood." It is based on watershed development as it exists at the time of the mapping.

Regulatory flood: The city's more extensive and restrictive system is based on the "regulatory flood," a 100-year flood calculated as it will occur when the basin is fully developed.

Floodplain Maps

For greater protection, Tulsa's regulatory floodplains generally exceed those mapped by the National Flood Insurance Program. Tulsa's broader floodplains are based on full future urbanization of watersheds.

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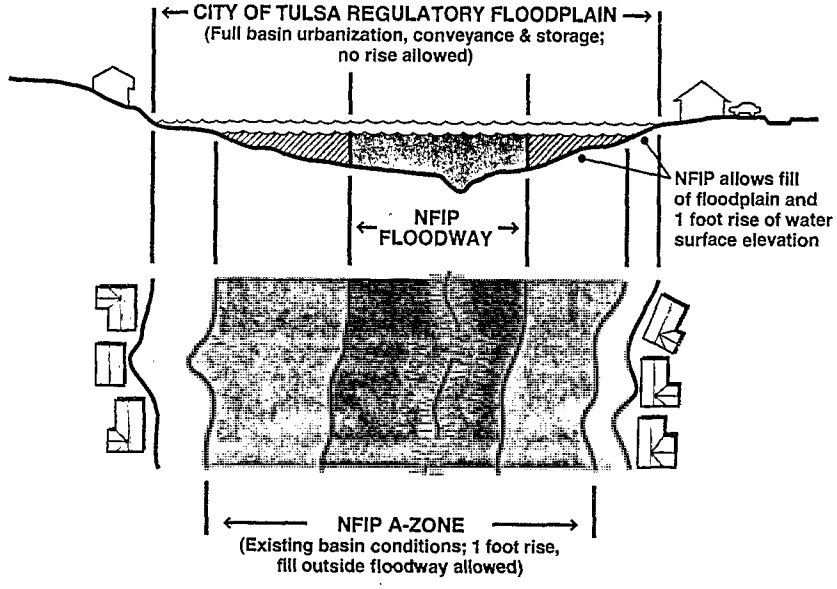
NFIP standards are inadequate for urbanizing watersheds. Many developments permitted today under less restrictive NFIP standards will flood tomorrow as upstream urbanization increases runoff.

Ultimate watershed urbanization. Runoff generally becomes deeper and faster, and floods become more frequent, as watersheds develop. Water that once lingered in hollows, meandered around oxbows, and soaked into the ground now speeds downhill, shoots through pipes, and sheets off rooftops and paving.

Insurance purposes require the NFIP floodplain maps to be based on *existing* watershed development.

But unless plans and regulations are based on future watershed urbanization, development permitted today may well flood tomorrow as uphill urbanization increases runoff. Tulsa enforces the NFIP minimum regulations and maps, to retain eligibility for federal flood insurance.



Regulatory Floodplains
Tulsa's floodplain regulations are more stringent than the National Flood Insurance Program's, because Tulsa regulations are based on full urbanization of the watershed and do not allow any rise in the water surface elevation.

In addition, the city enforces its own more extensive maps and regulations, which are based on *ultimate watershed urbanization* as forecast in the comprehensive plan.

Watershed-wide regulation. Floodplains are only part of flood-management considerations. Water gathers and drains throughout entire watersheds, from uplands to lowlands. Each watershed is an interactive element of the whole. A change at one place can cause changes elsewhere, whether planned or inadvertent. Therefore, Tulsa goes above and beyond the floodplain in its regulatory program, extending its regulations watershed-wide.

Stormwater detention. One way to avoid increased flooding downstream from new development is to provide stormwater detention basins throughout watersheds.

New or substantially improved developments must detain the excess stormwater on site – unless they are exempted in master plans or allowed to pay a fee in lieu of on-site detention. Water from detention basins is released slowly downstream.

In-lieu fees are allocated for regional detention facilities. In most instances, the city has found regional detention basins to function more satisfactorily than smaller, scattered on-site facilities.

Valley storage. Flood water cannot be compressed. It requires space. Encroachments into a channel or floodplain can dam, divert, or displace flood waters. So Tulsa requires compensatory excavation if a development – including a flood control project – would reduce valley storage. Preserving or recreating floodplain valley storage is a keystone of the city's program.

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Freeboard. NFIP regulations require finished floors of new development to be at or above the base flood elevation, based on existing watershed conditions. Tulsa includes freeboard as another margin of safety, requiring finished floors to be at least 1 foot above the regulatory flood elevation, based on ultimate watershed urbanization.

Erosion and sedimentation. Erosion and sedimentation rob hillsides of valuable topsoil, dam lowlands, clog streams, and pollute rivers. Builders must control site erosion from new development.

Permits and performance standards

Tulsa requires a watershed development permit to be issued before developing, redeveloping, building, excavating, grading, regrading, paving, landfilling, berming, or diking of any property within the city. There are five types of watershed development permits: floodway, floodplain, stormwater drainage, stormwater connection, and earth change permits. Individual residential lots outside the floodplain are exempted.

Tulsa's regulations are based on adopted floodplain maps (both Tulsa and NFIP), watershed-wide master drainage plans, and development permits based on specific performance standards.

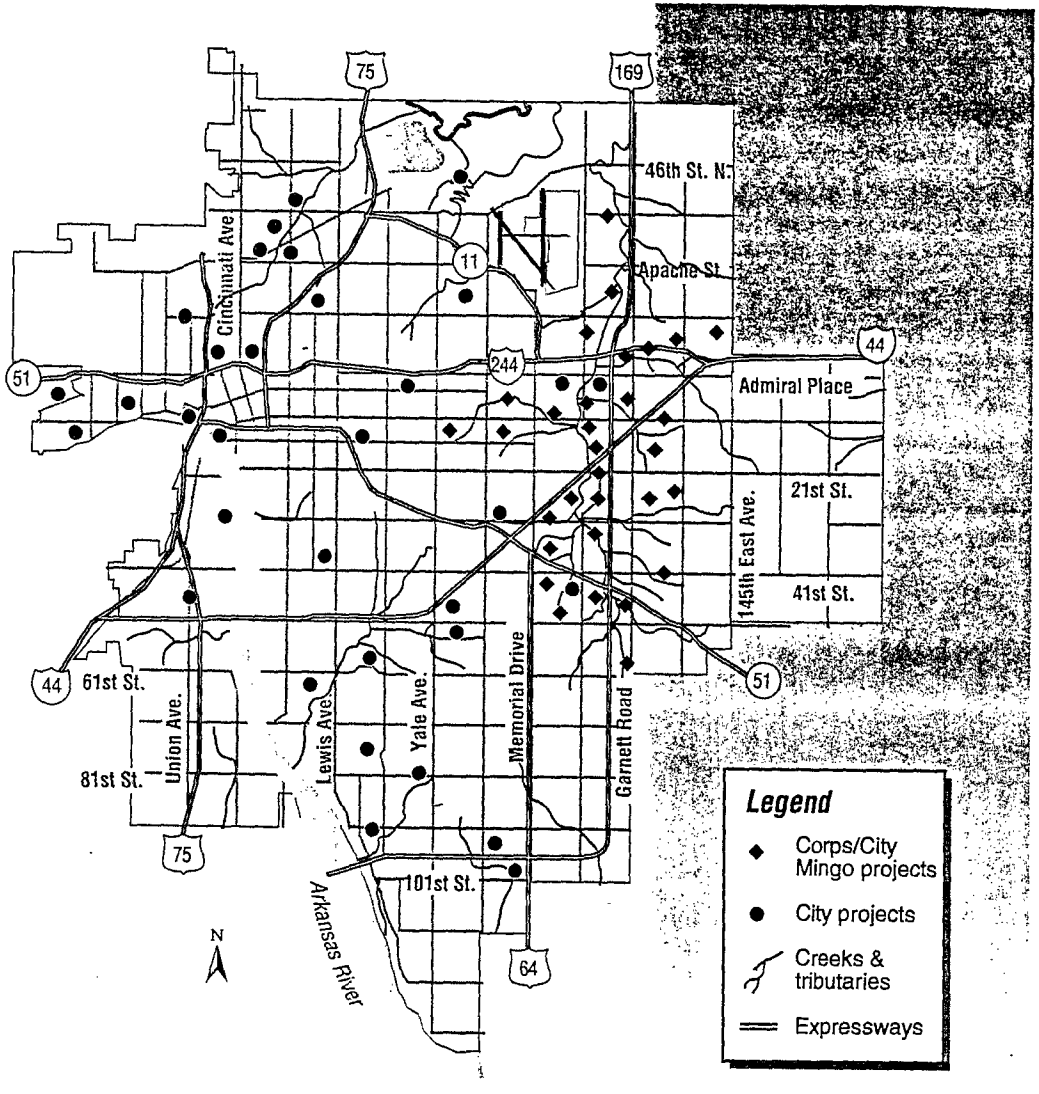
PLANNING AND CAPITAL PROJECTS

A decade ago, Tulsa faced up to its need for half a billion dollars in corrective flood projects. The city had been built, over decades, without much of a drainage system, and the result was disastrous. The task appeared overwhelming.

Since then, Tulsa has completed or under construction more than $200 million in capital plans and projects, including $80 million in federal funds.

The capital program includes structural, nonstructural and multi-objective projects. By combining techniques, flood hazards have been reduced for thousands of Tulsans.

More than $300 million in flood-reduction projects are still needed. Tulsa's program is still under way,



Major Capital Projects
Tulsa has under way or completed more than $200 million in flood projects, most since 1984. They include structural and nonstructural projects. This map generally shows only projects costing more than $100,000.

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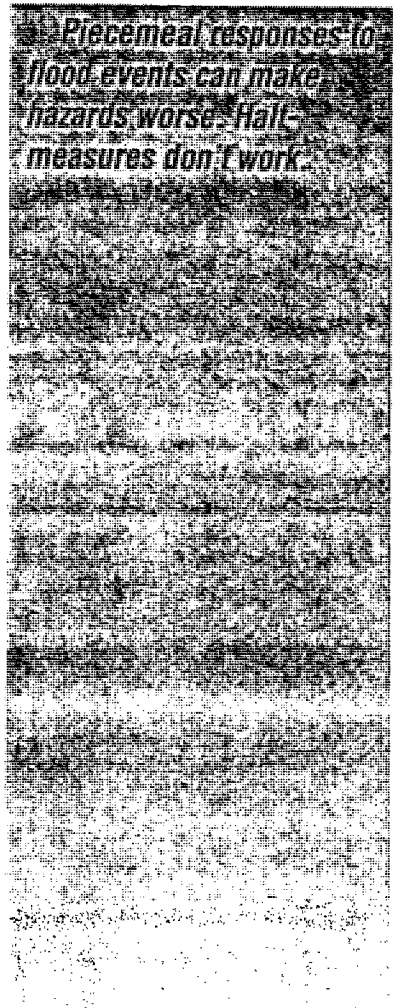


and will be for years, to correct drainage problems that were created over many decades.

Planning

The backbone of Tulsa's stormwater management system is its master drainage planning. The planning process involves extensive citizen participation, including hundreds of public meetings over the past decade.

Master drainage plans. Tulsa has completed master drainage plans for virtually all drainage basins. Each plan is a comprehensive, watershed-wide study of a drainage basin that documents existing floodplain information and recommends solutions for flooding and drainage problems.

A typical master drainage plan is developed within the context of the community, and so takes into account community values, existing conditions, goals and objectives, and future plans. The result is a plan for actions and projects, including costs and benefits.

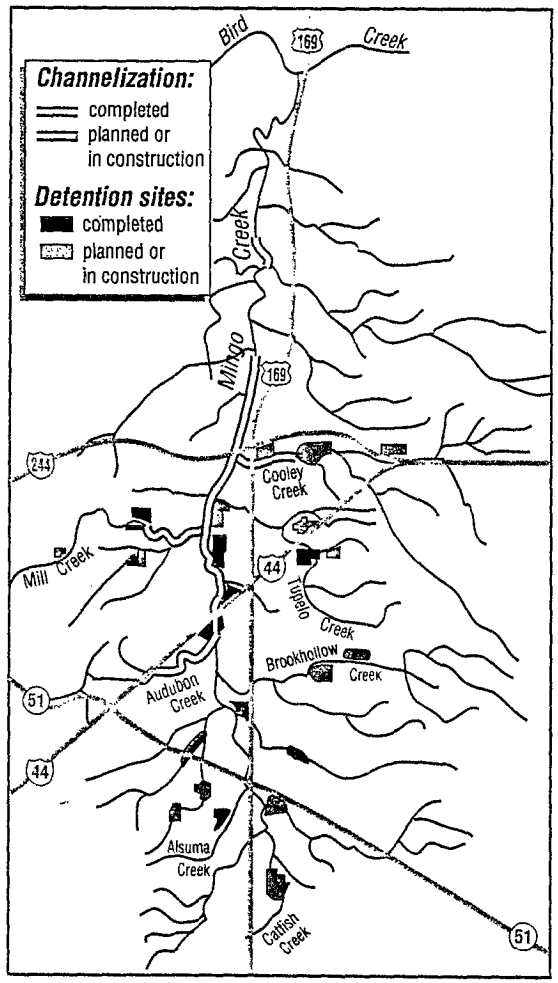
City-wide master plan. In 1989, the city synthesized its various master drainage plans into one city-wide document, *The City of Tulsa Flood and Stormwater Management Plan, 1990-2005*. This city-wide plan ranks and prioritizes hundreds of recommended projects, to guide capital scheduling.

Capital projects

Priority-setting was challenging. Citizens in every watershed faced severe flooding problems. In general, priorities are based on hazard, cost, benefit, and feasibility.

Mingo Creek project. The 61-square-mile Mingo watershed drains the eastern one-third of the city but has accounted for two-thirds of Tulsa's flood damages in recent years. The U.S. Army Corps of Engineers and the city worked together in the late 1970s to develop a plan for Mingo flood control, which Congress authorized for construction in 1986.

The Corps estimates that the completed $143 million project will prevent $32 million in average



Mingo Creek Flood Project
Most Tulsa damage has come along Mingo Creek in east Tulsa. To curb Mingo flooding, the city and the Corps of Engineers are building the $143 million Mingo project. It includes 23 stormwater detention basins and about 10 miles of channels, all to be completed in 1996.

R0013814

annual flood damages. With an average annual cost of about $16 million, the Mingo project has a benefit-to-cost ratio of 2 to 1.

The local cooperation agreement signed by the city helped forge new legislation, written into the Water Resources Development Act of 1986, which also gives communities credit for past construction projects. The federal government recognized that before 1986 Tulsa had constructed some Mingo channels and detention basins that were compatible with the Corps project. The federal government agreed to give the city credit toward its local share plus reimbursement for the federal share of prior expenditures that pertain to the project. Tulsa has received $10 million in reimbursements and expects to receive about $10 million more.

Acquisition and relocation. Over the past 15 years, Tulsa has cleared more than 900 buildings from its floodplains. The largest clearance came after the 1984 flood, when more than 300 single-family homes and 228 mobile homes pads were acquired and cleared.

The city's floodplain program is gradually reducing its inventory of thousands of floodprone buildings. The city is also updating its post-flood mitigation plan to include acquisition and relocation recommendations for before, during, and after a flood.

Small capital projects. Many flooding and drainage projects throughout the city are localized but troublesome. They are addressed through small capital projects, generally less than $100,000 each. Every year, $700,000 is allocated from the utility fee for small projects. Some are also funded through long-range capital sources.

Floodproofing. In some instances flood damages to existing structures can be averted by spot flood-proofing, such as elevation of the existing structure on site, shields for windows and doors, and ring levees. Oklahoma law does not allow the city to spend public funds to floodproof individual structures, so currently the city's role is limited to technical assistance to private property owners.



Tulsa has cleared more than 900 buildings from its floodplains.

◀ Lands cleared after Mingo Creek floods (left) now serve as picnic grounds (below) ▼



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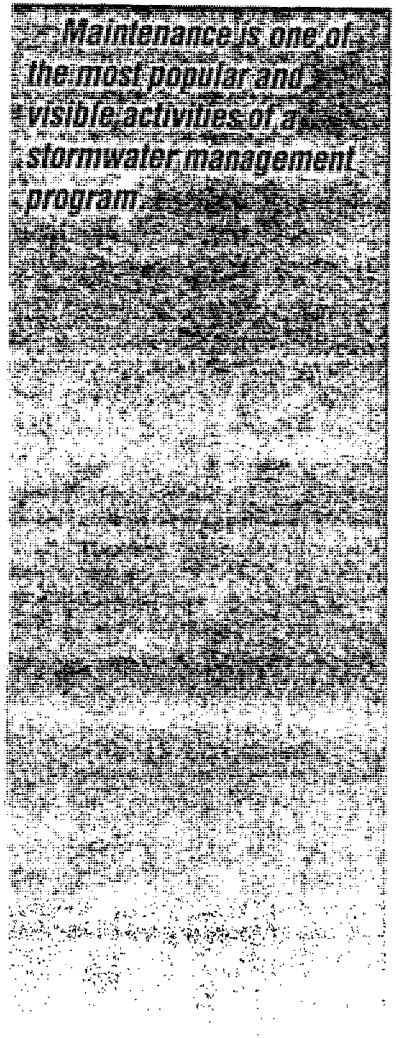


STORMWATER QUALITY

Stormwater quality is of growing concern in municipal drainage management. Tulsa has geared up to meet new federal requirements for stormwater discharge NPDES permits (National Pollutant Discharge Elimination System permits). Tulsa's most serious problem with runoff quality was found to be sediment, which is being addressed through vigorous regulation of erosion from construction projects.

The city is also emphasizing street sweeping, environmental monitoring, and stormwater laboratory services as part of its stormwater quality program.

MAINTENANCE AND OPERATIONS

City leaders clearly saw the need for better maintenance when the 1984 flood swamped debris-choked creeks and channels, clogged and collapsed sewers, and neglected pump stations. The resulting public and private costs were enormous.

The flood triggered a search for stable, continual maintenance funding. The answer came in 1986, when city fathers approved a drainage utility fee. Now maintenance is an essential element of Tulsa's program.

The contrast is telling:

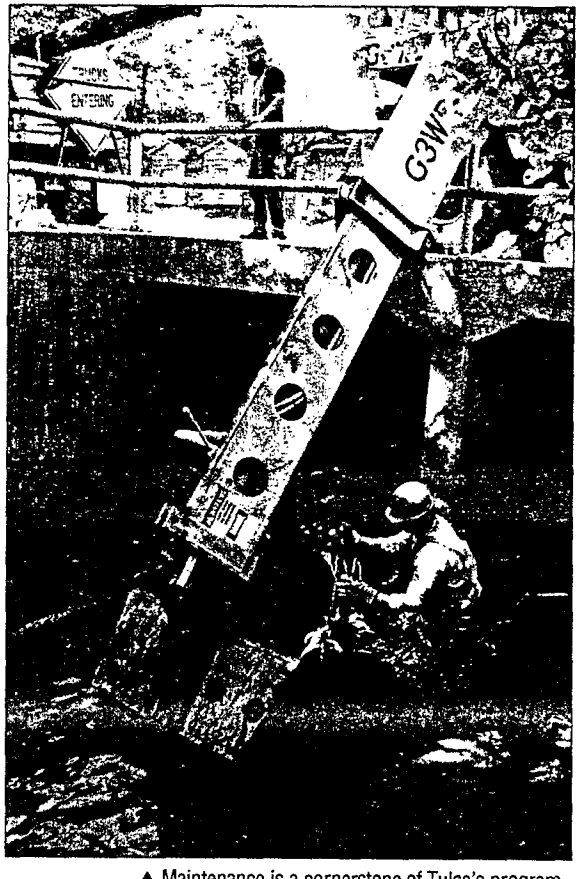
- In 1980, the city spent about $400,000 on stormwater maintenance.
- By comparison, in 1993, the city was able to spend about $6 million on stormwater maintenance.

The difference was the stormwater utility fee.

The maintenance program's first goal is to keep systems operating at full capacity.

The system includes hundreds of miles of surface channels and floodplains, thousands of miles of underground sewers, public detention basins, pump stations, roadside ditches, bridges, and the curbs and inlets along the street system.

The list of duties continues to expand, extending through turf control and tree planting, debris removal, emergency response during storms, and management of maintenance trails along drainageways.



▲ Maintenance is a cornerstone of Tulsa's program, based on stable and on-going funding by the stormwater utility fee.

EMERGENCY MANAGEMENT

Capricious climate makes Tulsa vulnerable to weather emergencies, particularly tornadoes, violent thunderstorms, and floods.

Overall responsibility during emergencies lies with the city-county Tulsa Area Emergency Management Agency; but in flood management, TAEMA shares its lead with Tulsa's Public Works Department.

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Tulsa's emergency management goal is to reduce hazard and damage before, during and after storms.

Forecasting and warning

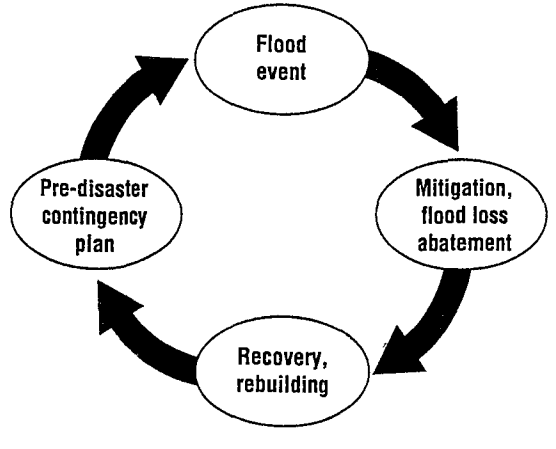
Flash floods require the earliest possible warnings. Tulsa's system works in cooperation with the National Weather Service, news media, TAEMA, and the City of Tulsa. A computerized ALERT system includes 39 rain, 19 stream, and seven detention gauges that report changes as they happen. The system is based on detailed basin inventories and includes a hydrologic program that develops stream and flood forecasts, to be released for appropriate action before flooding occurs.

Response

Emergency response is triggered by the possibility of severe weather anywhere in the community. Response teams are guided by detailed plans and protocols – and their extensive field experience during emergencies. The plans also identify critical facilities with hazardous materials, vulnerable occupants, and essential community functions.

Recovery and mitigation

Traditionally, recovery meant rebuilding as fast as possible. But recurring disasters have taught Tulsans that rebuilding in kind can mean reinvesting in disaster. Tulsa today emphasizes mitigation projects, which seek to make the response to each disaster reduce future losses. For example, hundreds of flooded homes have been relocated to dry sites. In addition, the city is updating its flood-hazard mitigation plans, to include actions to be taken before, during, and after a flood.





▲ A prototype ALERT System helps manage emergencies.

PUBLIC AWARENESS

The city pushes public information and involvement to keep citizens aware that floods frequent Tulsa, requiring prudent preparation.

Diverse information pieces include flood maps,

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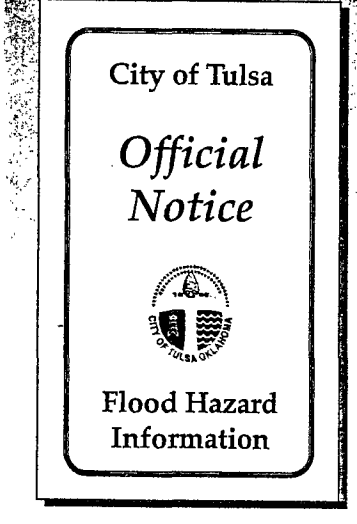
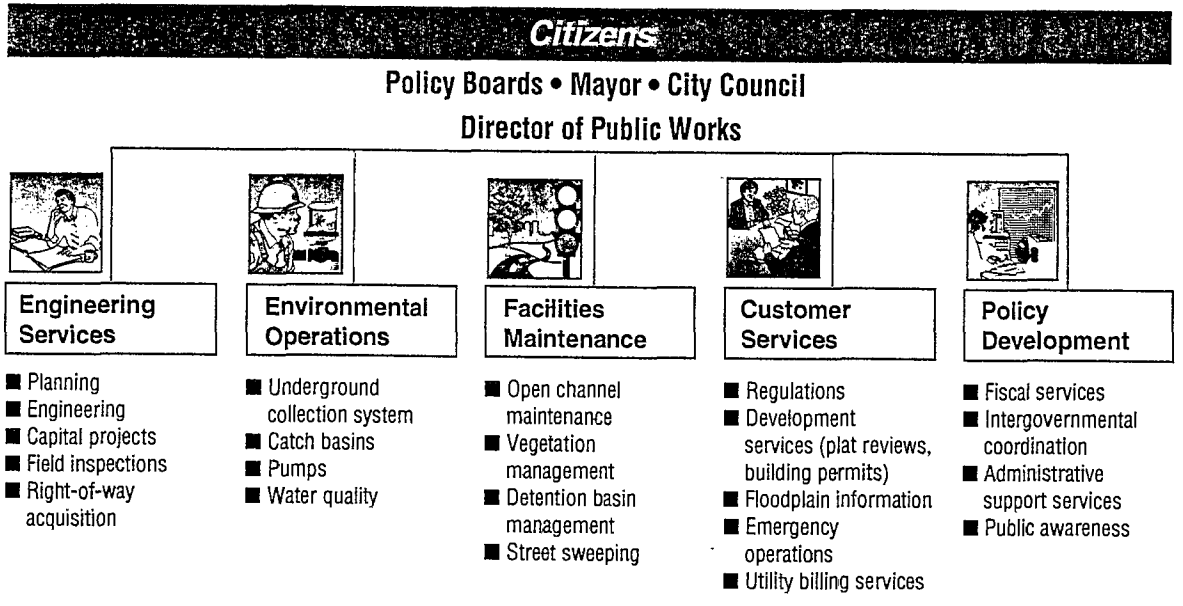
Public awareness and backing can become, over time, the best insurance against a repetition of a kind of history that wreaks physical damage and, worse, leaves emotional scars.



Stormwater Management Structure



brochures, news releases, fact sheets, reports, slide shows, videos, direct mailings, displays, speeches and presentations, roadway signs, and individual contacts – anything and everything possible to get out the word.

For example, the city mails periodic notices to floodplain occupants, warning them of hazards, offering them flood preparedness tips, and urging them to buy flood insurance.

Tulsa's stormwater ordinances include requirements that full information about flood hazards must be provided by property sellers to prospective buyers, and by landlords to tenants.

PUTTING IT ALL TOGETHER: ORGANIZATION AND FINANCE

After the 1984 flood, Tulsa leaders determined that the city's drainage program was scantily funded, poorly coordinated, and largely neglected. They termed stormwater the "forgotten utility."

Creating a comprehensive program was a daunting challenge, beginning with the staff estimate that some $500 million was needed for high-priority flood control. As for the full range of maintenance and other needs, no one could hazard a guess.

By 1985, Tulsa had pulled all related functions together into a new Department of Stormwater Management. By 1986, the city had levied a new stormwater utility fee to finance it.

In three successful votes in 1985, 1987, and 1990, voters handily approved more than $135 million in capital sales tax and bond funds – including local match for the $143 million Corps of Engineers project to tame Mingo Creek.

With a change in the form of city government in 1990, the stormwater program was merged into a new Public Works Department.

Today, the program continues to progress, institutionalized in Public Works, under the executive wing of Mayor M. Susan Savage. Citizen advice is

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provided by the Stormwater Drainage Advisory Board, which was created after the 1984 flood. Tulsa's City Council is responsible for legislation, policy, and budgets.

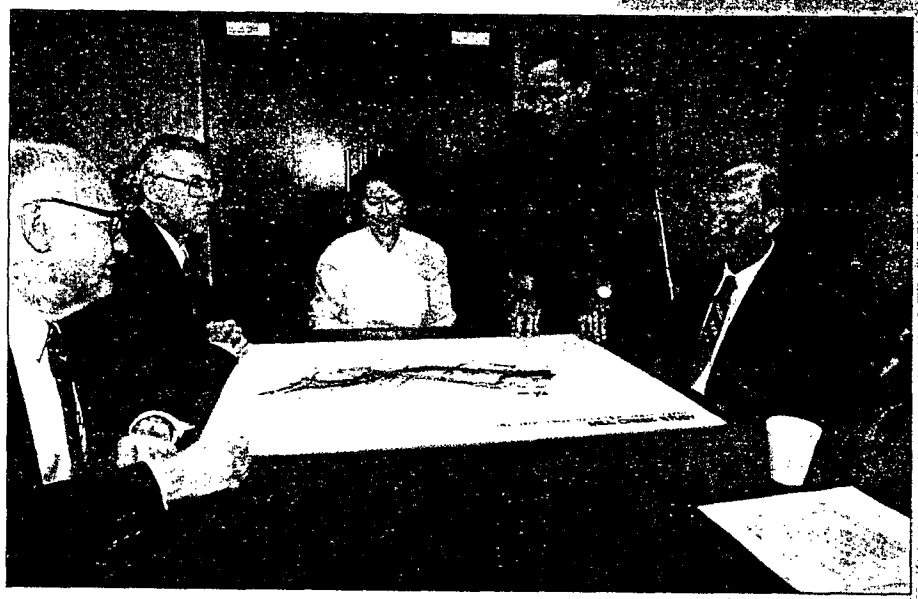
The fiscal foundation of Tulsa's program is the stormwater utility fee.

The fee was calculated by determining essential program requirements, then allocating the needed charges equitably to all homes and businesses. Residents of single-family homes pay $2.58 per month. Business owners pay the same amount for every 2,650 square feet of impervious surface on their properties.

The charge is based on the theory that stormwater runs off every property in the city; dwellers on both hillside and lowland contribute runoff. Since everybody helps create the need for a floodplain and stormwater program, everybody helps pay for it.

The utility fee yields about $9 million annually. The largest share goes to maintenance. The balance goes toward management, planning, public education, small capital projects, and other uses.

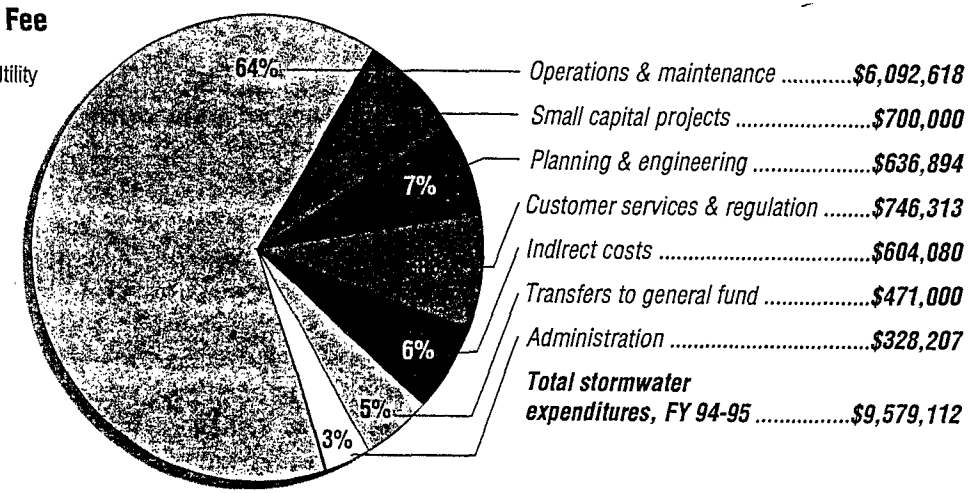
The utility fee is not used directly for major capital projects. Major projects are financed, instead, by general obligation bonds, sales tax revenues, and – when available – federal funds. Similar sources are used for master drainage planning. Other funds include fees in lieu of detention and permit fees.



▲ The Stormwater Drainage Advisory Board provides policy guidance.

Stormwater Utility Fee

Most of the Stormwater Utility Fee is budgeted for maintenance and operations. In addition, Tulsa spends about $10 million per year in local capital funds for flood projects.



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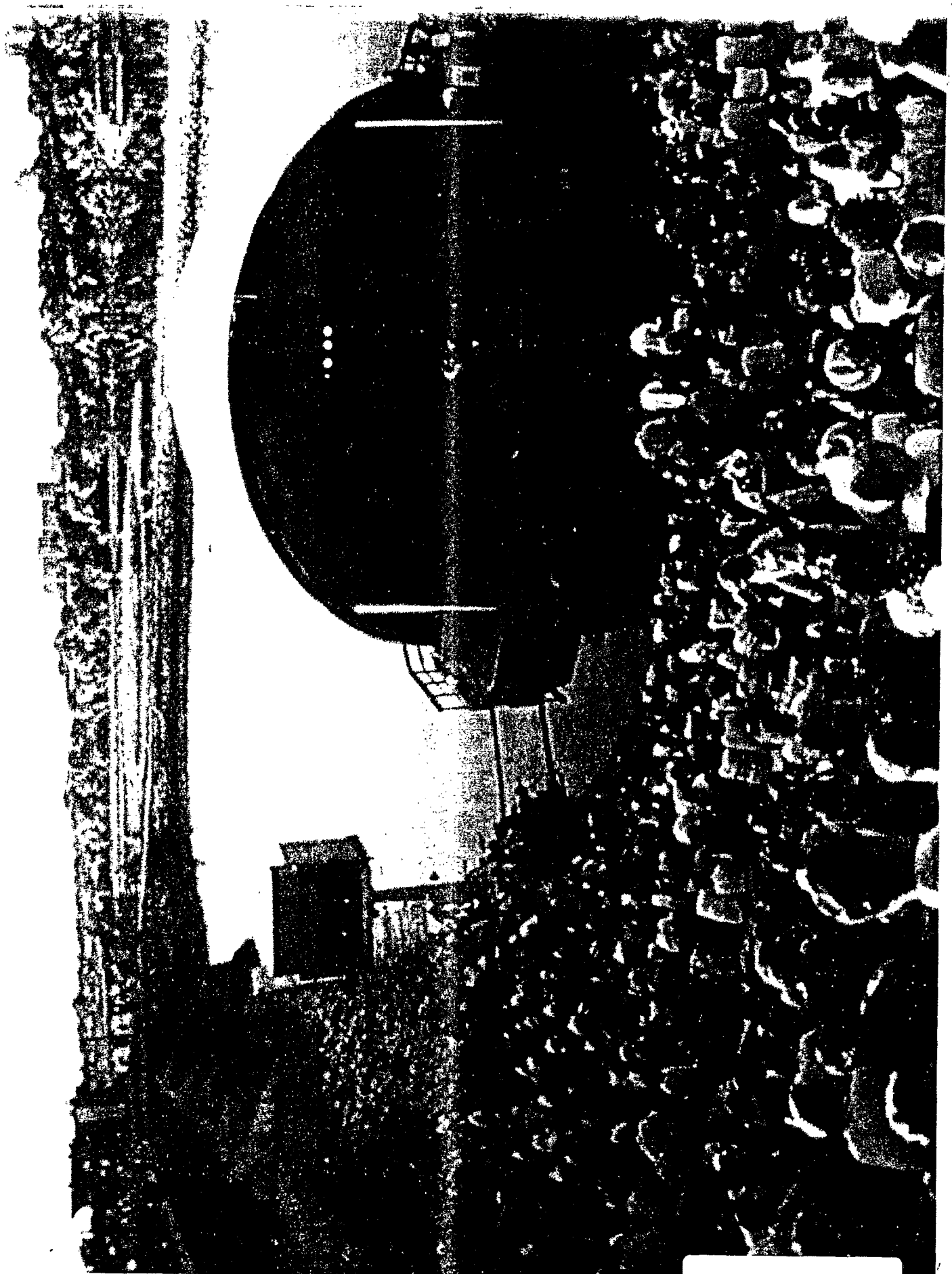

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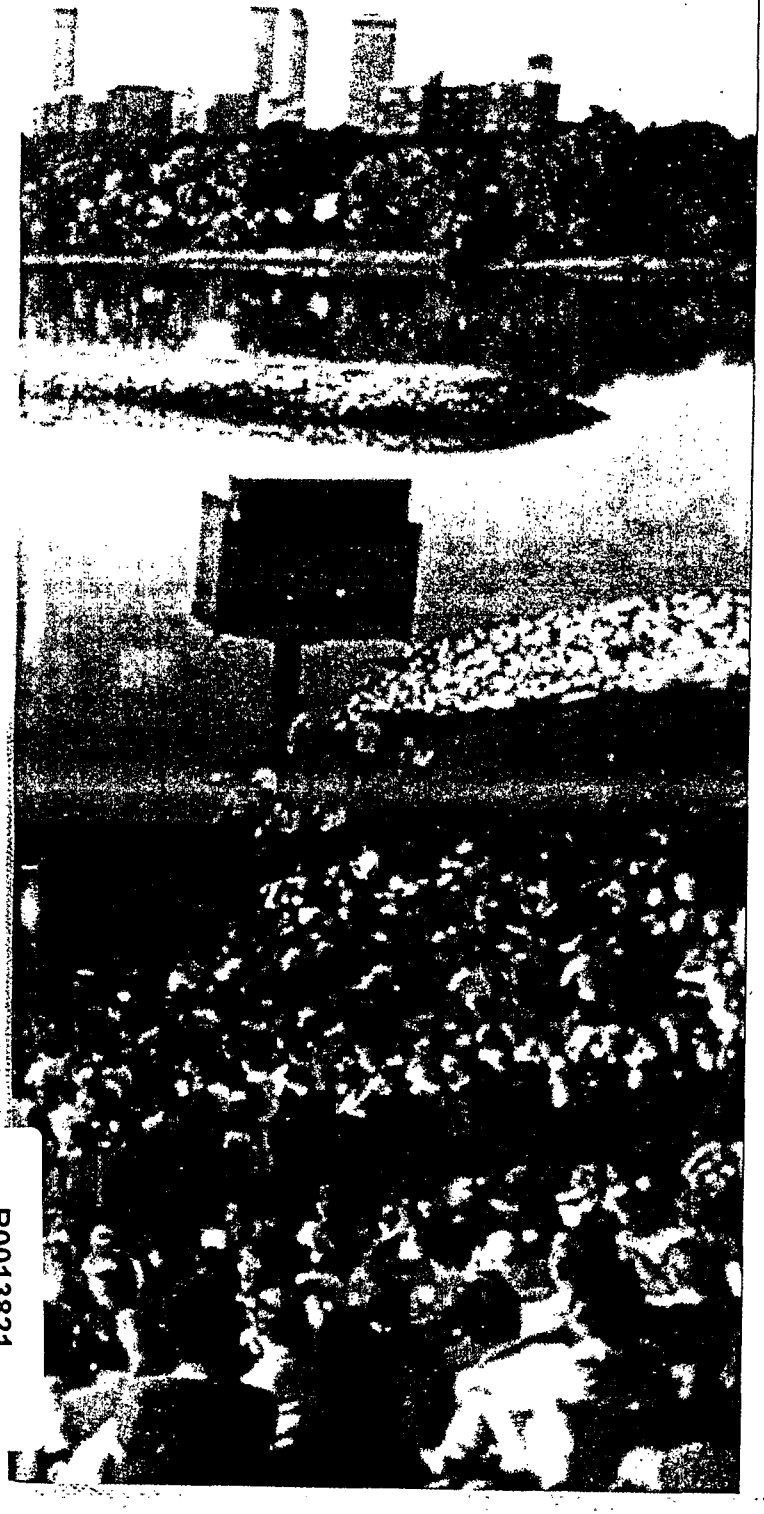

◀ Once a shunned dump, Tulsa's Arkansas River floodplain is now the city's prized River Parks.

The View Ahead

Beyond the Ark

When a town like Tulsa is battered by unrelenting disasters, the number one priority has to be public safety and loss reduction.

But in time, after enough progress and a spell of gentle weather, town leaders may be able to look beyond just "building an ark" for protection.

They are beginning to see that stormwater and floodplains can be among their most important community resources. They can become assets, not enemies.

Tulsans are slowly rediscovering the graceful floodplain treatments that marked the city's fine early development.

Now, whenever possible, flood projects include active and passive recreation and environmental elements. In some cases, projects are incorporated into existing parks. Elsewhere, acquisition areas, detention basins, and floodplains include recreation.

Some projects have become small nature oases in the urban area, used by migrating birds such as Canada geese and other wildlife.

The city is converting some drainageways into greenways.

On a backbone of maintenance roads along creeks, the Tulsa Trails program is building paths for jogging, hiking, and bicycling.

Tulsa's future may well go beyond the ark, to become more than merely floodsafe.

Where once loomed death and destruction, Tulsa's future floodplains can hold strip parks, landscaped creek banks, sporting fields, and reflecting pools, all in the name of floodplain and stormwater management, for the benefit of Tulsans for generations to come.

It's a long stretch to consider flood waters that can take human life as community assets and an even longer reach to suggest that a potential killing ground can become a place of recreation and renewal.

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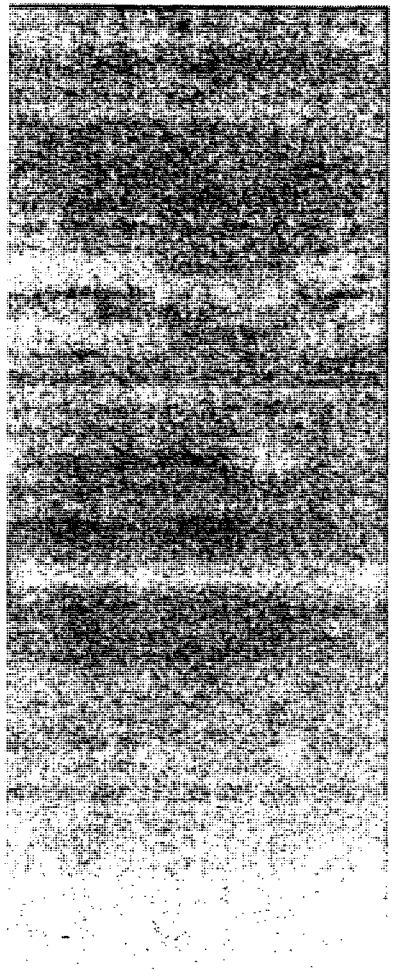

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Tulsa Park and Recreation Department photo

▶ Tulsa's Woodward Park: Water is an invaluable community resource.

After all, man can lend but paltry assistance to nature in the beautification of her open spaces.

—1924 Tulsa Plan

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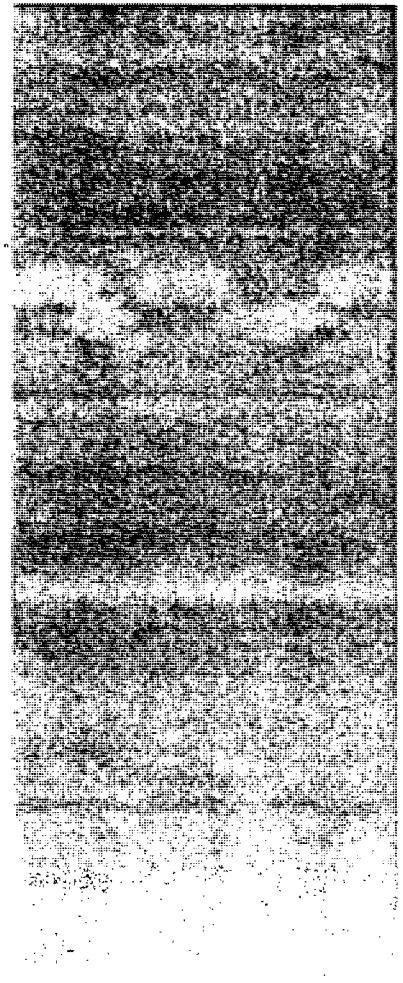

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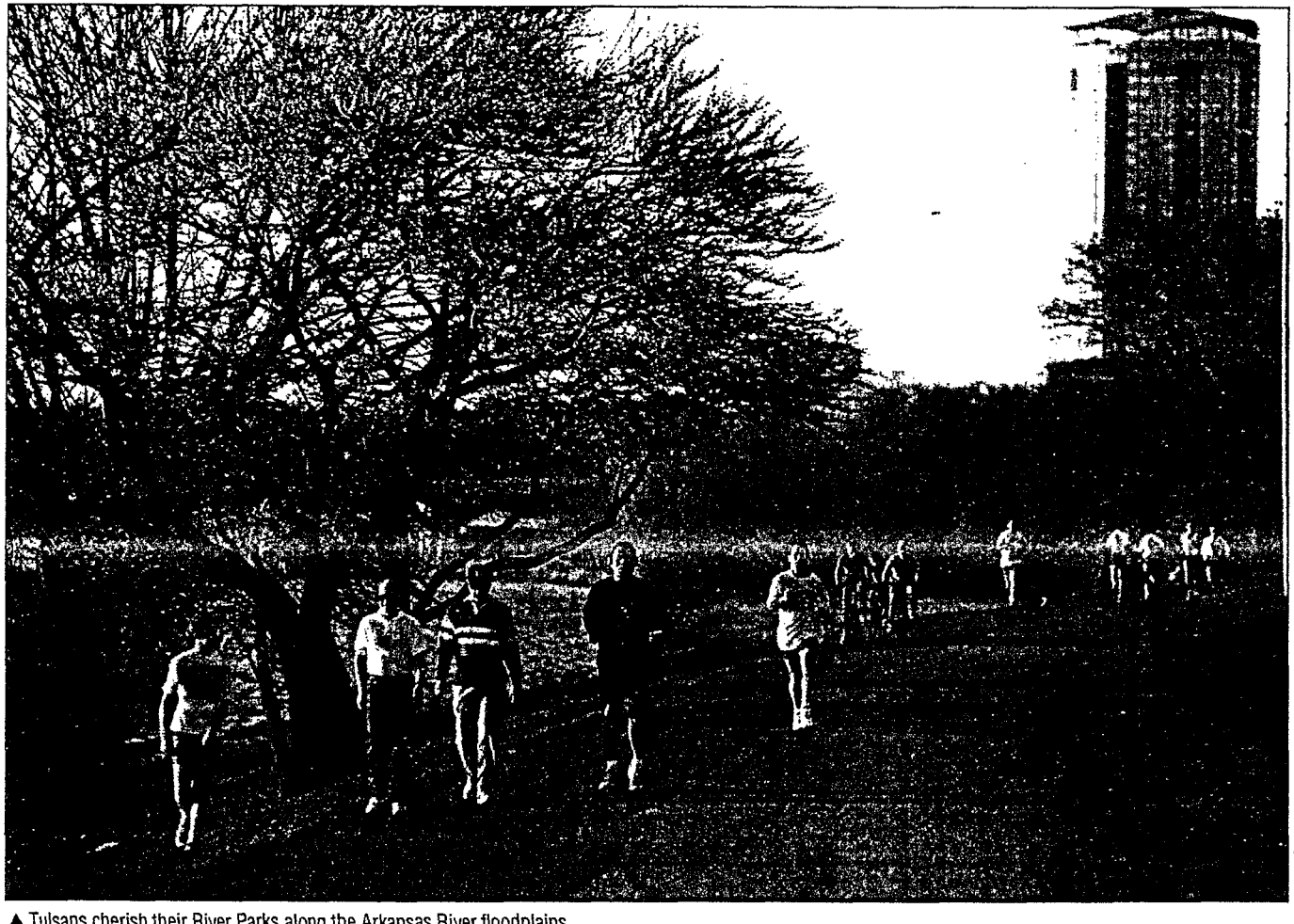

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▲ Tulsans cherish their River Parks along the Arkansas River floodplains.

"Your city, its growth, enterprise, cleanliness, beauty, and prosperity is your responsibility. Are you working at it? A City, like a tree, grows as it is trained, straight or crooked. If selfishness dominates it, it will not thrive, and no one will love it. If generous men and women with vision are its cultivators, it will grow and flourish, and the stranger at its gates will enter and ask for a chance to work for it."

– 1924 Tulsa Plan

CITY OF TULSA OKLAHOMA

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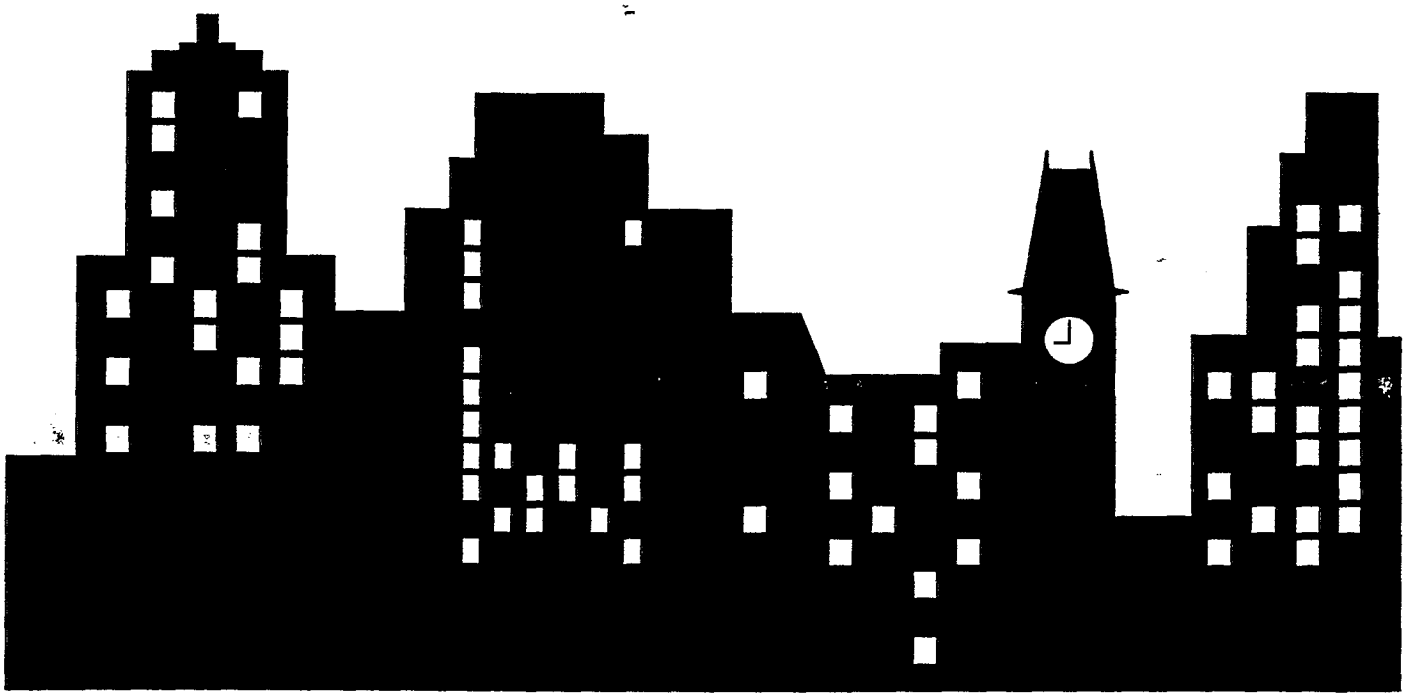
Developing Successful Runoff Control
Programs for Urbanized Areas
Final Report
General Reference 3rd shelf
July 1, 1994

Developing Successful Runoff Control Programs For Urbanized Areas



Prepared by:
Northern Virginia Soil and Water Conservation District
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Developing Successful Runoff Control Programs for Urbanized Areas

Prepared by:

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Final Report

July 1, 1994

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Executive Summary

This manual defines the institutional and programmatic issues which are crucial to the success of runoff control programs in already urbanized or urbanizing areas. These nontechnical factors are often decisive in determining the effectiveness and success of such programs.

The manual describes strategies which local communities can use to develop the institutional frameworks needed to implement runoff control programs. The strategies are described in the program development section of the manual and in the case studies presented.

Each community will have different urban runoff management needs, environmental concerns and available resources. Yet, building an effective program requires certain common key steps. This manual lays out the essential elements, which will also be useful in preparing the management plans required by various Federal regulations and programs. In addition, retrofitting for runoff control may be necessary in some urban areas to achieve the water quality improvements necessary under current Federal and state mandates.

The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA), §6217, required the development of the Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (USEPA, 1993). States with coastal zone management programs are required to develop coastal nonpoint pollution control programs consistent with these Management Measures. The "Existing Development Management Measure" of Chapter Four (Urban Areas) requires development and implementation of programs to reduce pollution from existing development.

The National Pollutant Discharge Elimination System (NPDES) Storm Water Permit Program, established by §402(p) of the Clean Water Act, requires permits for certain municipal and industrial storm water discharges. In addition, this program requires the development of storm water management plans for the areas covered by the permit, which usually includes urbanized areas.

Both of these programs could involve the use of retrofits to achieve water quality improvements. While program requirements may differ based on the specific regulatory authority, the goals of these programs are complementary and many of the same management practices are applicable and satisfy the requirements of both programs. The case studies presented in this manual provide examples of the innovative ways in which many local governments are meeting the requirements of multiple programs to improve water quality. However, communities need to refer to

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applicable state and Federal regulations to assure that they are in compliance with all regulatory requirements.

The manual describes ways that local governments can approach the issues surrounding the implementation of urban runoff retrofit technology even when the control options are limited. It reviews appropriate "ultra-urban" technologies for situations where more conventional, land-intensive control practices are not feasible. Specific recommendations are summarized to help program implementation personnel develop strong institutional frameworks and create effective urban runoff control programs. The recommendations presented are largely based on the program implementation experiences of the case study communities featured in the manual. They include:

Problem Identification

- Identify problems clearly at the outset
- Define runoff control program objectives, requirements, and penalties

Priority & Goal Setting

- Consider innovative and cost effective retrofit methods
- Prioritize retrofit alternatives and set realistic goals to implement

Adequate Funding

- Identify stable and/or dedicated funding sources for urban runoff management programs
- Utilize cost-share approaches among agencies
- Utilize economic incentives to reduce amounts of stormwater discharges, e.g., utility fee reductions for reduced amounts of impervious surface
- Identify opportunities for public/private partnerships to conduct nonpoint source pollution control activities
- Obtain participation and support from private interests who will benefit from urban runoff control programs

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Multilateral Approaches

- Use teams or multi-agency work groups wherever possible
- Create effective institutional structures
- Identify related Federal, state and local programs and assess their storm water control effectiveness and degree of interaction
- Designate a lead agency to coordinate program development and implementation
- Designate sufficient agency staff to support implementation projects

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DEFINING THE PROBLEM OF URBAN RUNOFF MANAGEMENT

Introduction

This manual recommends strategies for communities to use to develop the institutional frameworks necessary for the successful implementation of urban runoff control projects, including retrofit projects in developed areas. It provides practical information for local government personnel who wish to develop such programs. While each community will have different runoff management needs and available resources, building an effective program requires certain common steps. This manual describes the step-by-step procedures necessary to develop effective programs to reduce nonpoint source pollution from urban runoff in developed areas.

Institutional factors have a significant impact on the effectiveness of urban runoff control programs. Because the development of institutional frameworks is vital to effective program implementation, this manual emphasizes program development, rather than specifying technical requirements for programs. (Technical manuals for the implementation of urban runoff controls are listed in the Bibliography.) It recommends strategies and outlines the step-by-step procedures which are necessary to develop urban nonpoint source pollution control programs.

Finally, in the accompanying case studies, this manual describes some approaches which local governments have successfully used to implement urban runoff control programs.

Purpose and Intended Audience of this Manual

This manual provides specific guidance to help local governments implement urban runoff programs. It does not track all regulatory requirements; these will differ by state and locality. Rather, it addresses certain elements of urban runoff control programs that are often problematic for municipalities considering program implemention. It is designed to help them through the program development and implementation process.

A local government wishing to develop an urban runoff control program for developed areas needs to base its approach on local conditions. This manual describes the basic issues in sufficient depth, with the use of examples, to enable a local government to design an effective program based on its particular needs.

The audience for this manual includes public agencies such as local environmental regulatory agencies; regional and local planning agencies; councils of governments; planning commissions, departments of public works, soil and water conservation

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districts, and other agencies concerned with land use, development, and urban runoff management.

However, the general public also needs to be included along with interested environmental groups and elected officials as part of the process of managing urban runoff problems and issues; this manual seeks to impart a basic level of knowledge about these issues to the nonprofessional or nontechnical person.

The purpose of the case studies is to present alternatives for local governments to consider in formulating solutions to urban runoff problems. They have been chosen to provide examples of innovative and successful alternatives in the field.

Brief History of Runoff Control

Urban runoff has not always been recognized as a major contributor of pollutants. Historically, urban nonpoint source pollution has been overlooked by surface water regulation agencies at the local, state and federal levels. Efforts to control surface water quality degradation concentrated on point sources. Urban nonpoint source pollution control focused on street sweeping, used motor oil recycling, and public education.[1] In addition, local governments have historically been concerned mostly with urban runoff quantity control. Water quality concerns have now become equally important for municipalities because of federal and state mandates.

During the first fifteen years of the national program to abate and control water pollution, EPA and the states have focused most of their water pollution control activities on so-called "point sources," such as discharges through pipes from sewage treatment plants and industrial facilities. These point sources have been regulated by EPA and the states through the National Pollutant Discharge Elimination System (NPDES) permit program established by Section 402 of the Clean Water Act.

Congress also amended the Clean Water Act in 1987 to require EPA to establish phased NPDES requirements for storm water discharges. Storm water discharge permits will provide a mechanism for monitoring the discharge of pollutants to waters of the United States and for establishing appropriate controls.[2]

The attempts to control point source pollution have reduced pollutant loads and

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[1]Murray, James, "Nonpoint Pollution: First Step in Control," in Design of Urban Runoff Quality Controls, Roesner et al, eds. American Society of Civil Engineers (New York, 1989), p. 378.

[2]USEPA, "Overview of the Storm Water Program," Office of Wastewater Enforcement and Compliance, Permits Division. Washington, DC: March, 1993.

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considerable progress has been made in restoring and maintaining water quality. However, the abatement of point source pollution did not solve all water quality problems. Recent studies and surveys by EPA and by state water quality agencies indicate that the majority of the remaining water quality impairments in our nation's rivers, streams, lakes, estuaries, coastal waters, and wetlands result from nonpoint source pollution and other nontraditional sources, such as urban storm water discharges and combined sewer overflows.

Congress amended the Clean Water Act in 1987 to focus greater national efforts on controlling nonpoint sources. Section 319 of the Act was enacted to establish a national program to control nonpoint sources of water pollution. In addition, Congress enacted Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) in 1990 to address the impact of nonpoint source pollution on coastal waters.

In recent years EPA introduced the Watershed Protection Approach (WPA) as a flexible framework for focusing and integrating current efforts and exploring innovative methods for achieving environmental objectives. The WPA focuses on four major elements: 1) identifying specific geographic locations; 2) integrating available authorities to deal with all pollution sources; 3) involving all stakeholders in analyzing and creating solutions; and 4) measuring effectiveness against clearly established objectives. These key elements are derived from experience gained over the past few years in many states and other EPA efforts such as the Clean Lakes and National Estuaries Programs.

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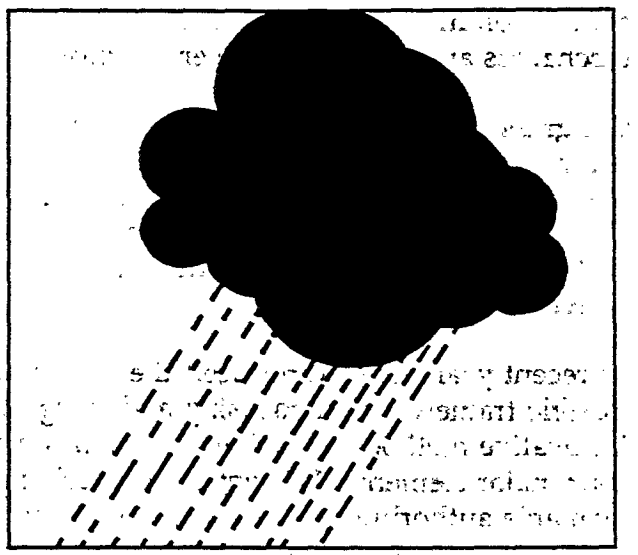
How Urban Runoff Adversely Affects Water Resources



Urbanized areas and areas in which development has altered the natural hydrology and infiltration characteristics of the land typically experience increased surface runoff. Land development alters the natural balance between runoff and natural absorption areas by replacing them with greater amounts of impervious surface. The result is increased rates and volumes of surface runoff.

The negative impacts of urbanization on water quality has been well-documented in a number of sources, including the Nationwide Urban Runoff Program (NURP) and the States' reports written in response to the requirements of §305(b) and §319 of the Clean Water Act. For example, the States report that urban runoff and storm sewers are the second leading source of water quality impairment of lakes and estuaries, and the third leading source of water quality impairment of rivers in the United States.[3]

As a consequence of the increased quantity and rate of runoff, greater amounts of pollutants are carried into receiving waters, and water quality degradation increases. Other negative impacts include the increased susceptibility of eroded land to flooding, other hydrologic changes, and wildlife and in-stream habitat degradation. [See Box 1]

The Need for Urban Runoff Management

Many American cities contain areas in which buildings, parking facilities and urban streets and walkways cover almost one hundred percent of the land surface. This creates runoff conditions but offers no room for structural urban runoff quality management facilities such as extended dry detention or wet ponds. Even when redevelopment occurs within these areas, high land values usually require replacement by similarly intense land uses in order to provide economic viability for the project. Conventional best management practices (BMPs) are difficult, if not

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[3]USEPA, The Quality of Our Nation's Water: 1992, Office of Water, EPA Document 841-S-94-002, March 1994, p. 10.

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impossible, to implement in this context.

In such situations, innovative BMP applications requiring little or no above ground coverage are necessary in order to meet increasingly stringent Federal and state urban runoff pollution control requirements. In highly urbanized areas, the use of innovative urban quality control retrofitting is the primary option to improve the water quality of surface waters which receive runoff discharges from older urbanized areas.

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Why worry about urban runoff?

What is the problem with urban runoff anyway?

Storm water runoff picks up pollutants and debris as it traverses developed areas, particularly parking lots and streets. During storm events, pollutants are picked up and flushed directly into local lakes, creeks, and streams, without being filtered by the soil or natural vegetative cover. This endangers water quality. Better pollution control is needed to reduce the amount of contamination affecting these water bodies.

Isn't new development the cause of all these problems?

New development, in many localities, has to meet strict regulations on the quality and quantity of storm water runoff. However, many of our current water quality problems are caused by runoff from older, developed areas. We can't solve the problem without retrofitting older stormwater control devices or installing them where none currently exist.

How can we solve this problem?

As the public becomes aware that there are problems with urban runoff quality, and begins to take action, the water quality of area streams and rivers should improve. As people learn that the storm drain at the end of the street flows straight to a nearby stream, they will be more interested in what drains to, or is dumped in, the street catch basin. They will also press their elected officials to incorporate stronger stormwater treatment standards into both new development and redevelopment projects in their community.

How urban runoff affects water resources.

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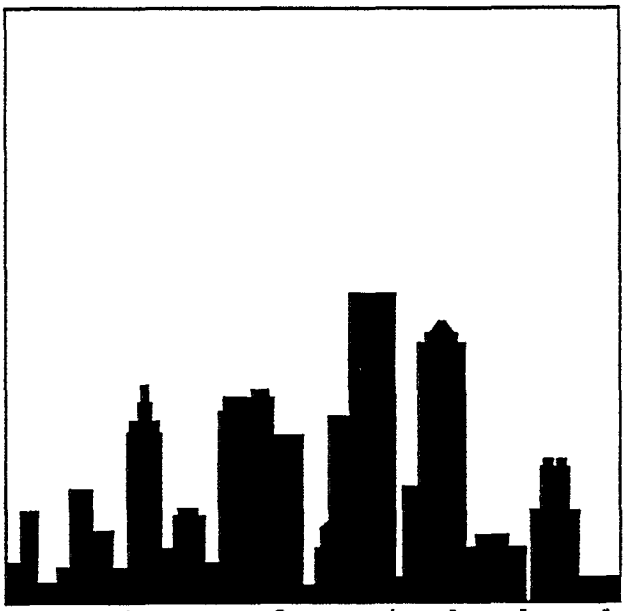
Retrofitting Developed Areas

As urbanization occurs, and areas of impervious surface increase, maintenance of water quality becomes increasingly difficult. Retrofit of structural controls is often the only feasible alternative for improving water quality in developed areas.

Ideally, as land is developed best management practices would be implemented to control present and future urban runoff problems. However, controlling pollutants in runoff from new development alone will not solve existing water quality problems. Therefore, retrofitting is necessary. It is also the primary option for developed areas to improve urban runoff water quality.



Impervious surfaces in developed areas may cover 100% of the land surface.

Retrofitting is a process that involves the modification of existing surface water runoff control structures or surface water runoff conveyance systems which were designed to control flooding, so they will also serve a water quality improvement function.

Retrofitting should also be considered as an opportunity to improve existing water quality best management practices. Existing practices may be inadequate or performing poorly, or they may simply lack the pollutant removal capability of newer BMP designs. The least expensive and most practicable retrofit opportunities often involve the improvement of existing urban BMPs. BMP retrofits are a widely used technique. The opportunity to improve existing urban BMPs at modest cost, or to convert older dry storm water detention ponds, for example, into more efficient wet extended detention ponds is afforded by a retrofit approach.

Factors such as the presence of existing development, or a community's financial constraints, may limit runoff management options; targeting may be necessary to identify priority pollutants and select the most appropriate retrofit methods. This is particularly true in highly urbanized areas where land is limited and the use of conventional pond systems is restricted.

In highly urbanized areas, sand filters or water quality inlets with oil grit separators

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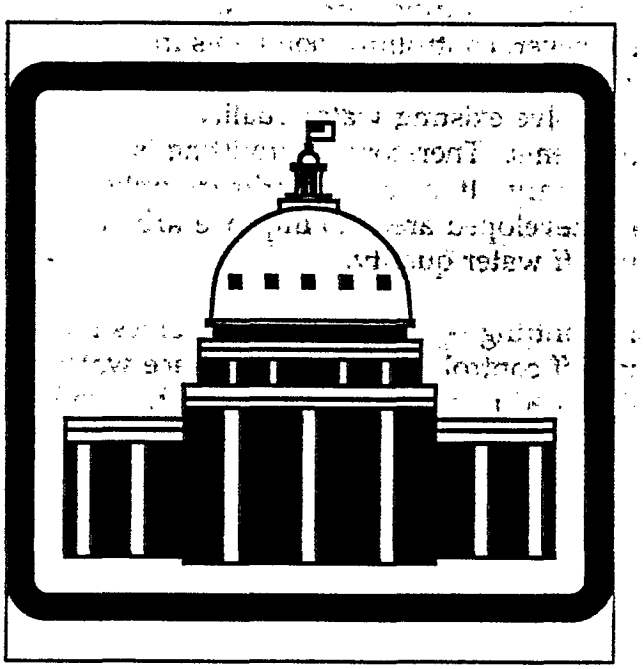
may be appropriate for retrofits because they do not limit land usage. Sand filters, however, may be a better alternative for treating hydrocarbon runoff from small sites than oil grit separators because sand is a superior filtering medium. Recent research questions the effectiveness of oil grit separators at removing hydrocarbon pollutants.[4]

Urban runoff retrofitting for nonpoint source pollution control includes a broad range of different techniques which attempt to reduce the adverse impacts of urban runoff on receiving waters. The types of retrofit techniques will differ depending upon where they are placed in the storm drainage network.

Local Governments' Compliance with Federal and State Regulations

The current storm water management requirements and drainage needs in major population centers are significant. EPA storm water permit regulations require large (>250,000) and medium (>100,000) size municipalities to have storm water discharge permits for discharges from their storm sewer systems under the National Pollutant Discharge Elimination System (NPDES) storm water permit program. Large- and medium-size municipalities nationwide are now applying for these permits which will require implementation of comprehensive storm water management programs to control storm water runoff.



In addition, Section 6217(g) of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 requires States to develop coastal nonpoint source pollution control programs, including a management program to control runoff from existing development. The new coastal zone requirements are only applicable, however, in areas which are not subject to the NPDES storm water permitting regulations.

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[4] Schueler, Thomas R., "Hydrocarbon Hotspots in the Urban Landscape: Can They Be Controlled?" in Watershed Protection Techniques. Volume 1(1), February 1994, p. 3-5.

R0013841

The increasing stringency of federal, state and local regulations are all examples of the emphasis being placed on minimizing both point and nonpoint source pollution from urban runoff.

Summary of Selected Federal Water Quality Programs

Coastal Zone Management Act of 1972 (CZMA)

- established a program to encourage states to develop comprehensive programs to protect and manage coastal resources

Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) §6217

- mandated state coastal programs to address nonpoint source pollution affecting coastal water quality and required the development of the Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters which states are to incorporate into their coastal nonpoint source programs

National Pollutant Discharge Elimination System (NPDES) Storm Water Permit Program

- established by §402(p) of the Clean Water Act; requires permits for certain municipal and industrial storm water discharges

Clean Water Act §319: Nonpoint Source Control Program

- initiated a national program which resulted in state nonpoint source management programs to control nonpoint sources of water pollution and protect groundwater

Clean Water Act §320: National Estuary Program

- focused point and nonpoint pollution control on geographically-targeted, high priority estuarine waters; controls are selected and implemented on a watershed basis

EPA's Watershed Protection Approach

- voluntary effort to align traditional regulatory and nonregulatory programs to support watershed protection in an integrated, holistic manner

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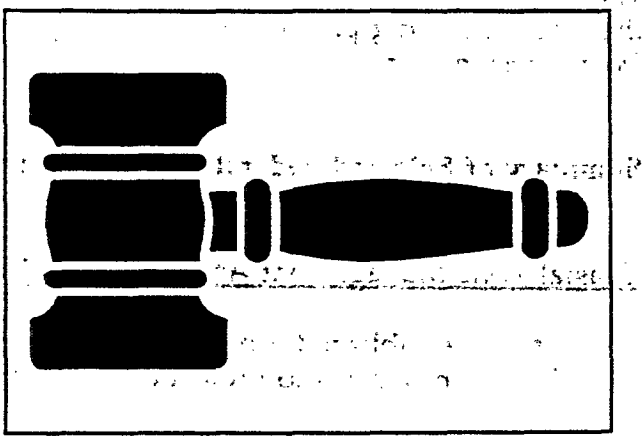

While program requirements may differ based on the specific regulatory authority, the goals of these programs are complementary and many of the same management practices are applicable and satisfy the requirements of multiple programs. The case studies presented in this manual provide examples of the innovative ways in which many local governments are meeting the requirements of multiple programs. This manual will help communities develop and implement programs to improve water quality. However, communities need to refer to applicable state and Federal regulations to assure that they are in compliance with all regulatory requirements.

For example, some communities are not subject to NPDES permit requirements but may be subject to requirements under the Coastal Zone Act Reauthorization Amendments of 1990 ("CZARA"), and vice versa. In addition, some states have additional regulatory programs that may govern the management of storm water or runoff in the absence of Federal requirements. Other communities may not be subject to any regulatory requirements at this time, but the public is increasingly aware of runoff problems and their causes and some control of runoff is becoming inevitable.

R0013843

Types of Urban Runoff Retrofit Techniques[5]

Retrofit techniques can be differentiated depending upon where they are placed in the storm drainage network. Some of these are described below:

- Source retrofit: Use of techniques that attenuate runoff and/or pollutant generation before it enters a storm drain system, e.g., reducing impervious areas, using pollution prevention practices
- Open channel retrofit: These are installed within an open channel below a storm drain outfall, e.g., an extended detention shallow marsh pond system.
- Natural channel retrofit: Depending on the size of the channel and the area of the floodplain, a natural channel may provide several retrofit options
- Off-line retrofit: Involves the use of a flow-splitter to divert the first flush of runoff to a lower open area for treatment; used where land is available for off-line treatment
- Existing BMP retrofit: The retrofit of an existing BMP to improve its pollutant removal efficiency or capacity (ability to detain flow) or both.
- In-line retrofit: Used where there are space constraints that prevent the use of diversions to treatment areas.

Urban runoff retrofits involve a broad range of different techniques intended to reduce the adverse impacts of urban runoff on receiving waters. [See Box 2] The overall goal should be to achieve some reasonable degree of hydrologic control and pollutant removal (in relation to cost-effectiveness) as a result of the retrofit. Otherwise, the retrofit is not worth doing.

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[5] as identified in MWCOG, Watershed Restoration Source Book, p. 59.

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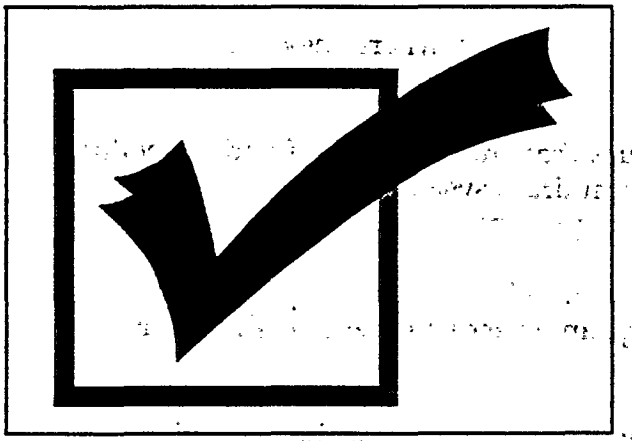
Technical factors affect the site-specific suitability of particular retrofit technologies. A checklist of these factors includes:



- land use
- climate
- size of drainage area
- soil permeability
- slopes
- depth to water table
- space requirements
- type and condition of the water resource to be protected
- depth to bedrock
- pollutants to be addressed
- maintenance access

Nonstructural Methods to Control Urban Runoff

Land use controls can be a cost effective means to control urban runoff. They have a maintenance cost/multiple use advantage over structural BMPs in many cases, and should be employed in redevelopment situations where appropriate. Furthermore, land use controls may be necessary along with structural measures in order for a jurisdiction to meet its water quality goals.

Strategies for implementing land use controls may include limits on impervious surfaces, encouragement for the preservation of open space, and promotion of cluster development. The use of nonstructural and structural best management practices for controlling urban nonpoint source pollution can also be required as a condition of development approval.

Zoning

Zoning is a powerful tool which communities can use to control the type of development or redevelopment allowed within their boundaries. Following are some examples of zoning controls that can be used to protect water resources:

- cluster development: constructing dwellings close together to preserve open space
- down-zoning: changing an established zone to require a lower density
- conditional zoning: allowing certain activities only under specified conditions that protect water resources

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- overlay zoning: placing additional zoning requirements on an area that is already zoned for a specific activity or use; through the use of resource overlay zoning, high pollution activities can be controlled in sensitive areas

- open space preservation: protecting open space and buffer zones near water bodies, e.g., greenways or riparian corridors

Structural Runoff Controls for Highly Urbanized Areas[6]

1. Innovative Practices

In areas where impervious materials cover almost one hundred percent of the surface, conventional BMPs requiring large amounts of land and good soil conditions are usually not feasible. These types of BMPs include dry ponds, wet ponds, constructed wetlands and various sorts of infiltration devices.

On sites where standard BMPs are not feasible, one should consider the use of unconventional or innovative BMPs sometimes known as "ultra-urban" BMPs. These systems are designed to function by gravity flow between the components. They include: 1) sand filtration systems; 2) underground sand filters consisting of multiple chambers; 3) surface sand filters such as double-trench systems; and 4) peat/sand filtration systems.

Each is briefly described below:

Sand filtration systems: The City of Austin, Texas has developed a BMP which consists of a sedimentation and filtration basin and is appropriate for use on redevelopment sites where topography, space limitations and high value land do not allow the use of traditional BMPs. These filtration systems are primary water quality control structures. In order to ensure the long-term effectiveness of these systems, it is necessary to protect the filter media from excessive sediment loading. A sediment trapping structure is required to be located prior to the filtration basin. Austin sand filter sytems are particularly well-suited to regional storm water control.

Underground sand filters with multiple chambers: This is a system consisting of a structure containing three chambers, one each for pre-treatment, filtration and discharge. The first chamber is a pre-treatment facility performing the same function as a water quality inlet, removing floating debris and material such as oil and grease.

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[6] A more detailed description of these controls and their effectiveness is provided in the Alexandria Supplement to the Northern Virginia BMP Handbook. [see Bibliography]

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The second chamber is a filtration device, while the third is a clear well discharging directly to the storm sewer system. The District of Columbia uses underground sand filters as in-line facilities for both storm water quality and peak flow attenuation. One of the major advantages of the D.C. sand filter is that it does not take up any space on the surface, allowing full use of high-value urban land. This aspect makes it particularly attractive to land developers.

Surface sand filter systems: This system is usually referred to as the Delaware sand filter because it was developed for use in Delaware. Unlike the other filters described in this section, the surface sand filter system is intended to be an on-line facility, processing all runoff leaving the site up to the point where the overflow limit is reached. It consists of two parallel concrete trenches, one for sedimentation, the other for filtration. A major advantage of this filter design is that it requires a depth of only 30 inches from the ground surface to the bottom of the paved trench, making it useful in areas with high water tables. The simplicity of the design also facilitates maintenance.

Peat/sand filtration systems: Peat/sand filters are filtration systems which were first developed as alternative wastewater systems. Peat is an excellent natural filter of many types of effluents and pollutants and is just beginning to be used for urban runoff quality management. A peat/sand filter system should be considered for use on developments of several acres where the pollutant removal requirement is higher than could be expected to be achieved through the use of other ultra-urban BMPs. In addition, peat/sand filters require less site area than most conventional BMPs. However, it should be noted that, under certain conditions, peat filters can become net exporters of nutrients.

Use of Public Rights-of-Way

A retrofit technique which has been identified for use in a land-limited context is the use of public rights-of-way as an opportunity for runoff controls such as wet ponds, vegetated swales or meandering vegetated channels. This would include the use of land under bridges and overpasses, the median strips of roads and highways, and the exit ramp rights-of-way off major highways.

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2. Retrofit Capability of Selected BMPs[7]

Extended Detention Ponds: Frequently used in retrofit applications, particularly within dry storm water management ponds.

Wet Ponds: Occasionally used in retrofit situations, particularly within dry storm water basins

Constructed Storm Water Wetlands: An effective retrofit technique. Can be achieved by adding wetland features to dry storm water basins.

Infiltration Trenches: Limited by soil conditions.

Infiltration Basins: Not recommended for retrofit settings, especially in the coastal zone.

Porous Pavement: Limited by soils which have been modified in most urbanized watersheds and are not capable of providing adequate infiltration.

Sand/Peat Sand Filters: Designed as end-of-pipe retrofits in several applications. A double-trench version has been designed for parking lot retrofits.

Grassed Swales: Although not suitable for ultra-urban areas because of the difficulty of preventing erosion in highly impervious areas, retrofit option may involve installing check dams to increase contact time in existing swales.

Filter Strips: Although the percentage of impervious surface in highly urbanized areas limits the usefulness of this practice as a water quality control device in ultra-urban settings, this type of retrofit is appropriate if enough land is available.

Water Quality Inlets: Although water-quality inlets are often used in ultra-urban areas, their low pollutant removal capability limits their usefulness as a retrofit technology.

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[7] More detailed information on the retrofit capability of these practices can be found in A Current Assessment of Urban Best Management Practices. [see Bibliography]

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DEVELOPMENT & IMPLEMENTATION OF AN URBAN RUNOFF CONTROL PROGRAM

While the program elements discussed in this section are considered important to program development and success, they do not necessarily fulfill all regulatory requirements which may be applicable to a given municipality. Planners and program managers should check on all relevant program requirements when developing their programs.

Important Program Elements

An urban runoff control and retrofit implementation program involves both technical and programmatic components and should include the following elements:

- technical capability
- use of appropriate technology
- implementation authority/enabling legislation
- funding mechanism or resource commitment
- institutional support structures

The case studies which are part of this manual demonstrate that local motivation is critical to the successful implementation of urban runoff controls. Also, successful implementation will not occur without a strong local commitment of personnel and resources. Regulations, ordinances, enabling legislation, design criteria, construction specifications, inspections and enforcement, and operations and maintenance procedures should all be clear and explicit. Appropriate technology for implementing runoff control measures must exist and must be at an affordable cost to the agency. If the foregoing are not present, implementation or continued successful program performance may not occur.

R0013849

Important Elements for Program Success

- Technical Capability
- Design Criteria for Selection of Appropriate Technology
- Implementation Authority/Enabling Legislation
- Dedicated Funding Mechanism
- Staffing/Training/Institutional Support/Operations & Maintenance

The box above depicts some of the key elements for developing and conducting a successful urban runoff control program. All of them may significantly affect program outcome:

- technical capability and the choice of an appropriate technical solution
- implementation authority and a dedicated funding mechanism
- the often-neglected elements of program staffing, proper training, strong institutional support, and the proper operations and maintenance procedures

R0013850

Building a Strong Institutional Foundation

Urban runoff management program practitioners strongly support the view that the success or failure of urban runoff control programs depends upon effective institutional frameworks. The following elements are often cited as crucial to program success:

Programmatic:

- adequate problem assessment
- BMP targeting and selection methodology (e.g., on-site vs. regional facilities)
- appropriate design criteria
- adequate staffing and training
- responsibility for success of total program vested in a single agency at an appropriate level of authority

Funding/Implementation:

- dedicated program funding, such as a storm water utility fee
- ease of operation and maintenance procedures
- administrative mechanism to ensure O & M is performed

Each of these elements must receive adequate institutional support if a successful urban runoff control program is to be implemented. In order to develop the necessary institutional frameworks, the local government should focus sustained attention on the institutional aspects of program development. There should be a recognition that developing an institutional framework is essential to support a successful multi-agency, long-term urban nonpoint source runoff program.

R0013851

How can communities develop a successful program?

Each local government may have different tasks to complete to create a successful program. However, certain common threads run through all the case studies described in this manual and these can be instructive in helping local governments to put together effective urban runoff control programs.

A strong motivation to act is essential.

Frequently the strongest motivation to act is economic. In the Southeastern Massachusetts area case study, the closure of thousands of acres of shellfish beds due to contamination by storm water runoff resulted in millions of dollars of lost income to local residents and serious disruption to local economies.

For other communities, such as Austin, TX, protection of drinking water supplies is a high priority. Still others, such as Orlando, FL, are concerned about the water quality of the hundreds of lakes within its metropolitan region.

Teamwork is essential to accomplish your goals.

Pick the right people and the right organizations. The experience gained from the case studies proves that teamwork is necessary to achieve the desired results. The nature of the urban runoff problem means that any solution will cut across departmental, bureaucratic and organizational boundaries. The high cost of storm water control projects, especially retrofits, makes cost-sharing among organizations particularly advisable. So identify the key players early and make good working relationships a high priority. Don't neglect the important role of private organizations and interests.

The need for adequate staffing and training should be recognized.

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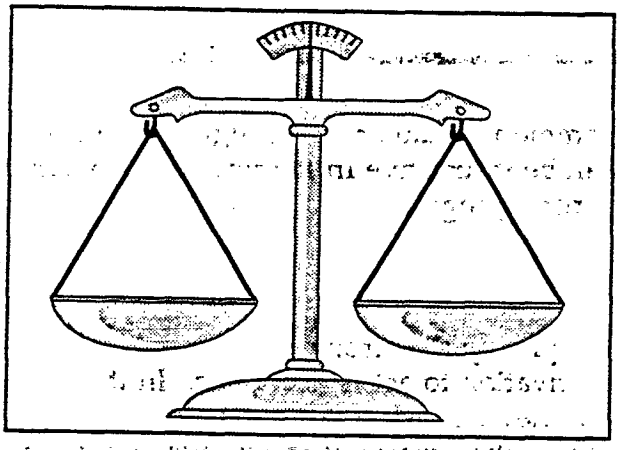
Assessing Institutional Resources



Two initial goals should be considered by a local government interested in developing an urban runoff control program:

1) developing or improving its institutional capacity to mitigate the urban runoff water quality problems which it faces

2) ensuring that its institutional capacity matches its technical ability to deal with the problem.

Implementation personnel should evaluate the following factors as part of an initial assessment of institutional structures:

- Identify the key agencies and personnel

Determine who the key players are in the relevant agencies. Typically, there are four major groups involved in the institutional water quality decision-making process:

1) legislative
2) regulatory
3) consulting professionals
4) "users" such as developers, clients, citizens (also includes environmental advocacy groups)

The program manager should be aware that the typical bureaucratic organization of institutions into branches, divisions, departments, etc., can hamper the ability of the organization to carry out its program goals and hinder program effectiveness. The most successful programs find ways to break the bureaucratic logjam.

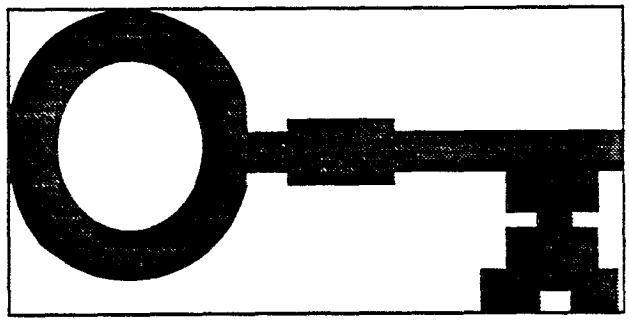
- Identify all relevant existing programs and assess their effectiveness

This may involve looking at an array of water quality programs scattered across different agencies and departments. Look for opportunities to modify these programs to reach the desired goals. Make sure that existing governmental structures are capable of implementing proposed programs. Finally, identify what new programs are needed.

R0013853

- Determine the motivations and goals of the key agencies

They may be acting in response to a perceived problem such as a health hazard or to a water use impairment. Remember that not all organizations are subject to the same level of political pressure.



- Determine whether political support exists

This includes both established and grassroots structures. Political support for environmental issues becomes especially significant in times of resource constraints and competing interests.

- Identify appropriate pollution control techniques

Consult a BMP manual, such as those listed in the Bibliography, for the types of control mechanisms appropriate to a particular site.

- Identify funding options

This might include study of the feasibility of a dedicated funding source such as a storm water utility and development of a fee structure.

- Consider the limitations of available technology

The potential for solving a problem may be limited by many factors over which the implementing authority has no control. This includes performance limitations of technology as well as any site-specific constraints.

Conclusion

The importance of developing institutional structures cannot be overstated. Effective urban runoff management is greatly helped by the presence of strong institutional mechanisms. Furthermore, the case studies support the conclusion that where urban runoff quality control is institutionalized through dedicated funding mechanisms such as storm water utilities, innovative and comprehensive programs (including retrofit activity) are the rule.

R0013854

Setting Priorities/Selecting Management Practices

Urban nonpoint source runoff problems may be numerous in a given area and the solutions are often complex. Funding to solve these problems is usually limited, so it is necessary to set priorities so that the worst problems can be targeted for attention. A ranking methodology should be developed for a specific study area (e.g., a watershed) in order to encourage a phased approach and to allocate scarce resources optimally. Once particular waterbodies and sources have been targeted for action, the local government can then determine the most cost effective approach to solve the problem.

The following factors should be considered in the ranking process:

- waterbody importance
- type of use (recreation/aquatic life/drainage)
- status of use (impaired or denied uses)
- level of use
- pollutant loads

The key point to be made about the ranking process is that it should reflect local issues and concerns. The ranking factors can be assigned different degrees of weight based on the degree of local importance.

In evaluating and selecting appropriate control practices, local governments should consider:

- Does the practice selected meet any applicable regulatory requirements?

- Is the selected control buildable and effective?

Relying upon structural controls is different from the use of source controls and regulatory or non-structural controls. Complex structural controls pose both construction and future maintenance challenges that should not be overlooked.

Use the following as a checklist of the tests which the proposed BMP should pass to be considered for implementation:

- Does it meet regulatory requirements?
- Is it effective at pollutant removal?
- Can it gain public acceptance?
- Is it technically implementable/easily maintained?
- What are the associated costs?

R0013855

The process of setting priorities and targeting urban runoff problems is a complex process consisting of many factors and should be performed in a systematic manner.

How To Overcome Roadblocks to Implementation

Two of the biggest "roadblocks" to implementation of urban runoff control retrofit projects are high cost and shortage of funding and the lack of available land in urbanized areas. Many participants in the urban runoff management and planning process describe the extreme difficulty of implementing urban runoff retrofits because of the lack of available land at highly urbanized sites and the lack of funding for these typically expensive projects. The most difficult sites are those where land for siting control practices is severely constrained or non-existent. The high cost associated with retrofitting older urban storm drainage systems requires a careful evaluation of pollutant reduction goals and the targeting of control practices.

Land Availability

In the urban context, land may be strictly limited and/or its value may be prohibitive for some uses. Practices requiring large land areas are simply not feasible. The three most used control devices for storm water quality management, viz., dry ponds, wet ponds, and infiltration devices, are not always suitable for urban retrofit situations because of space constraints or underlying soil conditions.

On sites where these types of conventional practices are not feasible, innovative and experimental approaches should be tried. Newer ultra-urban technologies that take up little or no above-ground space should be used. Performance monitoring should be done to verify effectiveness.

Cost of Implementation

The extremely high cost of retrofit projects - engineering studies, land acquisition, and the actual construction costs - raises the question of how realistic these projects are for many local governments to achieve. In addition to initial project cost, there is also the continuing and long-term cost associated with operations and maintenance. Some ways to reduce the high cost of these projects include:

- utilizing state or federal cost-share programs where available (e.g. FEMA floodplain "buyout" or EPA nonpoint source grants)
- encouraging multi-jurisdictional efforts to spread the cost and benefits
- soliciting volunteers and in-kind contributions to reduce project cost

R0013856

- creation of special districts or dedicated funds such as storm water utilities

- low interest state revolving fund (SRF) loans for nonpoint source control projects

The use of high value urban land is the biggest obstacle to implementing retrofits for many municipalities. Land which would ordinarily be generating revenue for the municipality is removed from the tax rolls. This is a clear institutional disincentive to implement retrofits in highly urbanized areas. If a local government considers water quality improvement as a goal desired by the community, then the revenue loss might be viewed differently by the public, and would be easier to justify politically.

Localities are increasingly turning to methods of returning the costs of storm water discharges to individual property owners, through mechanisms such as storm water utility fees or storm drainage and flood control fees. The goal of these programs is to provide economic incentives to property owners to reduce the amount of storm water discharges from their land by offering credits for implementation of best management practices, as well as to reduce the burdensome cost to already fiscally-strained jurisdictions.

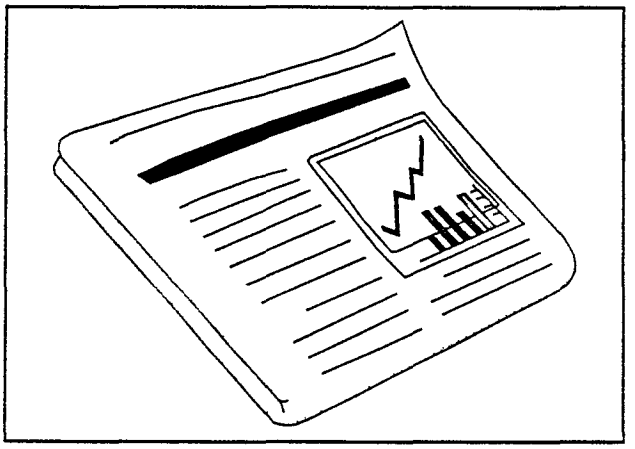
R0013857

Increasing Public Awareness



To ensure adequate support for urban runoff control programs, the public needs to be educated about the nature of urban nonpoint source pollution and the benefits of controlling urban runoff. These issues are not readily understood by large segments of the public. The need to heighten public awareness cannot be overemphasized.

Urban runoff control programs must have public backing and involvement to succeed. There is broad general support for environmental concerns and this support can be translated into political support for urban runoff control programs. However, adequate funds must be devoted to public information and education programs about the nature, causes and solutions of urban runoff and urban nonpoint source pollution. The public must recognize the seriousness of urban runoff pollution, and understand the importance of local commitment for a successful urban runoff management or retrofit program.

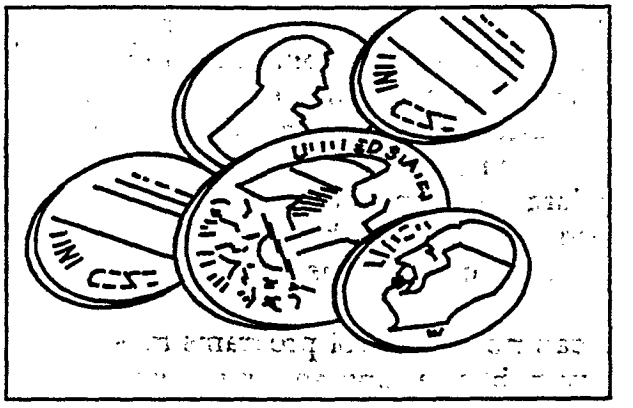


Public education is an essential tool for increasing public awareness and generating political support. Educational efforts typically include:

- program meetings and presentations
- program materials such as newsletters, fact sheets, brochures, and posters
- homeowner education programs
- media campaigns
- coordination with activist groups for program support

R0013858

Creating a Stable Funding Mechanism



Runoff control programs are usually implemented at the local level. Local communities generally have limited budgets and limited staffing which impedes effective implementation. Sources of funding at the Federal and state levels are also limited and uncertain, and cannot be counted upon to provide total project funding.

One successful institutional response by many municipalities has been the establishment of storm water utilities. Some jurisdictions have used storm water utilities to fund the basic "hardware" of urban runoff management, while others have included funding for watershed planning and retrofitting programs.

Special taxing districts, such as a watershed improvement district, can levy taxes and borrow money to engage in a wide range of nonpoint source pollution control activities. A special taxing district is similar to a school district or a sanitary district and functions as a special governmental unit in a particular area. Real estate within its boundaries is appraised and taxed to fund program activities.

The purpose of a dedicated funding source such as a storm water utility or a special taxing district is to provide a stable and reliable method of financing storm water management programs. The development of comprehensive and effective programs requires a secure funding base.

[More information on funding options is provided below.]

R0013859

Policies and Procedures vs. Programs and Institutional Frameworks.

Effective prevention and control of urban runoff pollution requires both defined policies and procedures, and effective programs and institutional structures. Just having policies on paper is no guarantee of an effective program. Institutions must be organized in such a way as to implement the policies and carry out the procedures.

Indeed, the implementation phase is just the final step in an often long process of planning and preparation. It must be accompanied by a real institutional committment to change ineffective and outmoded structures, to break through political or bureaucratic impasse, and to see that programs function effectively.

The question for the local program manager is: Are the local government's agencies organized to efficiently and effectively carry out runoff control activities? Are the various agencies involved clear about their responsibilities? Responsibilities of each involved party can become a major issue when urban nonpoint source control projects involve multiple agencies, as they almost always do.

The responsibility of each agency involved in an urban runoff control project should be clearly spelled out.

The complexity of developing and implementing urban runoff control programs, including the special considerations relative to retrofit situations, means that the following distinct phases should be well-known to the program manager:[8]

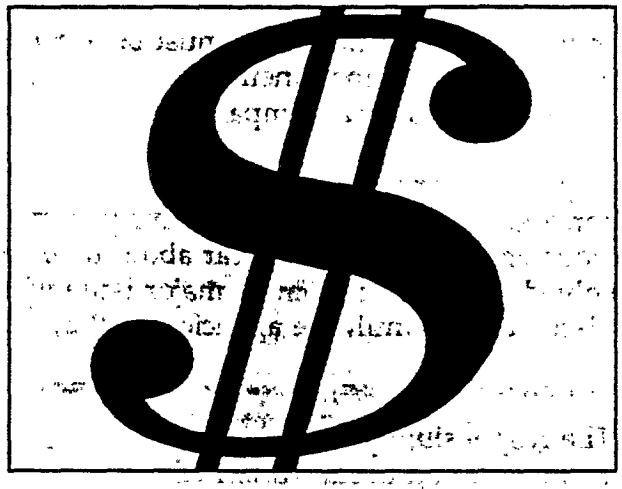
- planning phase: analyze, evaluate, plan
- preparation phase: prepare budget, allocate resources, and obtain permits
- pilot project phase: test selected BMPs
- full-scale implementation: construct selected BMPs
- evaluation/documentation: evaluate program effectiveness

[8] U.S. Environmental Protection Agency, "Evaluating Nonpoint Source Control Projects in an Urban Watershed," in Nonpoint Source Watershed Workshop. Seminar Publication # EPA/625/4-91/027.

R0013860

Funding Options/Alternative Funding Approaches

Implementation of urban runoff control programs at the local level often requires non-Federal funding. Now that governments at all levels are facing fiscal constraints, alternative funding sources are becoming increasingly important. Following is a discussion of some of these approaches:



Local governments with strong institutional frameworks have led the way in the development of utilities specifically designed to abate NPS pollution or targeted at a particular type of NPS pollution:

- Local governments are using the utility concept to develop institutional approaches incorporating homeowner responsibility for some runoff management practices (e.g., septic system maintenance, small construction grading and landscaping permits requiring best management practices to control runoff)

- Storm water utilities are spreading all over the country as a way of providing a dedicated funding source for urban runoff control projects; a storm water utility is to storm water what a sewage utility is to sewage and a water utility is to drinking water. It is a dedicated funding source or "stand alone" service unit within the city government which generates revenues through fees for service. It is responsible for the operation, construction and maintenance of storm water management devices and for storm water system planning.

State revolving loan funds were very successful in the early years of point source pollution control and are now being adapted to nonpoint sources:

- State revolving loan funds, originally established for states to upgrade sewage treatment facilities through construction grants, may also be used to fund a wide variety of nonpoint source control projects and best management practices (BMPs)

R0013861

Special fees and taxes are another source of dedicated project funds for nonpoint source pollution control:

- This approach involves the use of user fees/special taxes to fund nonpoint source pollution projects and programs, such as special taxes and fees on the sale of fertilizers and pesticides, waste disposal, and underground storage tanks

Some innovative approaches being used to fund urban nonpoint source pollution control programs include:

- Special tax districts, such as watershed improvement districts, which can be created to protect highly valued water bodies.
- Checkoff on tax forms to fund restoration and conservation programs.
- Revenue bonds, which are long-term municipal bonds guaranteed solely by the dedication of project funds.
- Public/private partnerships can be used to pay for capital and/or operating expenses for storm water facility projects when neither could fund them alone.
- An annual nonpoint source pollution control tax based on property size and land use (not on value) is being used in Puget Sound, Washington.
- The sale of special license plates in Maryland and Virginia has raised substantial amounts of money to restore the Chesapeake Bay.

Types of Funding Mechanisms Available to Local Governments

- General funds

  The use of general funds may require the re-allocation of existing revenues.

- Long-term borrowing

  Large structural BMPs may require funding through bond issues.

R0013862

- Pro-rata share fees

  These fees are typically based on an assessment of the development's potential to contribute to urban runoff problems.

- Storm water utilities

  Utilities typically assess a fee based on the percentage of a site's impervious area.

- Special assessment districts

  Funds for projects in a district can be raised by assessing fees to landowners in the district.

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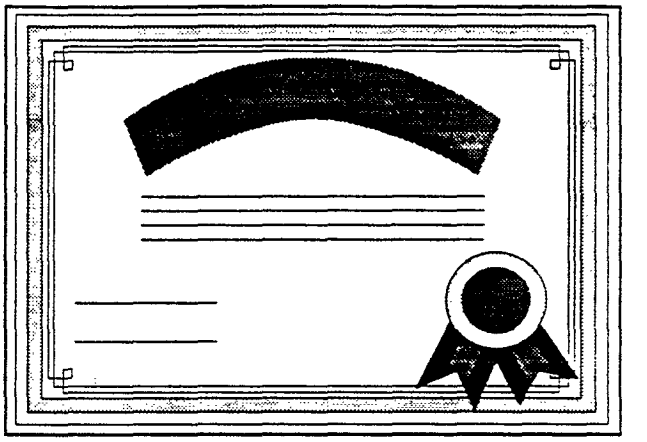
Elements of Successful Programs/Solutions



The case studies presented in this manual were selected as examples of exemplary local government initiatives in the area of urban runoff control and/or retrofit implementation. The case studies included are all "success stories," and they display certain common elements. Among these are the following:

- strong institutional motivation to act on problem
- political and/or grassroots support for action
- skilled personnel
- knowledge of available technologies
- dedicated funding source, such as a storm water utility fee
- an environment of institutional cooperation and a long-term commitment to work together
- targeting strategy/process to maximize use of limited resources

Many communities are recognizing the benefit of preventing ecological and habitat destruction to avoid the very high costs associated with the restoration of degraded resources. The most successful communities take a pro-active stance with regard to regulatory requirements, and use proper planning techniques to prevent degradation of water resources. They are realizing the economic, environmental and social benefits of protecting the existing ecosystem through land use controls, development restrictions and urban best management practices.

Conclusions and Recommendations

Effective urban runoff control programs are built upon numerous institutional, economic and technical factors. The most successful programs examined in this project displayed a strong institutional or programmatic focus, in additional to having a strong motivation (usually economic) to act on a problem. Furthermore, the case study communities displayed strong political and/or grassroots support for community action as well as skilled personnel.

Solutions must be tailored to each communities' particular circumstances, but the following recommendations may assist the interested community to more quickly develop an urban runoff control or retrofit program for developed areas.

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Recommendations

- Identify and obtain stable, if not dedicated, funding sources for urban runoff programs, including retrofit programs.
- Utilize cost-share approaches among agencies to maximize resource impact and obtain participation and support from private interests benefitting from urban runoff control projects.
- Use team or multilateral approaches wherever possible; given the nature of urban runoff problems, most solutions will need to cut across bureaucratic and organizational boundaries.
- Focus effort initially on building institutional structures to support comprehensive urban runoff control programs.
- Identify water quality problems and prioritize retrofit alternatives.
- Identify all existing related programs and assess their effectiveness and modify where needed.
- Consider innovative, cost effective, and environmentally responsible ways of retrofitting.
- Utilize economic incentives (such as tax or fee reductions) to motivate property owners to employ runoff control and/or retrofit strategies.
- Make retrofit projects a condition of approval for redevelopment projects.
- Create a single management agency charged with overall responsibility to plan and coordinate program implementation and conduct and/or monitor operations and maintenance activities.
- Designate agency staff to support implementation of projects.
- Do adequate retrofit planning and realistic goal setting.
- Select knowledgeable contractors or contractors with a good track record in water quality and urban runoff control projects.

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- Supervise, even direct if necessary, the construction phase of all projects.

- Educate developers, consultants, contractors, politicians and the general public about urban nonpoint source pollutions issues.

- Identify opportunities for public/private partnerships to conduct nonpoint source pollution control activities.

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Introduction to the Case Studies

The following case studies exemplify many of the institutional, regulatory, planning and implementation issues discussed throughout this manual. They describe the experiences of selected local governments in dealing with the problem of urban runoff management in developed areas. Many of the approaches described in the case studies are highly innovative and will be useful guides for other localities considering the implementation of urban runoff control and/or retrofit programs.

This manual utilizes the case studies to illustrate some approaches which localities are successfully using to manage urban runoff problems. It provides examples of jurisdictions where institutional frameworks have been successfully developed to support urban runoff management and retrofit programs. Institutional issues are given great emphasis in the case studies, as in the main narrative, because institutional issues, rather than purely technical ones, are believed to be a common obstacle to the successful implementation of urban runoff management projects.

The case studies demonstrate the many different ways communities have developed and implemented urban runoff management programs. Each program is unique, based on the magnitude and negative impact of that community's urban runoff problem, the available resources and existing pollution control programs, and the existing regulatory context in which the local government is operating.

City of Alexandria, Virginia

Introduction

Municipalities are being confronted by increasingly stringent local, state, and Federal environmental regulations. Complying with these regulations is a challenge. The approach taken by the City of Alexandria, Virginia is a case study which illustrates this point.

Alexandria is situated on the tidal Potomac River, across and down river from Washington, DC. Because of its location, the City must comply with Virginia's "Chesapeake Bay Preservation Act." The Act's implementing regulations required the City to designate "Chesapeake Bay Preservation Areas" within its boundaries. The City as a whole was designated to be a preservation area. This designation means that development and redevelopment of land in the City must achieve specified storm water management criteria. For permitted development, nonpoint source pollution loads cannot exceed pre-development loads based on average land cover conditions. For redevelopment of land currently served by water quality best management practices (BMPs), nonpoint source pollution in post-development runoff cannot exceed the load existing prior to redevelopment. For redevelopment of land not currently served by water quality BMPs, a ten percent reduction in nonpoint source pollution in runoff must be achieved when compared to the load existing prior to redevelopment.

Meeting these storm water management criteria in Alexandria has indeed been a challenge. Implementing conventional water quality BMPs to control the quality of storm water discharges is often either economically impractical or physically impossible because of a number of factors such as a lack of physical space, extremely high land values, a high water table, or unsuitable soil conditions. The City has met the challenge by adopting and adapting for local use a class of BMPs dubbed "ultra-urban."

Ultra-urban BMPs are non-conventional BMPs that are particularly suited for use in highly urbanized areas. They are based on sand filter technology and are currently used in other parts of the United States. Alexandria has installed four of these ultra-urban BMPs in intensely developed areas. In order to facilitate the use of sand filter technology, the City has published design criteria for various ultra-urban BMPs in the Alexandria Supplement to the Northern Virginia BMP Handbook.

The Alexandria Supplement states that the standard types of BMP facilities such as dry ponds, wet ponds, and infiltration devices are not suitable for use in large areas of Alexandria because of space limitations or poor soil conditions. The planner, developer, or engineer is therefore urged to consider the use of unconventional or

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innovative BMPs. It should be noted that infiltration is not the preferred method in Alexandria and will only be approved where it can be clearly demonstrated that it will work. Most areas of Alexandria do not contain soils that are conducive to the use of infiltration devices. (Marine clay is the prevalent soil type in Alexandria and the region.)

To complicate the problem, Alexandria, in common with many older cities developed in previous centuries, has sections of combined sanitary and storm sewers. During heavy or prolonged storm events, combined sewer overflows (CSOs) may occur, discharging directly into streams. Alexandria has applied for an NPDES permit for the CSOs from the Virginia Department of Environmental Quality.

Strategy

The development of design criteria to guide local developers, culminating in the Alexandria Supplement to the Northern Virginia BMP Handbook, resulted from the City's engineering staff consulting with jurisdictions across the country where similar ultra-urban technology is being proposed or has been implemented.

It should be noted that the City's strategy of implementing ultra-urban BMPs was essentially driven by the lack of available land and alternatives. Most other BMPs were fairly easily screened out because of the severe space constraints. Available technology aside, the other principal strategy issue requires that opportunities be seized as they arise, usually from redevelopment.

The general strategy employed in the implementation of these retrofits was one of exploiting any available opportunities. Cooperation was solicited from developers. The double trench Delaware sand filters which were implemented did not take up any valuable land above-ground and this was a strong selling point for bottom-line conscious developers. This allowed them full economic use of the land. The focus has been on available sites. Parking lots have been the chief sites suitable for the Delaware sand filters, and implementation has been limited to them.

One advantage of the Delaware sand filter for Alexandria is that it requires a total depth of 30 inches from the ground surface to the bottom of the paved trench. This is critical in portions of the city where the depth to groundwater is minimal. In addition, the simplicity of the system and the ready accessibility of the chambers for regular maintenance makes the Delaware-type filter very suitable for site conditions which are typical in Alexandria. This type of system is appropriate for up to five acres of 100% impervious cover.

Two [District of Columbia] underground vault sand filter systems were installed on a 3-acre townhouse development in the Winter/Spring of 1994. The principal advantage of these systems is that they may be placed under streets, and in cells of

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parking garages, allowing full economic use of the surface areas.

Cost

The cost of implementing sand filter technology varies due to site-specific conditions. Most of the devices already implemented in Alexandria were prototypes, making accurate cost estimates difficult. However, a range based on the characteristic design of the Delaware, Austin, and District of Columbia designs can be estimated. The costs of Austin sand filters, typically suitable for large-scale sites, range from $13,000 to $19,000 per impervious acre. The D.C. sand filter, which is characterized by an underground vault with sediment and filtration chambers, originally cost around $35,000 per unit, but through economies such as pre-cast concrete and standardized design, costs have come down considerably to the $12,000 to $16,000 range. It should be borne in mind that the early models of these systems are essentially prototypes and that costs are highly variable. Economies of scale are likely to come about through routine implementation. The use of prefabrication and modular units may further reduce costs in the future.[9]

Effectiveness of Ultra-Urban BMPs compared with Conventional BMPs

Most of the (Delaware) double-trench sand filters implemented to date in Alexandria have not been subjected to long-term monitoring and Delaware does not rate these systems for nutrient removal efficiency. Based on long-term monitoring of sand filtration systems done by Austin, Texas, the Delaware system is rated at 80% suspended solids removal rate. Alexandria, however, recognizes a TP (total phosphorus) removal rate of 40%.[10]

The Virginia Chesapeake Bay Local Assistance Department has provided a grant to the City of Alexandria to monitor the performance of the first two Delaware sand filters constructed in the city.

Other Institutional Issues

This case study illustrates the benefit of having a committed public official dedicated to implementation of nonpoint source pollution control technology. The City Engineer has implemented retrofits mostly on his own initiative, having had relatively few bureaucratic obstacles to overcome.

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[9] Warren Bell, A Catalog of Stormwater Quality Best Management Practices for Ultra-Urban Watersheds. Presented at the National Conference on Urban Runoff Management in Chicago, IL on April 2, 1993.

[10] Ibid.

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There are other programs described in case studies in this manual where institutional support comes from the "grass roots." It is vital to have public support for pollution control programs, but building support for these programs may sometimes require that public officials take the lead and steer programs past the numerous bureaucratic obstacles.

For more information...

For more information on the City of Alexandria's program, call the Transportation and Environmental Services Department at (703) 838-4320.

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Southeastern Massachusetts

This case study looks at storm water retrofit projects in the following areas of Cape Cod:

- Buzzards Bay/Buttermilk Bay:

  1) Sprague Cove Storm Water Remediation Project (Town of Marion)
  2) Broad Marsh River Storm Water Remediation Project (Town of Wareham)
  3) Electric Avenue Beach Storm Water Demonstration Project (Town of Bourne)
  4) Hen Cove NPS Pollution Mitigation Project (Town of Bourne)

- Town of Yarmouth
- Town of Orleans

Existing Nonpoint Pollution Problems on Cape Cod

A Cape Cod Section 208 planning study identified the following pollutants in storm water runoff from urban sources at various locations on the Cape:

Organics: Oil and grease (hydrocarbons), benzene, xylene, and toluene from auto emissions or atmospheric deposition. Runoff from roads into Buzzards Bay is estimated to contribute 33,000 lbs. of petroleum hydrocarbons a year to the Bay.

Inorganics: Nitrates, phosphates, ammonia, chloride, sodium, calcium, potassium, barium, iron, cadmium, chromium, copper, lead, and zinc have all been identified in runoff from a section of Route 28 near Falmouth.

Biological: Bacteriological contaminants (mostly fecal coliform) in storm water runoff were strongly implicated in the closure of shellfish beds in Buttermilk Bay (Bourne).

I. Case Studies

Buzzards Bay Area

In Buzzards Bay, over 8,000 acres of shellfish beds are believed to be closed as a

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direct result of storm water contamination. This represents an estimated economic loss of $24 million to communities in the Buzzards Bay area.[11] The Buzzards Bay Comprehensive Conservation Management Plan (CCMP) adopted in 1992 calls for the prevention of new storm water discharges to the Bay, as well as the remediation of existing discharges that pose a threat to water resources. The plan also calls for towns to inventory and prioritize storm water discharges for remediation. After towns have evaluated their storm water needs, they can proceed based on available resources. Funding, however, is one of the most significant factors affecting the ability of Southeastern Massachusetts area towns to deal with their urban runoff problems.

The development of the Buzzards Bay CCMP resulted in some significant accomplishments for the Buzzards Bay region:

- it established overlay district protection to limit nitrogen inputs to marine waters of Buttermilk Bay (a first in the nation)
- it resulted in the development of regional strategies, approaches and enforceable mechanisms as part of the Massachusetts Coastal Zone Management program

1. Electric Avenue Beach

Strategy and Rationale

An existing storm water system was retrofitted at Electric Avenue Beach in Bourne, Massachusetts as a demonstration project as part of the Buzzards Bay Project (a joint project of the Massachusetts Coastal Zone Management Program and the U.S. Environmental Protection Agency). The project was undertaken in response to high fecal coliform bacteria levels found in wet weather storm drain discharges to Buttermilk Bay, a tidal embayment in the towns of Bourne and Wareham at the northern end of Buzzards Bay. The Buzzards Bay Project funded the implementation of a storm water infiltration system in order to test the effectiveness of these systems in removing bacterial and nutrient contamination from the storm water runoff entering Buttermilk Bay.

The storm water infiltration system was designed to intercept a one-year design storm from the adjacent watershed and to avoid direct discharge of the first flush to the Bay. Instead, the flow enters a settling tank for removal of solids and floatable waste and is then discharged to infiltration galleys. The only flow which is

[11] Buzzards Bay Project, "Bay Watch," (Newsletter) Spring/Summer 1993 Vol. 7 (5), p. 1.

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discharged from the original outfall is from a one-year storm or better. Monitoring provided by the Barnstable County Health Department has confirmed a reduction in bacterial loading.

There are other points which make this project noteworthy:

- the infiltration galleys are preceded by oil/grit chambers designed to reduce clogging in the infiltration devices
- because the infiltration devices are very close to the beach area, the distance to groundwater is approximately two feet - groundwater sampling has not shown any contamination, however
- a substantial reduction in construction costs was achieved by utilizing personnel from the Town of Bourne's Department of Public Works

One of the unique aspects of this demonstration project was that the EPA Region I and Buzzards Bay Project oversight staff utilized the Department of Public Works personnel from the Town of Bourne for construction of the storm water infiltration system. The significant institutional consideration here is that the experience gained by Town staff in the design of the demonstration project could be used for the construction and maintenance of additional storm water infiltration systems. This enhances the storm water quality control expertise of Town personnel and further institutionalizes the process.

Effectiveness

At the Electric Avenue demonstration project site in Bourne, monitoring indicates that the retrofit structures are removing over 95% of the fecal coliform from storm water runoff.

2. Hen Cove Nonpoint Source Pollution Mitigation Project

Storm water runoff pollution was implicated in the closure of shellfish beds and a swimming beach in Hen Cove. The Buzzards Bay Project assisted the Town of Bourne in retrofitting the adjacent storm drain systems so that pollutants are not discharged directly to the Cove.

Strategy and Rationale

The Hen Cove project targeted specific storm drain systems which currently allow direct discharge of untreated storm water into the Cove. The mitigation project incorporated the use of leaching chambers and the surrounding soil to treat the "first flush." (During heavier or more severe storms, excessive runoff will overflow into the

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conventional storm drain system.) Several individual leaching chambers were placed under the road surface throughout the watershed (there are 13 so far). At each location, runoff from the road will be diverted into a storm drain with a settling basin to allow sediments and other solids to settle out. From the storm drain inlet, the storm water is then piped under the road surface into leaching chambers. The leaching chambers are pre-cast, perforated concrete structures which are surrounded by crushed stone. Storm water is temporarily stored in the chambers and in the voids between the crushed stone until it seeps into the surrounding soils. Groundwater monitoring will determine the success of this approach by determining the amount and type of pollution attenuation in the surrounding soils.

3. Spragues Cove Storm Water Remediation Project

The Buzzards Bay Project is working with the Town of Marion, Massachusetts, to reduce pollutants associated with storm water runoff entering Spragues Cove. Spragues Cove is a small, shallow embayment on the shore of Sippican Harbor. Currently its three-acre area of valuable shellfish beds is closed for shell-fishing because it exceeds both state and Federal bacteria standards for shellfishing.

The largest storm drain system drains approximately 64 acres of watershed directly in the Cove. The mitigation project will incorporate the use of a constructed wetland system to treat the "first flush."

Strategy and Rationale

Several treatment alternatives for the storm water draining into Spragues Cove were considered:

- No action. The drainage system continues to function and shellfishing areas remain closed because of high fecal coliform counts
- Mechanical treatment methods such as chlorination, ultraviolet light, ozone and reverse osmosis
- Physical methods of treatment such as infiltration, settling or constructed wetlands

The Town of Marion reviewed the alternatives and decided that a constructed wetland system met the objectives of the project. The system will include a settling basin, marshland vegetation, and an open, deep water pool. The settling basin allows for coarse sediments and particulates to settle out prior to entering the wetland treatment system. In the wetland itself, physical and biological processes will treat and remove pollutants from the water. The restored wetland system will have a hydraulic detention time of over 14 days.

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The wetland system will be constructed where a salt marsh previously existed. The site was filled decades earlier with dredge spoil from nearby Sippican Harbor. In addition to providing water quality improvements, the restored wetlands system will enhance the fish and wildlife habitat in the area. Currently the site has little habitat value.

Effectiveness

Existing research on using wetlands to treat wastewater for fecal coliform indicates that at least 95 percent or greater is typically removed. Fecal coliform counts associated with storm water from the Spragues Cove outfall are significantly lower than previously recorded levels. The water quality monitoring plan will be part of the quality assurance/quality control (QA/QC) plan required by the U.S. Environmental Protection Agency.

Costs and Funding

The Town of Marion and the Buzzards Bay Project obtained $25,000 through the Massachusetts Department of Environmental Protection's 319 grant program. The Town provided an in-kind match valued at $35,000 to cover the cost of construction, equipment and labor. The Town also donated the land on which the wetland system will be constructed (estimated value of $100,000 per acre). A total of two to three acres of land will be utilized for the project at a total cost of $200,000 to $300,000. Additionally, the U.S. Fish and Wildlife Service granted the Town $10,000 for the project under the Wetland Restoration Program. Planning and technical assistance will be provided by an interdisciplinary team from the Soil Conservation Service (SCS).

4. Broad Marsh River Storm Water Remediation Project

Broad Marsh River is a tributary to the Wareham River estuary. It is located in the Town of Wareham in the northern part of Buzzards Bay. The entire Broad Marsh River has been closed to shellfishing and some beaches closed to swimming due to high fecal coliform concentrations. The most significant source of pathogens and fecal coliform pollution in the river is associated with storm water runoff from discharges from adjacent storm drain systems. Other potential sources, such as migratory waterfowl and boats, have been deemed insignificant.

The primary objective of the storm water remediation project is to reduce the amount of pollution (mostly fecal coliform) from storm water runoff entering Broad Marsh River.

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Strategy and Rationale

Several alternatives were considered for the treatment of storm water runoff from storm drain systems adjacent to the Broad Marsh River:

- No action. Fecal coliform pollution would continue unabated and result in the continued closure of shellfishing beds and many beach closures for swimming.
- Extended detention basins, wet ponds or constructed wetlands would be used to detain the first flush of runoff for at least 24 hours.
- Infiltration structures such as infiltration basin at the end of each storm drain system, or a series of leaching chambers under the existing road surface

The selected alternative was the use of leaching chambers placed under the road surface. The rationale for selecting this alternative is typical in many retrofit situations; detention basins were rejected because, as an "end-of-pipe" practice, they require considerable commitment of land to function properly. Since there are 16 storm water outfalls to this section of the Broad Marsh River, there would have to be 16 detention basins and this would require the acquisition of a large amount of land, including some dwellings. This choice was not deemed feasible. Infiltration basins located at the end of a pipe have a similar need for large land commitment. The leaching chamber option was chosen because leaching chambers placed under the road surface would minimize the disruption to the present drainage system and would not require a large land commitment.

Effectiveness

This project is not yet fully established. However, to demonstrate the effectiveness of the leaching chambers, the project will monitor a minimum of three chambers.

Costs and Funding

The Buzzards Bay Project was initially unable to fund the Broad Marsh River project. However, the Buzzards Bay Project together with the Town of Wareham, requested funding under the Massachusetts Department of Environmental Protection's 319 (Nonpoint Source) Program and successfully secured funding in the amount of $88,450 to help reduce pollution loadings from storm water runoff.

5. Town of Yarmouth

In 1991, the Town of Yarmouth implemented the retrofit of a drainage system to

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eliminate the direct discharge of storm water runoff containing high fecal coliform counts to the Bass River. The drainage system was retrofitted to direct the flow into a retention basin to allow storm water to percolate through a gravel bed. This design also allowed for evaporation to remove pollutants. The retrofit substantially reduced fecal coliform counts from pre-retrofit levels and improved the water quality in several ways:

- it has reduced velocity, encouraging infiltration
- it further reduced the velocity through infiltration and evaporation
- fecal coliform counts are lower even after similar pre-retrofit rainfall events

Effectiveness

Water quality monitoring performed by the Barnstable County Department of Health Laboratory both before the retention basin retrofit and afterward revealed substantially reduced fecal coliform counts.[12]

6. Town of Orleans

The Town of Orleans, Massachusetts is a community on Cape Cod which has extensive coastal waters, including three estuaries. These waters contain important commercial shellfishing areas. In 1988, several areas within the Town's waters were closed to shellfishing due to bacterial contamination. Through sampling of storm drain outfalls and receiving waters, and from a review of existing water quality data, the Town identified storm water runoff as a significant source of contamination from bacteria and other pollutants to its coastal waters.

Strategy and Rationale

Three drainage areas were targeted as having significant adverse impacts on water quality in sensitive areas and in need of remediation. The Town's strategy was to: 1) identify the three high priority areas for development and implementation of pollution control measures; 2) establish a storm water management committee; 3) screen BMP alternatives to choose best available means to remove bacteria and solids; and 4) appropriate funds for study of conceptual approaches and engineering designs and for construction of the BMPs at the three high priority sites.

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[12] Town of Yarmouth, "Effects of Route 6 Storm Drainage Improvements on Water Quality in Bass River," November 11, 1992.

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Prior to undertaking the projects, which are scheduled for completion in May, 1993, the Town acted on the consultant's recommendations and took the following actions:

- scoped potential solutions
- focus on BMPs for control of bacteria and solids
- prior to choosing BMPs, Town conducted field investigations, which included the following steps:
  - mapping drainage systems
  - analyzing pollution treatment alternatives
  - sizing treatment facilities
  - designing O & M programs

The BMP selection process identified the most feasible and cost effective practices for use in the three drainage systems which were to be retrofitted. In addition, the Town of Orleans Storm Water Quality Task Force was set up to insure the project's technical quality and to address local concerns.

A range of BMPs were considered for control of bacteria and solids and their associated nutrients. The following BMPs were considered for this project, because they are targeted for the control of solids and bacteria:

- extended detention ponds
- retention basins
- infiltration trenches (subsurface leaching gallies)
- filtration beds

A system of sub-surface leaching gallies was used at three sites because of limited land but suitable soil conditions; one site consisted of a detention basin upstream of a filter bed structure because soil conditions were too poor to permit infiltration.

Institutional Issues

The Town's principal institutional motivation for implementing the retrofit projects was the adverse economic impact of closed shellfish beds. Abating and controlling the bacterial contamination from storm water runoff was directly tied to economic concerns and this was a very strong motivation for the Town to organize a task force and to act on the problem. The Town appropriated funds to develop conceptual approaches and engineering designs, as well as for the construction of the necessary BMPs.

II. Regional Cooperation: Role of the Cape Cod Commission

The Cape Cod Commission works with towns on Cape Cod on various matters

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including local transportation projects. In Barnstable County, shellfish bed closures were the principal motivation for the Commission to become involved with storm water issues. The Commission trys to de-politicize issues and use all "levers" available, including state environmental review processes, such as coastal zone management consistency review, to affect outcomes.

Strategy

The strategy employed by the Cape Cod Commission utilizes several different components to maximize the leverage which the Commission can employ to facilitate implementation of storm water retrofit projects on Cape Cod. They try to use all the "levers" available, such as coastal zone management consistency review and the implementation of the Buzzards Bay Management Plan as part of the National Estuary Program (EPA). The Cape Cod Commission works as a coordinator [much like MWCOG in Anacostia watershed restorations] with the Massachusetts Department of Public Works (Mass DPW) and local governments on storm water remediation and retrofitting as part of local transportation projects.

The Cape Cod Commission (through the Cape Cod Marine Water Quality Task Force) has developed a process for prioritizing storm water drainage mitigation projects. This process includes the development of a numerical index to rank proposed projects. The worksheet is keyed to the concerns of Barnstable County, viz., the safety and harvestability of shellfish beds, as well as the safety of areas used for swimming and recreation.

For more information...

For more information about the Buzzards Bay Project and other programs in Southeastern Massachusetts, call the Buzzards Bay program office at (503) 748-3600.

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City of Austin, Texas

Background

The City of Austin, Texas, stretches from the Texas hill country of the Edwards Plateau, eastward to the Blackland Prairie and the Gulf Coastal Plain. A unique environment results from this rapid geologic and ecologic transition.

The Colorado River flows directly through the City. Three riverine lakes - Lake Travis, Lake Austin and Town Lake - are the three most downstream reservoirs of a chain of reservoirs on the Colorado River known as the Highland Lakes. These reservoirs are the City's main water supply, as well as being tourism and recreational resources.

Another key water resource in the area is the Edwards Aquifer, a limestone aquifer on the western side of the City. The aquifer is the sole source of water supply to several communities south of Austin.

These water resources are potentially threatened by water pollution resulting from storm water runoff and other sources of nonpoint pollution. In response to this threat, the City has developed one of the best watershed protection programs in the country. The keystone of this program is the Comprehensive Watersheds Ordinance.

Development of the Comprehensive Watersheds Ordinance

In order to protect water resources from degradation due to urban nonpoint source pollution, the City enacted several watershed protection ordinances in 1988. These ordinances were combined into a single code which applies to the entire city and to its extraterritorial jurisdiction. The City of Austin Land Development Code and the Environmental Criteria Manual provide guidance for water quality management. The 1988 regulations became the basic building blocks of the Austin storm water management and BMP implementation and retrofit program.

The original catalyst for the consolidation of the existing watershed protection ordinances was the comprehensive planning effort known as "Austin Tomorrow." This plan identified nonpoint source pollution as a potential threat to Austin's environmental and economic well-being.

Monitoring of Austin's creeks and lakes followed this study and in 1978 the Lake Austin Watershed Ordinance became the first water quality related ordinance and nonpoint source pollution control ordinance to be adopted in the region.

In 1981, the City of Austin joined the EPA-sponsored Nationwide Urban Runoff

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Program (NURP) study and began monitoring its storm water structural controls in 1982. Subsequent watershed protection ordinances were passed from 1980-1984 to cover additional environmentally-sensitive areas.

By 1986, the City of Austin had had eight years of experience with watershed protection ordinances and appointed the Comprehensive Watersheds Ordinance Task Force to develop the consolidated ordinance and provide final review and recommendations for implementing the consolidation of the numerous existing ordinances.

Overview of the Comprehensive Watersheds Ordinance

The Comprehensive Watersheds Ordinance (CWO) was directed at preventing urban runoff pollution by placing requirements on proposed new development with Austin and its extraterritorial jurisdiction. Although the Comprehensive Watersheds Ordinance originally existed as a stand-alone document, it has since been incorporated into the City's Land Development Code. In addition, there have been several amendments to it since 1986 and more are anticipated in the future to better protect various sensitive areas. Nevertheless, knowledge of the evolution of the Ordinance is helpful to understanding Austin's strategy for urban nonpoint source pollution control.

Specific pollutants were not addressed in the Comprehensive Watersheds Ordinance. Control of specific pollutants was instituted only for the sensitive Barton Springs Zone, which recharges the Edwards Aquifer. Several ordinances for the protection of this sensitive area have been put in place over the last several years.

The Ordinance required a range of widely accepted and proven structural and nonstructural nonpoint source pollution controls to be included in new development projects. These controls included best management practices (BMPs) such as impervious cover limitations, water quality buffer zones, protection of critical environmental features, limitations on disturbance of the natural stream, erosion control practices, sedimentation and filtration basins, and wastewater disposal requirements. One significant aspect of the ordinance was the use of nonstructural controls to prevent and mitigate nonpoint pollution associated with development. The rationale behind this approach was that impervious cover limitations and buffer zone requirements have been proven to maintain the basic hydrologic balance.

Protection of non-drinking water supply watersheds in the eastern side of Austin were not given high priority. Downstream of Town Lake the Colorado River is not used for drinking water supply. Furthermore, clay soils dominate on the eastern side of the City; therefore, maintaining infiltration and recharge is not a critical goal in these watersheds.

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Effectiveness of the Ordinance

The City of Austin standard sand filter design requires the first half inch of runoff from a site to be diverted into a sedimentation basin and then filtered through sand. This design is based on eight years of monitoring filter ponds of different designs.[13] The demonstrated removal efficiency of the sedimentation/filtration ponds for total suspended solids is 75% to 97%.

An important consideration learned from the Austin experience regarding effectiveness is that maintenance is critical to ensure BMP effectiveness, yet timely maintenance is problematic at both a local and nationwide level. Another is that the best protection for water resources is believed to be afforded by a combination of structural and non-structural controls as provided for in the Comprehensive Watersheds Ordinance. Structural controls alone are not always effective, nor can they prevent an increase in pollutants from high intensity developments.

Austin's non-degradation strategy for contributing watersheds is to limit the percent of impervious cover in new developments and to reduce post-development pollutant loads through a menu of storm water control practices, and a program of retrofitting storm water treatment measures in developed areas. Austin has incorporated this strategy into the framework of the City of Austin Land Development Code through a mechanism known as an "impervious cover cap." The impervious cover cap is established by setting a Maximum Sustainable Removal Rate for storm water treatment measures at 90%; beyond this point, storm water control measures cannot be relied upon to reduce the pollutant loads associated with additional impervious cover down to the pre-development level.

This strategy aims to reduce excessive reliance on storm water treatment measures because of their inherent limitations and risk of failure due to lack of maintenance and their need for replacement. Impervious cover levels, on the other hand, do not change over time, do not require maintenance, and their life span is infinite provided their nature is unchanged.

However, the Austin program recognizes that modification of the City's development regulations would provide only a partial solution to the problem of water quality degradation. It sees retrofitting of structural storm water controls as the only way to reduce pollutant loads from existing development and development projected but not

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[13] Parrish, John H. and Stephen Stecher, "Nonpoint Source Pollution Control in the City of Austin." City of Austin, Environmental and Conservation Services Department, March 1991, p. 5.

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yet built.[14]

The Austin program has recognized that, in light of the growing trend toward limiting building density and/or impervious cover as a means of nonpoint source control in residential areas, there is a need to establish a clear linkage between development density or impervious cover and pollutant loadings. In addition, the city recognized that more study is needed on the effects of types of land use on the quality of storm water runoff.

The City's Storm Water Monitoring Program has provided the city an opportunity to evaluate the effectiveness of its varied array of storm water quality controls, and also to assess whether they are over- or under-designed relative to site conditions.

First Flush of Runoff and its Effects on Storm Water Control Structure Design[15]

Austin's Environmental Resource Management Division published a report (1990) showing that the first 1/2 inch of runoff did not necessarily carry the bulk of the storm load. This was contrary to the prevailing assumption that the first 1/2 inch of runoff in a storm washes off 90% of pollutants from the impervious cover. The report suggested that for a development with 90% impervious cover, only 40% of the total storm load would be washed off in the first 1/2 inch of runoff.

The implication of the report for control structure design was that a control structure designed to capture and treat only the first 1/2 inch of runoff would only remove about 40% of the total annual load. The bypass or untreated annual load could be substantial. The report did not suggest an alternative structural control design; it merely raised the issue of a substantial amount of pollutant load in excess flow from a structure designed to capture and treat the first 1/2 inch. Changes to the City's Land Development Code in December 1993 resulted in the treatment volume increasing with the amount of impervious area on the site, starting at .50 inch plus .10 inch per 10% increase in impervious cover over 20% of the site.

However, urbanized watersheds should be targeted for priority control based on other findings. Another Austin study confirms that storm water runoff pollutant loads increase with watershed imperviousness, and that loading rates of urbanized

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[14] Ibid., p. 15

[15] City of Austin, Environmental Resource Management Division, "The First Flush of Runoff and Its Effects on Control Structure Design." June, 1990.

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creek watersheds were significantly higher than those from small suburban sites.[16]

Sand Filter Program

The City of Austin has developed a sand filtration best management practice for use in storm water quality management. The sand filtration systems are the primary water quality control structures.

The City had previously implemented a storm water monitoring program in 1984. This study was conducted to determine annual removal efficiencies of six storm water quality control structures, including three filtration basins, one wet pond, one sedimentation (dry) pond, and one retention/filtration basin system. The structures were monitored between 1984 and 1989, and comparative measurements of inflows and outflows were taken to determine concentrations of pollutants.

Effectiveness of removal for the following parameters was measured:

- Fecal coliform
- Total suspended solids (TSS)
- BOD/COD
- Nitrogen
- Phosphorus
- Heavy metals

The study[17] concluded that the sand filtration basin is an effective structural control measure for most of the described pollutant parameters. Sand filtration is a demonstrated success in Austin, although officials concede that maintenance is sometimes inadequate and sporadic.[18] There have also been some isolated technical and/or design failures, such as slope erosion and construction failures which have resulted in inadequately performing BMPs.

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[16]City of Austin, Environmental Resource Management Division, "Stormwater Pollutant Loading Characteristics for Various Land Uses in the Austin Area." March, 1990.

[17]City of Austin, Environmental Resource Management Division, "Removal Efficiencies of Stormwater Control Structures." Final Report, May 1990, p. 16.

[18]Personal communication with Les Tull, Engineer, City of Austin, Texas, May 25, 1993.

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Strategy

The Austin sand filter program was implemented in response to regulatory requirements, viz., the consolidation and enactment of several watershed protection ordinances in 1988. In addition, political pressure to act came from citizens demanding action to protect water quality. The City of Austin's Land Development Code and Environmental Criteria Manual provide documentation and guidelines for the City's water quality management efforts.

Prior to enactment of the watershed protection ordinances, the City implemented a storm water monitoring program in 1984 to evaluate storm water control measures and to develop a database to quantify the effects of impervious cover and land use on water quality and also to evaluate the effectiveness of various structural storm water control measures already in use.

The basic strategy and philosophy guiding the Austin program has been to make new development and redevelopment pay the costs attributable to its impact and to mitigate all impacts of new development. While this has been the strategy, it has not been possible to accomplish this for all aspects of the development process, such as permits and review. In addition, the City assumes responsibility for maintaining water quality controls for single-family development. This approach includes a provision for payment of a fee in lieu of constructing BMPs so as not to restrict development. "Fee in lieu of" funds are used for retrofit projects for existing development, but only within the most highly urbanized and developed watersheds classified as "urban" in the Land Development Code.[19]

There are many components to the Austin storm water management amd urban nonpoint pollution control program. These include retrofit watershed master planning, source control of pollutants, and public education. A current emphasis is on the public education component, which includes videos and posters with the theme of abating urban nonpoint source pollution.

Austin's strategy sees the key to a successful nonpoint source control program as the targeting of critical areas to achieve high pay-off returns. The City's focus is on potential deterioration of local water supplies, viz., Lake Travis, Lake Austin, Town Lake and the Edwards Aquifer. The Comprehensive Watersheds Ordinance requires the strongest nonpoint source controls in those developments in watersheds which contribute to the drinking water supply.

Targeting new development is seen as a cost effective method of preventing future nonpoint source problems. Required controls which are prescribed in the Ordinance

[19] Ibid.

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can be included in the initial land planning. Since the primary controls set forth in the Ordinance are non-structural, raw land cost is the main cost for new development associated with nonpoint source controls. However, structural controls are also used and these have a cost to the developer. Since impervious cover limitations are the most important non-structural control specified in the Ordinance, retrofitting existing development has proven to be difficult. Retrofitting structural controls has also been difficult, due to limited location and high land costs.

The City's retrofit program uses public education as its main tool to build and keep the necessary public support for storm water management programs through the use of videos, posters, and other media. In addition, Austin has initiated a process of storm water retrofit master planning as a way of maximizing the scarce public resources available for this purpose.

Developing a strategy for controlling nonpoint source pollution from urbanized watersheds is particularly difficult, and much more complex than preventing nonpoint source pollution from developing watersheds. Retrofitting BMPs in urban areas is still a "pioneering" activity and involves considerable experimentation and cost. While there are an increasing number of localities pursuing retrofit strategies, there is no broad national experience with retrofit implementation. BMP selection in retrofit situations is also problematic; for example, wet ponds are an excellent BMP for controlling nutrients, yet they are often very difficult to site under retrofit conditions.

Non-degradation Strategy[20]

Austin has developed a non-degradation strategy for a particularly sensitive and important area known as the Barton Springs Zone, which covers several watersheds. The strategy is "design-based" rather than being entirely a technology- or performance-based approach. The design-based approach requires that compliance be designed into a project before it is built based upon best available scientific and engineering principles. This strategy includes a City-funded program for retrofitting storm water controls.

Other elements of the non-degradation strategy include:

- strengthening existing regulations by limiting exemptions
- limiting impervious cover to levels at which generated pollutants can be

[20]Parrish/Stecher, "Nonpoint Source Pollution Control in the City of Austin," March 1991., p. 12

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reduced to background levels by an array of storm water control practices

Importance of Non-structural Controls in Austin's Program

One of the distinctive features of Austin's storm water management strategy is the emphasis given to the use of non-structural controls. The basic assumptions of this approach are the following:[21]

- structural controls alone cannot prevent an increase in pollutants from high intensity development
- maintenance requirements are high for structural controls compared to the maintenance needed for impervious cover limitations and buffer zones
- sole dependence on structural controls is not wise for protecting the City's water resources; a combination of structural and non-structural controls is the best strategy

Institutional Issues

Austin created a city department of environmental conservation, the Environmental and Conservation Services Department, in 1987. Its central focus is resource conservation and environmental protection, as distinct from public works. This department is co-equal with other City departments. It oversees the work of public and private agencies under its jurisdiction. This institutional arrangement is clearly intended to provide support for effective environmental and regulatory (enforcement) action.

The Environmental and Conservation Services Department and the Department of Public Works "share" a drainage utility (storm water utility). Drainage projects are funded with fees from the drainage utility. "Storm water" is not separately identified on the utility bill, nor described as such officially.

Costs and Financing

Most storm water programs are funded by the drainage utility. or drainage fee. Public works drainage projects in the Capital Improvements Program are paid for with bond sales which are repaid with tax (general fund) revenues at this time.

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[21]Parrish/Stecher, "Nonpoint Source Pollution Control in the City of Austin," p.6

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Development is expected to "pay for itself," that is, development must pay for the cost of controls associated with that development. However, in reality, development fees pay for approximately 30% of the land development review and permit programs. Nevertheless, the program's emphasis on non-structural controls means that the cost for the City is considerably lower (because of less monitoring and inspection) than if structural controls were the sole means of control.

The Austin program also takes the view that preventing adverse water quality impacts from nonpoint source pollution is much less expensive than trying to restore water quality after it has been degraded. One of the stated goals of the Comprehensive Watersheds Ordinance is to avoid the cost of retrofitting existing development.

There are significant costs throughout the institutional structure related to control of nonpoint source pollution. Preventing NPS pollution can avoid or reduce other costs such as wastewater treatment, the need for dredging lakes and waterways, and health risks associated with toxics pollution. The Austin view is that the cost of restoration, retrofitting, dredging, advanced types of water treatment, development of new water supplies, and lost recreational and economic values can easily dwarf the cost of prevention.[22]

Other NPS Control Programs

The City of Austin has also initiated non-structural and low-structural development controls to limit impervious surface areas for storm water management purposes. They have established a critical zone in which no construction is allowed, as well as a transition zone where development is limited or not allowed in order to preserve riparian areas.

Other programs which the City has instituted to control urban nonpoint source pollution include the following pollution prevention and source control programs:

- household hazardous waste collection: provides for safe disposal of hazardous materials
- street cleaning and litter collection program
- xeriscape and integrated pest management (IPM) programs: minimizes inputs to the environment from fertilizers and pesticides; both approaches stress the minimal use of the least harmful substances to control pests and weeds; IPM is encouraged in municipal operations

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[22]Parrish/Stecher, "Nonpoint Source Pollution Control in the City of Austin," p.7

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BMP Siting Considerations

There is a diversity of opinion as to whether it is better to construct large regional BMPs or numerous smaller BMPs closer to pollutant sources. The preferred approach in Austin is to construct numerous smaller BMPs and capture water as close to the source as possible for the following reasons:

1) need to capture less water to achieve the pollutant removal desired

2) capital and maintenance costs are less if the BMPs are smaller

3) maintaining the natural hydrology is easier with smaller BMPs - in addition, the need for groundwater recharge is addressed, whereas if channeling water further down the watershed was done, groundwater recharge would not occur (or recharge of polluted water could occur before the runoff reached the treatment device)

4) protection of smaller waterways from pollution and channel erosion

Summary and Conclusion

Austin has attempted to come to terms with its nonpoint source pollution problems through implementation of the Comprehensive Watersheds Ordinance and other ordinances since 1986. The City recognizes the actual and potential costs of nonpoint source pollution as it relates to safeguarding of drinking and groundwater supplies, maintaining tourism and recreational opportunities, and protecting wildlife habitat, to name a few.

Austin is "ahead of the curve" in terms of meeting EPA and state water quality goals. These efforts will continue to pay benefits into the future. The development and implementation of the Comprehensive Watersheds Ordinance could be a model for other local governments in their efforts to control nonpoint source pollution.

Relevance of Austin's Watershed Approach for Other Jurisdictions

Austin's Comprehensive Watersheds Ordinance is easily transferable to other jurisdictions and to other hydrogeologic conditions. The Texas Water Commission cited Austin's Ordinance as an example of the kinds of controls which local governments in Texas could implement as part of the Nonpoint Source Management Plan which the state submitted to the U.S. Environmental Protection Agency.

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Because the Ordinance is based on BMPs instead of on design or performance standards, it is widely applicable to other situations and does not require specialized staffs for its implementation. The Ordinance is accompanied by a technical manual which specifies the technical aspects of the controls which it requires.

Numerous other jurisdictions in Texas have adopted watershed protection ordinances based on the same framework as Austin's. Governmental entities across the country have requested copies of the Comprehensive Watersheds Ordinance for guidance on how to protect their water resources and control nonpoint source pollution.

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Steps to Implementation

1) Comprehensive Planning Process: "Austin Tomorrow"

2) Appointed Watershed Ordinance Task Force

3) Consolidation of Watershed Protection Ordinances

4) Passed Comprehensive Watershed Ordinance

5) Targeting of Critical Areas: Austin's strategy uses targeting of critical areas to achieve cost effective control.

- Controls for New Development
- Identify Candidate Retrofit Sites

Retrofit Program

A strategy for controlling nonpoint source pollution from urbanized watersheds involves considerable coordination, experimentation and cost.

1) Use Public Education to Build Support

2) Use Retrofit Master Planning to Maximize Scarce Resources

For more information...

For more information about the City of Austin's program, call the Environmental and Conservation Services Department at (512) 499-2501.

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City of Orlando, Florida

Introduction

The City of Orlando, Florida has taken a pioneering role in trying to solve its water quality problems related to urban storm water runoff. Protection of its numerous lakes and wetlands has been a primary motivation for action. Within the corporate limits of Orlando there are some 83 named lakes, which lie within five major drainage basins. The City has the distinction of having been designated a "National Storm Water City of the Year" by the U.S. Environmental Protection Agency. It earned this distinction because of its aggressive storm water management and retrofit program.

Some of the innovative storm water treatment systems and retrofit methods used in Orlando include storm water wetlands, alum injection, exfiltration, lake aeration, sediment control devices, trash screens and shoreline and littoral zone vegetation.

Some of the other approaches being used in Orlando are:

- storm drain retrofits and water quality enhancements when performing corrective maintenance (e.g., vertical volume recovery unit for drainage to Lake Lawsona)
- exfiltration basin retrofits to existing city storm drains
- littoral zone enhancement and revegetation with native aquatic plants
- creation of storm water wetlands for pre-treatment of runoff entering lakes (e.g., Lake Lorna Doone)
- depressional landscaping to encourage runoff infiltration (e.g., Lake Ivanhoe)

One of the many major retrofit projects in the Orlando area is the Lake Greenwood urban wetland, which is a wetland and storm water management system in an urban environment close to downtown Orlando.

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Evolution of the Florida Storm Water Program/Major Regulatory Components

The major components of Florida's storm water program are three pieces of legislation: the 1982 storm water permit requirements for new development; the 1987 Surface Water Improvement and Management Act (SWIM), which provided a framework for watershed planning; and the 1989 storm water legislation, which established program goals and extended program coverage to existing agricultural and forestry sources.

The Surface Water Protection and Management section of the 1989 storm water legislation provides the regulatory framework for the Florida storm water management program, particularly the watershed approach. This program was enacted by the Florida legislature to restore the state's degraded water bodies and to protect those still in good condition.

The landmark 1989 storm water legislation was intended to integrate the various existing storm water laws and programs into a comprehensive watershed management program. Most importantly, the 1989 law emphasized the watershed approach to correcting existing storm water deficiencies and it gave a regulatory impetus to retrofitting. The 1989 law also established the State Storm Water Demonstration Grant Program which provides matching grants for storm water treatment projects undertaken by local governments which have implemented storm water utilities. The grant program is clearly an inducement to Florida municipalities to set up storm water utilities.

Lessons Learned in Florida's Storm Water Program

The Florida storm water program has been successful at minimizing storm water problems associated with new growth, but it has been much less successful in restoring water bodies degraded by storm water discharges. The piecemeal approach cannot address one of the state's largest problems, however, the problem of retrofitting drainage systems, which includes:

- retrofitting of existing storm water drainage systems to reduce pollutant discharges to state waters
- correcting storm water infrastructure deficiencies related to the state's rapid growth

Livingston stresses that the solution is comprehensive and coordinated work

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throughout the watershed.[23] He emphasizes the need to address land use, water resources, and infrastructure planning within a watershed context. He also states that a dedicated funding source, such as a storm water utility is also important for maintaining an effective program.

Lessons Learned in Orlando

The Orlando experience suggests that one of the requirements for successful urban runoff control and retrofit projects is the importance of control of the project and the need to write very good specifications so that water quality goals are met. Engineers and consultants may have an economic incentive to design BMPs which may not be commensurate with the implementing authority's water quality goals.

Experience reveals that engineers and consultants may sometimes have a mechanistic approach to problem solving and therefore advocate a hydraulic solution rather than water quality one in some instances. They know how to get the water off-site as quickly as possible, but this is not necessarily commensurate with a water quality solution.

The best way for the implementing authority to ensure success is to be in control of the project, to know the solution that is necessary, and then see that it is done correctly.

Greenwood Urban Wetland

The Greenwood Urban Wetland in Orlando is a constructed urban wetland located within a 522-acre drainage basin. Storm water runoff collected within the 522-acre sub-basin flows into Lake Greenwood, which lies at the lowest point in a 4.5 square mile urbanized area. The artificial wetland was built to alleviate flooding, to pre-treat storm water runoff prior to discharge into drainage wells (which discharge water to the upper Floridan acquifer), and to re-use the stored water to irrigate an adjacent cemetery and park. City-owned land which was previously vacant was excavated to form a series of ponds and a bypass stream leading to five drainage wells.

The storm water quality enhancement component of the wetland plan came about as a result of the City's concern for protecting its groundwater supply. Proximity to groundwater is a prime concern in most of Florida.

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[23]Livingston, Eric H., "Lessons Learned from a Decade of Stormwater Treatment in Florida." Bureau of Surface Water Management, Florida Department of Environmental Regulation, Undated.

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The storm water "treatment train" concept was incorporated into the Lake Greenwood urban wetland. The BMPs included in this treatment train are: a sediment and trash screening device; a littoral zone with vegetation; and aerators to increase microbiological activity.

Effectiveness of the Greenwood Urban Wetland

Water quality monitoring of Lake Greenwood was begun in 1987 - one year prior to the beginning of construction of the wetland. This was done to obtain a baseline profile and to ascertain the trophic state of the lake. Both before and immediately after construction, the lake exhibited eutrophic to hyper-eutrophic conditions. After completion of the project, the lake's trophic state indices were in the mesotrophic range.

Prior to construction, the water quality of Lake Greenwood was not in compliance with Florida Class III (recreation and wildlife propagation) water quality standards. Since construction, there have been no water quality standards violations of any parameters tested, including EPA-listed pesticides. Further monitoring of the storm water treatment system is being planned for wet weather pollutant removal efficiencies and further hydraulic analysis. An ongoing storm water monitoring program was begun in 1991.

Based on the preliminary sampling data, it is clear that the Lake Greenwood urban wetland storm water management system has enhanced water quality within the lake and also the quality of the water discharged to the drainage wells (which discharge to a major acquifer).

Development of Orlando's Storm Water Utility

Storm water projects in Orlando have traditionally been financed out of general fund revenues, as is common in most municipalities. In addition, Orlando has used revenue from a state gasoline tax for projects which also have a road/transportation component. Depending upon general fund revenues, however, often results in projects being deferred to pay for more critical governmental functions such as police and fire. The City has adopted an aggressive program of storm water system repair and replacement, pollution control, and lake enhancement. This problem has been funded in the past through the City's general property tax budget, but this source is no longer adequate for the scope of the problem today, particularly in view of increasingly stringent state and Federal water pollution control requirements.

To provide for the effective management and financing of a storm water system within the City of Orlando, the City established a storm water utility. The storm

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water utility generates its revenue through user fees. A storm water service charge is levied on every parcel of land in the City. The fee is based on the amount of storm water which a particular parcel passes on to the storm water drainage system.

The storm water utility is responsible for the operation, construction and maintenance of storm water management devices, for storm water system planning and lake management.

Packed Bed Storm Water Filter Artificial Wetland[24]

One innovative project which was proposed by the City and implemented through a consultant was the "packed bed filter." This experimental storm water BMP will be used (just coming on line in July 1993) to treat a small but highly urbanized portion of the drainage basin which flows into Clear Lake. The project was initially proposed in response to concerns about the lake's water quality.

The drainage basin for Clear Lake consists of over three square miles of highly developed urban area. This retrofit technique became necessary because best management practices (BMPs) for new development are not appropriate in the highly urbanized and completely built-out Clear Lake basin. This innovative method of storm water treatment was selected both for its presumed pollutant removal efficiency, as well as the necessity of using a BMP which could function within a limited area where land utilization constraints exist.

The packed bed filter is an example of technology transfer - a common wastewater treatment technique which has application to urban storm water pollution treatment. The filter utilizes a treatment train of two components, one of which is a packed bed filter system planted with wetland macrophytes for nutrient uptake. Put more simply, the system is a packed-bed filter (similar to a trickling filter) with hydroponically-growing aquatic plants. During dry weather or low flow conditions, the device will treat water from Clear Lake using the continuous flow to maintain the planted beds.

The device has a limited storage volume, so a decision was made that in order to maximize the removal of the most pollutants, the goal would be to capture less than the first one-half inch of runoff from a larger acreage than a greater amount from a smaller acreage. It is hoped that this will result in the treatment of a dirtier waste stream and reduce the amount of pollutants reaching the receiving waters of Clear Lake.

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[24]Dyer, Riddle, Mills & Precourt, Preliminary Engineering Report: Packed Bed Filter. Prepared for the City of Orlando, FL, April, 1991, p. 4-3.

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Pollutant Removal Efficiency Cosiderations for Packed Bed Filters

Although the packed bed filter implemented by the City of Orlando has only recently been brought on line [July 1993], there are certain operational considerations for packed bed filters as they relate to treating urban storm water runoff. Packed bed systems intended to treat storm water do not have to meet the strict effluent quality criteria that would be required for wastewater. Indeed, the concentration of pollutants in storm water most closely resembles tertiary treated wastewater with the exception of solids concentrations. This is one reason why the packed bed storm water treatment system was designed to treat a larger flow with lesser removal efficiency than a higher removal rate from a smaller flow.

The packed bed filter employs the concept of a "treatment train." The concept of a treatment train of BMPs involves a series of unit operations designed to remove the largest amount of contaminants from runoff, typically greater than the pollutant removal achievable through individual unit operations.

The packed bed filter system is a new technology and a transfer of technology from wastewater treatment systems to storm water management systems. As an experimental practice for storm water treatment, many elements need to be monitored for their relation to long-term effectiveness:

- hydraulic residence time
- bed media
- plant materials for the packed beds
- depth
- travel length
- velocity
- liners

Use of Alum for Treatment of Storm Water Runoff

One technology showing promise is the use of alum to treat storm water runoff. Two lakes in Orlando, Lakes Dot and Lucerne, and one in suburban Winter Park, Lake Osceola, are having their storm water inputs from large urbanized drainage basins pre-treated with alum. The alum treatment concept was initially tested on Lake Ella in Tallahassee.

Alum treatment of storm water runoff was selected after an analysis of the pollution abatement alternatives. Conventional storm water management techniques such as retention, detention, or exfiltration were deemed not feasible due to space limitations, or because of the poor infiltration capacities of watershed soils. The alum is injected and mixes with the storm water in the storm sewer lines. Floc accumulation begins

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immediately and the floc settles on the lake bottom.

Alum injection is wastewater treatment technology being adapted to storm water quality control. There is still some question whether it can be considered a retrofit technology, but its use as a pollution abatement alternative involves many of the hallmarks of a retrofit situation:

- infeasibility of conventional storm water management techniques such as retention/detention
- infeasibility of using exfiltration systems due to limitations of available space and poor infiltration capacities of watershed soils

Another Case Study in Florida

Lake Jackson Regional Storm Water Management System

Rapidly urbanizing areas in the Megginnis Arm watershed were causing water quality degradation in Lake Jackson in Leon County near Tallahassee. A regional storm water detention system was designed and constructed through a cooperative effort of the Florida Department of Environmental Regulation, the Northwest Florida Water Management District, and with funding from EPA's Clean Lakes Program and the State of Florida. The facility consists of a wet detention pond with a heavy sediment basin at the inflow, a sand filter system designed to filter particular pollutants from storm water, and a three-cell constructed wetland designed to remove dissolved pollutants such as nutrients.

Construction of the system was completed in 1983 at a cost $2,664,389. Maintenance operations, which consist of sediment and clay removal from the top of the filter fabric do not exceed $30,000 per year.

Effectiveness of the Lake Jackson facility

Florida State University researchers conducted a long-term storm water sampling program of the facility and its individual components. Overall, the facility has performed up to design specifications within the constraints of space and the technical level of the equipment used. However, the increasing urbanization of the watershed has resulted in larger volumes of storm water draining into the facility, well beyond its design capacity. To overcome these deficiencies, the facility was enlarged to provide longer detention of more storm water, allowing the facility to

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detain larger storms and limiting the discharge of untreated storm water into Lake Jackson.

Lessons learned from Lake Jackson experience

Some of the lessons learned in the construction of the Lake Jackson regional storm water management system include the following design considerations:

- storage volume and the amount of water bypassing the system are critical design elements; the system should be designed based on maximum anticipated buildout in the watershed
- adequate funding must be provided to operate and maintain the system
- wetlands systems require some maintenance such as dredging to remove accumulated sediments and organic matter; they will not work indefinitely without maintenance

For more information:

For more information about the City of Orlando's program, call the Storm Water Utility Bureau at (407) 246-2370.

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County of Fairfax, Virginia

Regulatory Context

Fairfax County, Virginia is subject to the following Federal and State legislation and programs:

- Amendments to the 1987 Clean Water Act requiring NPDES permits for storm water discharges
- Virginia storm water management regulations (at local option)
- Erosion and Sediment Control Law
- Chesapeake Bay Preservation Act
- Section 404 of the Clean Water Act (wetlands protection)
- Water quality requirements under the Reauthorization of the Clean Water Act pending Congressional consideration in 1994

The County may also be subject to some requirements related to recent coastal zone legislation to which Virginia as a coastal state would be subject. States must develop a coastal nonpoint source pollution control program as a requirement of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). The State programs must be approved by EPA and NOAA by 1995.

Background[25]

Fairfax County has been involved in storm water control for more than 30 years. During the 1950s and 1960s, the emphasis was on storm water conveyance and channelization, which included delineation of flood plains and implementation of flood control projects. Beginning in 1972, on-site storm water detention was required for all new development. In the 1980s, water quality BMPs were required for new development in the southern areas of the County draining to the Occoquan reservoir, the major source of drinking water for Fairfax County.

In addition to the Master Drainage Plans which were prepared for all watersheds in

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[25]County of Fairfax, Virginia. Draft. National Pollutant Discharge Elimination System. Municipal Storm Water Discharge Permit Application, Part 2. November 1992.

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the County during the 1970s, a supplemental Regional Storm Water Management Plan was prepared in 1988. This plan provides for regional storm water control ponds to control both quantity and quality. Wherever opportunities exist, the County intends to expand the implementation of regional storm water management ponds from the current pilot project involving seven watersheds. Implementation of the planned storm water control facilities over the past 20 years has resulted in expenditures of approximately $60 million, financed primarily through storm bonds.

There are presently over 1,500 storm water management facilities located in the County. In addition, there are 30 major lakes and over 100 smaller lakes and ponds which function as BMPs and provide water quality benefits in Fairfax County.

In 1989, the Fairfax County Board of Supervisors adopted the "Regional Storm Water Management Plan." The adoption of this plan marked a shift in philosophy on implementing storm water management from reliance on on-site controls to what are viewed as more effective regional controls.

Current Activities

The Fairfax County Department of Public Works is currently in the process of obtaining various permits or implementing programs designed to provide water quality improvements. These activities include:

- obtaining an NPDES permit from the Virginia Department of Environmental Quality; part 2 of the application has been submitted and the County is awaiting approval from the State
- implementing on-site best management practice (BMP) requirements for new developments in Chesapeake Bay Preservation Areas to protect water quality
- implementing a regional storm water management program to provide water quality improvements for both existing and new development, and to protect downstream wetlands and habitat
- implementation of stream channel erosion protection projects
- adopted a Water Supply Protection Overlay District requiring BMPs in the watershed of the County's water supply reservoir
- re-zoned much of the Occoquan watershed [water supply reservoir] to Residential/Conservation District (R-C) with 5 acre minimum lots
- adoption of an Environmental Quality Corridor Policy to protect land

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and surface water resources

Ongoing Activities

As part of the County program to comply with NPDES requirements, there is a 5-year monitoring program of selected storm water outfalls. The outfalls were selected based on different land uses and, based on the final monitoring results, typical pollutant loadings for each land use will be extrapolated.

There are approximately 44 regional storm water management facilities in the Difficult Run watershed alone. The County currently spends approximately $1 to $2 million per year on capital construction for storm water control facilities. However, prior to the recent downturn in the economy, typical drainage facility expenditures totalled $2 million to $4 million per year. Due to current economic conditions, the Fiscal Year 1994 appropriation has been reduced to $341,000.

To pay for these costs out of declining general fund revenues is becoming difficult for the County and this has led to discussion about establishing a storm water utility as a dedicated source of funding for storm water management and control. A storm water utility feasibility study is currently in progress.

Role of the Chesapeake Bay Preservation Act

In Virginia, the Chesapeake Bay Preservation Act (CBPA) is a significant storm water management program through its BMP requirements and use of buffers such as the environmentally sensitive Resource Protection Areas (RPA). The regulatory requirements of this program need to be considered by developers and local governments such as Fairfax County, in addition to other storm water management regulations.

Proposed Management Program

The County's proposed management program consists of the following elements:

- continuation of ongoing requirements and programs such as implementation of the Chesapeake Bay ordinance which requires structural BMPs on all new development
- implementation of suitable water quality control facilities
- providing inspection and maintenance of storm water management facilities

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- increased public awareness of the importance of clean storm water

The County recognizes that the proposed management program will require additional County funds and is currently evaluating the feasibility of establishing a storm water utility to provide a dedicated funding source for storm water management.

The County will look for opportunities to retrofit storm water devices and to implement additional regional ponds in all the County's watersheds in existing developed areas that are now without water quality controls. The County's Comprehensive Land Use Plan also encourages the retrofitting of existing storm water management ponds to become more effective BMPs.

Regional Storm Water Management Plan

In 1989, the County Board of Supervisors adopted a "Regional Storm Water Management Plan" which proposed 134 regional ponds in the most rapidly developing watersheds in the County. The adoption of this plan marked a shift in Fairfax County's approach to implementing storm water management from onsite controls to regional controls. This shift was based on the belief that regional controls are more effective. Concerning the retrofit of existing facilities, proposed development plans are reviewed by the Department of Public Works for opportunities to implement regional storm water management to supplement the pilot Regional Storm Water Management Plan for developing watersheds. In addition, the feasibility of retrofitting existing or porposed flood management projects to include water quality is evaluated.

Non-structural BMPs: Environmental Quality Corridors

Environmental Quality Corridors (EQCs) are the primary non-structural best management practice used by the County to protect water resources. Although the core of the EQC system will be the County's stream valleys, lands may be included within the EQC system if they achieve any of the following:

- habitat quality
- corridor-like quality
- aesthetic quality
- pollution reduction capability

The stream valley component of the EQC system includes the following:

- 100-year flood plains and flood plain soils
- soils with development constraints adjacent to wetlands, streams, and steep slopes

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- additional areas where above-described buffers are insufficient to protect water resources

Current Funding/Future Funding of Water Quality Programs[26]

There are ongoing County water quality programs which are supported out of the General Fund. These programs are:

- monitoring programs
- emergency response
- public awareness
- public facilities maintenance

The County's NPDES permit application clearly states the necessity of developing new funding sources for implementation of capital improvement projects for water quality.

The following point illustrates the tenuousness of funding water quality improvement projects out of general or bond funds: The currently approved bond referendum funds have almost been expended, and the latest storm bond referendum was defeated by voters in 1990. Neither the general or storm bond funds can be relied upon to provide stable funding for future storm water quality capital improvement needs.

Yet the County estimates that $11.79 million per year will be required to implement regional storm water management over the next decade, and to provide for maintenance of these facilities. County staff are determining the feasibility of establishing a storm water utility to provide long term capital as well as maintenance funds for the County's storm water control facilities.

In the interim, two methods to fund capital construction of water quality control improvements are being pursued. These are: use of storm drainage pro rata share program funds; and proffer agreements with developers. Both of these sources are relatively insignificant at the present time, due to the downturn in economic activity.

For more information...

For more information about Fairfax County's program, call the Storm Water Management Branch at (703) 324-5800.

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[26] Ibid.

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City of Eugene

Background

The City of Eugene developed its Comprehensive Storm Water Management Plan (CSWMP) in response to Clean Water Act regulations requiring medium-size cities and counties to improve and manage the quality of their storm water. The plan is a model of a rational and comprehensive approach to dealing with the problem of runoff from urbanized areas. From its beginning as a conventional program emphasizing flood control and rapid conveyance of storm water runoff off-site, the City has developed a plan which does not merely conform with, but exceeds, the evolving Federal mandates for water quality management.

The principal motivation for initiating development of the Comprehensive Storm Water Management Plan in 1991 was the imminent promulgation of a Federal mandate (NPDES) requiring jurisdictions of medium size (between 100,000 and 250,000 population), to reduce discharges of pollutants to receiving waters from storm water runoff.

The Comprehensive Storm Water Management Plan

The City's storm water management program goes further than meeting Federal and state water quality requirements. It has taken the problem of meeting its legal requirements and turned it into an opportunity to offer a broad-based solution through a **multiple objective approach** to protecting, enhancing and restoring the City's water quality.

The multiple objective approach of the Eugene plan includes storm water management. Wetlands adjacent to Amazon Creek and other drainage channels are considered to be hydrologically connected to the City's storm water conveyance system. The plan recognizes the central role that wetlands play in storm water management.

According to the plan, the five-year start-up phase of the storm water management program includes major program activities such as planning and administration, capital projects (including retrofitting), operations and maintenance, enforcement and inspections, and public communications and outreach. The City has already developed a storm water utility and user fee structure.

The City, however, did not have the necessary organizational structure and programmatic resources in place to address the many issues involved in managing

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storm water quality. It determined that the proper way to address the whole range of storm water issues was within a coordinated, comprehensive framework. Among the factors which influenced its decision to develop a comprehensive strategy were the following:

- commitments already made to implement the recently approved West Eugene Wetlands Plan (see below), as well as how the new mandates could be incorporated into this Plan
- a new proposed plan, the Natural Resources Functional Plan, aimed at protecting the city's riparian and waterways corridors; this plan calls for the City's urban runoff management plan to address the relationship between riparian habitat, water quality and flood conveyance
- implementation of other goals and policies contained in the city's general land use plan

The CSWMP encourages this multiple objectives approach to storm water management, including flood control, water quality treatment, and natural resources protection. In addition, it strengthens the existing ordinances and implementation activities already in place.

Relation of the Wetlands Plan to Storm Water Plan

Amazon Creek is the central drainage feature of Eugene. The channelization of Amazon Creek (completed in 1959) significantly altered the hydrologic and hydraulic conditions of the area. Although flood control benefitted the community and allowed agriculture, commercial, and residential development to spread westward in the city, it also had the unfortunate effect of hydrologically isolating surrounding wetlands. This isolation and the subsequent draining of wetlands resulted in environmental degradation.

Consequently, wetland restoration is a high priority for the City of Eugene. It proposes to begin this process through a demonstration project called the Lower Amazon Creek Restoration Project which aims to restore the hydrologic interchange with surrounding wetlands, and restore fish and wildlife habitat and other associated water resource values. This will be accomplished through the removal of levees, in whole or in part; through modifying culverts; and through breaching levees at selected locations.

In addition to restoration of historic wetlands, the city is developing a program to use constructed wetlands for storm water quality treatment. The City is interested in using these constructed wetlands to control (pre-treat) pollutants in urban runoff

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which enters a natural wetland system in West Eugene.

This idea grew out of the preparation and planning to develop the West Eugene Wetlands Plan (WEWP), with the goal being the preservation of the natural system through the pre-treatment of runoff from areas of the City. Without such treatment, the degradation of the remaining existing natural wetlands would be a virtual certainty. Storm water management is seen as critical to the success of the WEWP, and to the survival of the wetlands themselves.

The use of constructed wetlands as a treatment process for urban runoff is emerging as an alternative to conventional processes. Some of the advantages to using constructed wetlands to temporarily store or treat storm water include:

- water quality improvement
- flood, erosion and storm damage reduction
- replenishing surface and ground water supply
- provision of fish and wildlife habitat
- aesthetic or amenity benefit[27]

Regulatory Issues

There are numerous Federal laws and regulations, executive orders, as well as comparable state and local regulations and ordinances which regulate activity in wetlands or potential wetland areas. Current Federal policy forbids the use or modification of natural wetlands to treat storm water.

Nevertheless, the following points should be borne in mind:

- wetlands are functionally part of many municipal separate storm sewers

- wetlands in urban areas may be dependent on storm water for their very existence

Therefore, the strict application of regulations which forbid the degradation of wetlands can have unintended consequences in watershed and wetland planning. The City of Eugene experience suggests that flexibility should be allowed when determining the level of appropriate protection for wetlands and that this can be accomplished through a planning process which involves the local community as well as Federal and state agencies which regulate these resources.

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[27]City of Eugene, OR. Conceptual Engineering Design for Water Quality Workshop. Final Report. Department of Public Works, City of Eugene, OR, undated.

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Eugene's Existing Storm Water Program

The City's current storm water system has historically been focused on providing flood control services. With its emphasis on storm water conveyance and flood control, the existing program was in conflict with Federal mandates for water quality management. Since the natural water quality treatment systems, such as riparian areas, waterway corridors and wetlands have been extensively replaced with conventional, structural conveyance facilities, ways need to be found to not only stem the removal of natural systems, but seek opportunities to preserve them. The CSWMP recognizes this goal and integrates it into the plan.

The City is faced with significant and complex issues as it seeks to transform its existing storm water management program to meet the challenge of complying with Federal mandates and heightened citizens' expectations. The framework of the CSWMP will allow it to do this within a comprehensive planning context.

The City already has a dedicated revenue source to fund general and storm sewer capital projects, the storm water utility user fee. It is the major revenue source for the existing program, and is expected to be the principal revenue source for the new, expanded program. The City has reviewed and analyzed current policy in light of evolving Federal water quality mandates, and has refined its policy to include the following:

- that all users of the storm water system contribute to the financing of the program
- that property owners be encouraged to incorporate practices beyond the minimum required through the use of financial incentives such as fee reductions, etc.

Retrofitting and Eugene's Storm Water Management Plan

Eugene's CSWMP contains a specific capital facilities best management practice (BMP) for retrofitting existing facilities, where feasible and appropriate, to achieve water quality goals. These retrofits may include the installation of in-line sediment traps, detention/infiltration facilities, wetlands or riparian (re)vegetation, or simply the modification of flood control facilities (i.e., storm drain inlets, retention basins, or drainage channels) to function as water quality facilities.

Additionally, the capital facility BMP directly addresses the NPDES requirement that the City assess the existing drainage and flood control facilities in order to determine if retrofitting them would improve water quality.

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The capital facilities program includes retrofitting as one of the major activities scheduled during the five-year start-up phase of the City's comprehensive storm water management program, with retrofit implementation commencing around 1996.

The activities conducted as part of the retrofitting component of the Plan, include:

- preparing a master list of existing facilities with relevant retrofit considerations for each type
- conducting an inventory of existing flood control facilities that will provide information necessary to determine whether retrofits of these facilities are feasible or not
- reviewing inventory results to select sites and facilities where retrofits would be most appropriate
- developing a preliminary plan for retrofitting, with a schedule and estimated costs
- developing funding plans for retrofits

Eugene's Public Outreach Effort

An important feature in the evolution of the City's program are the numerous methods for disseminating information about the development of the storm water management program. These methods range from neighborhood newspapers such as the Eugene Storm Water Connections, with general information about the City's storm water management program, to more targeted information sheets, brochures, and stickers, to community workshops to introduce citizens to storm water pollution issues.

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Important Elements in Eugene's Program

The importance of the West Eugene wetlands to the overall stormwater management plan.

- the integration of natural resource elements into the overall stormwater management framework and looking at the watershed and how it functions as an integrated unit

The significance of the multiple objective planning approach and why it could be a model.

- opportunity to address urban runoff issues from a comprehensive perspective, including wildlife habitat, recreation, resource conservation education, etc.

The high level and quality of citizen involvement and how this reduces conflict.

- widespread citizen involvement with two-way communication and feedback mechanisms facilitates consensus decision-making

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For more Information...

For more information about the City of Eugene's storm water program, contact the Storm Water Program Coordinator at (503) 683-6839.

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City of Portland

Introduction

The City of Portland, Oregon, has developed innovative and comprehensive urban runoff control strategies to meet the water quality requirements of Federal and state legislation. Its program encompasses a wide range of activities for controlling both point and nonpoint source pollution. The range of activities alone - from transportation improvements to improved pesticides management - serves to illustrate the diffuse nature of nonpoint source pollution.

Portland's storm water management program has been designed to be a constantly evolving program which implements the management practices that succeed, modifies or eliminates those that do not, and seeks to develop the most efficient and productive practices throughout the program's life. Based on a balanced economic and environmental approach, its goal is to develop and implement the most successful municipal storm water permit program in the Pacific Northwest.

Storm Water Permit Program (NPDES) Activities

The City of Portland, whose total population is roughly 450,000, has been classified as a medium-size municipality for the purposes of the NPDES storm water permitting program because less than 250,000 people are served by its municipal separate storm sewer system. A significant portion of the city is served by combined storm and sanitary sewers, which are subject to other Clean Water Act regulations.

Under Oregon state-wide land use planning law, each city must define an urban growth boundary (UGB) within which urban development is confined. Once approved, they have the force of law. Within Portland's urban growth boundary, six other agencies operate "municipal-like" separate storm water conveyance systems. Together with the City, the six have become co-applicants for the Portland NPDES storm water permit application. The co-applicants include Multnomah County, Multnomah Drainage District #1, Peninsula Drainage Districts #1 and #2, the Port of Portland, and the Oregon Department of Transportation.

Although the permit has not yet been issued, the seven co-applicants are currently conducting a number of programs and practices that directly or indirectly improve the quality of storm water. While the NPDES permit application is a joint effort of all the co-applicants, each co-applicant has responsibility for implementation of their individual storm water management plan.

Significantly, from an institutional point of view, the City's NPDES program implementation schedule has been developed to coincide with the majority of the co-

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applicants' fiscal year budget schedules. The goal of this action is ease of implementation, but it also represents a concrete and very sensible method for facilitating institutional cooperation.

NPDES Program Implementation Strategy

Portland's NPDES program strategy is to build on a foundation of existing urban runoff control practices. The City developed existing management program (EMP) fact sheets corresponding to each regulatory requirement. Portland's proposed NPDES management program emphasizes and builds upon existing storm water controls and management practices. The program intends to limit the introduction of new practices as much as possible, but where appropriate it will phase in new practices during the life of the permit.

However, BMPs were developed to meet NPDES requirements not covered by existing programs. The co-applicants have grouped BMPs into implementation categories:

- public education and involvement
- operations and maintenance procedures
- industrial and commercial controls
- illicit discharge controls
- new development standards
- structural controls
- planning/system preservation and development

Nonpoint Source Program Activities - Some Examples

1. Used Oil Recycling Program

The City has a comprehensive solid waste and recycling program, which includes used oil curbside pickup that properly recycles used oil. Although many jurisdictions maintain used oil recycling programs, few offer pickup of used motor oil as in Portland. (The City also provides yard debris, cardboard, paper, newspaper, and metals residential curbside pickup.)

2. "Skinny Streets" Program

The City Office of Transportation has implemented new design standards for certain street categories in an attempt to reduce environmental impacts, such as minimizing the impervious area of new streets and preserving existing vegetation.

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3. Snow and Ice Control

Sand and gravel materials are used at varying levels and picked up as soon as possible after a storm has passed, which may take a few days or several weeks. By comparison, many jurisdictions remove these materials only after the winter has passed, if they collect them at all.

4. Pesticide/Herbicide Application

All applicators participate in an Integrated Pest Management (IPM) training program. In addition, the City Planning Bureau has landscape requirements which reduce the need for pesticides, herbicides, and fertilizer through the use of native plantings. They are also developing an environmental seed mix.

Approach to Institutional Issues

The process by which the Portland NPDES permit co-applicants put together their storm water permit application reveals some of the institutional issues which impact upon the ability of a jurisdiction to carry out effective storm water management. The seven jurisdictions have different institutional motivations and agendas and degrees of political accountability and these factors affect how they approach and deal with the problem of urban runoff management and control.

For example, the Oregon Department of Transportation (ODOT), one of the seven co-applicants in the permit process, has as its mission the building of roads, not managing storm water. Nevertheless, the ODOT maintains hundreds of miles of storm sewer pipes that collect and transport storm water surface runoff, in addition to open ditches and dry wells. It also has responsibility for 14 major storm sewer outfalls in Portland.

The ODOT, however, is not subject to the same direct political pressures to pursue its storm water management goals as, for instance, the City of Portland. The same holds for the special drainage districts, the Port of Portland and other co-applicants. This presents the potential for different outcomes. Such a divergence of institutional interests and objectives could potentially limit the effectiveness of the storm water management program.

However, the Portland experience illustrates how potentially problematic institutional issues can be dealt with early in the program planning process and the result is likely to be a more effective urban runoff control program. In the process of developing the storm water management plan, the City's consultants worked with all the co-applicants to define and clarify issues related to their proposed BMPs. As part of this process they considered:

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- the department or division within the agency which would be affected by or involved with the implementation of the BMP;

- the agency's existing conditions related to the BMP, and the tasks necessary to implement it;

- the degree to which the implementation of the BMP is likely to affect existing staff and/or resources

The fact that the process used in Portland considers these sometimes subtle but important institutional concerns increases the probability of a successful outcome. It also points up the importance of "issue scoping" and framework development to ensure program effectiveness.

Program Funding

The City finances its storm water management activities through the levy of a drainage fee which is based on the amount of runoff allowed to flow into the storm sewer system. In 1992, the City initiated a storm water drainage discount program. Discounts in the drainage fee are given to propoerty owners who limit the quantity of storm water discharged from their property. The discount may be as high as one hundred percent.

Discounts for water quality are not cuurently included in this program, but the City code permits the imposition of such a fee and discount program in the future. The existing discount program is directed at sites with on-site disposal systems.

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BMP Selection and Screening Factors used in Portland's Planning Process

- Life Cycle Costs - The approximate cost of initial implementation and future operation.

- Regulatory Requirements - Does it meet existing and anticipated Federal, state and local regulations?

- Pollutants - Does it offer reasonable control of the targeted pollutants?

- Implementability - Is it likely to be accepted and funded by the various public agencies, city departments, and the general public?

- Reliability - Does the BMP function predictably and is it effective over time?

- Environmental Impact - Consider the environmental impacts and benefits of the BMP.

- Equitability - How are the costs and benefits of the BMP distributed?

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Portland's proposed NPDES stormwater management plan is innovative and has the following components:

- It emphasizes **non-structural** source controls including education and maintenance programs.
- It builds upon **existing** programs such as curbside recycling, household hazardous waste collection, etc.
- It encourages **regional efforts** and programs.
- It emphasizes **cooperation** among its NPDES co-applicants to improve water quality.
- It **phases in** management plans to allow for budgetary and resource constraints.

Portland's NPDES program highlights

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Portland's Compliance Strategies

- Consider urban runoff issues as permanent issues which require a long-term planning approach.
- Share information and ideas and look for opportunities to cooperate on projects, or share costs with other jurisdictions, etc.
- Work closely with regulatory personnel throughout permit period to discern their objectives, priorities and intentions.
- Be creative and proactive in complying with permit and regulatory requirements.

For more information...

For more information about Portland's urban runoff management program, please call the Bureau of Environmental Services at (503) 823-7236.

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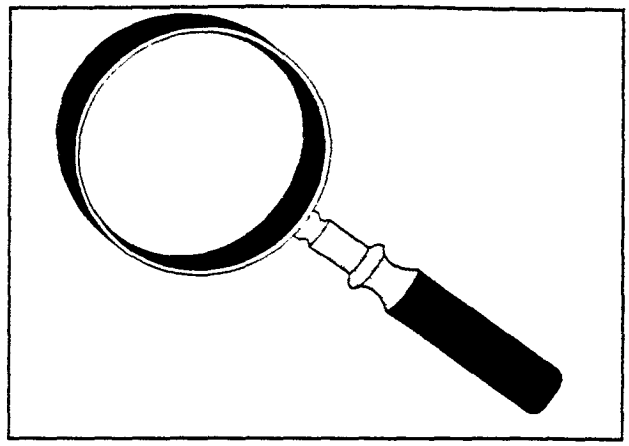

Best Management Practice (BMP): A practice or combination of practices that are determined to be the most effective and practical (including technological, economic, and institutional considerations) means of controlling point and nonpoint pollutant levels compatible with environmental quality goals.

Constructed urban runoff wetlands: Those wetlands that are intentionally created on sites that are not wetlands for the primary purpose of wastewater or urban runoff treatment and are managed as such. Constructed wetlands are normally considered as part of the urban runoff collection and treatment system.

Drainage Basin: A geographic and hydrologic sub-unit of a watershed.

End of Pipe Control: Water quality control technologies suited for the control of existing urban storm water at the point of storm sewer discharge to a stream. Due to typical space constraints, these technologies are usually designed to provide water quality control rather than quantity control.

First Flush: The delivery of a disproportionately large load of pollutants during the early part of storms due to rapid runoff of accumulated pollutants. The first flush of runoff has been defined several ways (e.g., one-half inch per impervious acre).

Impervious cover cap: A mechanism which establishes a Maximum Sustainable Removal Rate for storm water control measures at 90%. The City of Austin, Texas has incorporated this concept into its Land Development Code. It is designed to avoid over-reliance on storm water control measures and recognizes their inherent limitations and risk of failure due to lack of maintenance.

Impervious surface: A hard surface area that either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development and/or a hard surface area that causes water to run off the surface in greater quantities or at an increased rate of flow from the flow present under natural conditions prior to development. Common impervious surfaces include walkways, driveways, parking lots, concrete or asphalt paving, etc.

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Municipal separate storm sewer systems: Any conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains) that is owned or operated by the State or local government entity, is used for collecting or conveying storm water, and is not part of a publicly-owned treatment works (POTW).

NPDES: National Pollutant Discharge Elimination System, created by Section 402 of the Clean Water Act.

Post-development peak runoff: Maximum instantaneous rate of flow during a storm, after development is complete.

Retrofit: The creation or modification of an urban runoff management system in a previously developed area. This may include wet ponds, infiltration systems, wetland plantings and other BMP techniques for improving water quality. A retrofit can consist of the construction of a new BMP in a developed area, the enhancement of an older urban runoff management structure, or a combination of improvement and new construction.

Ultra-urban: Non-conventional BMPs that are particularly suited for use in highly urbanized areas; based on sand filter technology

Urban runoff: That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation. The land area that drains into a receiving waterbody.

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ITEM # 12

GUIDANCE MANUAL FOR IMPLEMENTING MUNICIPAL STORM WATER MANAGEMENT PROGRAMS

August 17, 1994

CHAPTERS 1 - 4

EPA

U.S. Environmental Protection Agency
Municipal Support Division

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL RISK MANAGEMENT RESEARCH LABORATORY
WATER SUPPLY AND WATER RESOURCES DIVISION
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OFFICE OF
RESEARCH AND DEVELOPMENT

February 10, 1998

MEMORANDUM

SUBJECT: Guidance Manual for Implementing Municipal Storm Water Management Programs - Volume I - Planning and Administration

FROM: Diana L. Meola, Secretary
Urban Watershed Management Branch

THRU: Daniel Sullivan, P.E., Chief
Urban Watershed Management Branch
Water Supply and Water Resources Division

TO: Gary W. Hudiburgh, Jr., Chief
NPDES Program Branch
Office of Wastewater Management

Enclosed please find three copies of the Guidance Manual for Implementing Municipal Storm Water Management Programs, Volume I - Planning and Administration which were requested.

Please contact me at (732) 321-6635 if I could be of further assistance to you.

Enclosures

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September 10, 1997
[DRAFT]

GUIDANCE MANUAL FOR IMPLEMENTING MUNICIPAL STORM WATER MANAGEMENT PROGRAMS

Volume I - Planning and Administration

U.S. Environmental Protection Agency
Office of Wastewater Management
Municipal Support Division
Municipal Technology Branch
Washington, D.C. 20460

and

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CHAPTER 1

INTRODUCTION

INTRODUCTION

Urbanization and industrial activities around the country have significantly altered the natural landscape of our Nation's watersheds. This, in turn, has adversely affected both the quantity and the quality of storm water runoff and has contributed to the chemical, physical, and biological impairment of receiving waters. Studies, such as the Nationwide Urban Runoff Program (NURP) study (EPA 1983), have shown that storm water from urban and industrial areas is commonly contaminated by heavy metals, synthetic organics, pesticides, fuels, waste oils, and pathogens.

Congress, recognizing the importance of controlling these discharges, passed amendments to the Clean Water Act (CWA) in 1987 requiring that the U.S. Environmental Protection Agency (EPA) issue regulations addressing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. Promulgated on November 16, 1990, the NPDES regulations establish permit application requirements for operators of certain municipal separate storm sewer systems (MS4), as well as of storm water discharges "associated with certain industrial activity." Regulated municipalities include those cities and counties operating medium and large MS4s (serving a population of 100,000 or greater) and other MS4s specifically designated by the permitting authority.

According to CWA mandate, municipalities regulated under the NPDES program must, at a minimum, achieve technology-based requirements (i.e., must reduce pollutant loadings in MS4s to the "maximum extent practicable" [MEP] and must effectively prohibit non-storm water discharges through their MS4s) as a first step toward achieving loading reductions consistent with applicable water quality standards. While MEP was not explicitly defined by Congress, EPA interpreted it to mean that municipalities will develop and implement comprehensive storm water management programs. These programs, proposed by the regulated municipalities under Part 2 of the permit application, are required to address a number of storm water control measures, including methods to detect and remove illicit discharges entering municipal storm sewer systems, as well as appropriate best management practices (BMPs) to address discharges from industrial, commercial, and development activities.

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At this time, all regulated Phase I[1] municipalities should have submitted both Parts 1 and 2 of the municipal storm water permit application and will soon begin implementing the storm water management programs they have proposed.

PURPOSE OF THIS MANUAL

The purpose of this manual is to provide practical guidance for municipalities on how to best implement their storm water management programs. As mentioned above, most municipalities have already proposed these programs under Part 2 of the application. Upon approval by the permitting authority, these programs will then be incorporated into the municipality's permit and will serve as the blueprint for the municipality's storm water management activities. Permit conditions, however, cannot specify all the procedures necessary to put storm water management programs into effect. It is suggested that municipalities may need to take steps to ensure that storm water management programs are implemented in a practical, cost-effective manner. As noted throughout this manual, the storm water program is a watershed-based stream protection program. Storm water sources include a host of source categories, many of them associated with residential, commercial, and industrial land uses. This, a host of controls is available for this diverse set of sources. An effective Storm Water Management Program (SWMP) will consider all sources and will provide a framework for establishing control priorities on a holistic, watershed basis.

This manual is intended to help municipalities through this implementation process for their storm water management program. A basic seven-step planning process described in this chapter provides a framework for effective decision-making and long-term planning. Municipalities are encourages to revisit decisions made during Parts 1 and 2 of the permit application process to reassess their overall planning strategies, selected controls, policies, and programmatic measures. In addition, this manual is intended to help municipalities transform their storm water management program elements from words into action. For example, many municipalities pledged to develop "public outreach programs" to promote awareness about the effects of storm water runoff. But how should such programs be structured? What are the most cost-effective methods for educating community members? What are the advantages of pursuing a public outreach program versus a public participation event? This manual will help municipalities answer such questions and provide guidance on implementing storm water management program activities into the future.

Finally, this manual emphasizes a watershed protection approach, an integrated, holistic strategy for more effectively restoring and protecting aquatic ecosystems and protecting human health. This approach represents a renewed effort by EPA to focus on hydrologically defined drainage basins—watersheds—rather than on areas defined solely by political boundaries. For a given watershed, regulated municipalities are encouraged to consider not only the water resource (e.g., stream, lake, estuary, or aquafer) but all the land from which water drains to that resource. As water drains off the land, it carries with it the effects of human activities throughout the watershed.

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[1]Pursuant to Section 402(p)(2) of the Clean Water Act, Phase I of the storm water program covers the following: A) a discharge with respect to which a permit has been issued under Section 402 before February 4, 1987. B) a discharge associated with industrial activity, C) a discharge from a municipal separate storm sewer system serving a population of 100,000 or more, and D) a storm water discharge that the administrator or State determines may be contributing to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. Phase II of the storm water program potentially could cover any sources not covered under Phase I. A request for public comment on Phase II targeting and control options appeared in the *Federal Register* on September 9, 1992.

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Consequently, to protect water resources, it is important to address the condition of land areas within the watershed. By concentrating on natural resources and systems, it is possible to detect and take remedial action for such problems as declines in living resources and habitat loss, as well as to identify the more commonly recognized problems associated with elevated pollutant concentrations. This manual provides guidance for municipalities to implement their storm water management programs within a watershed protection framework.

INTENDED AUDIENCE

This manual is intended to provide guidance for regulated municipalities as they begin implementing their storm water management programs. Regulated municipalities include cities and counties operating municipal separate storm sewer systems that serve populations of 100,000 or more, as well as certain municipalities specifically designated by the permitting authority. Individuals from a variety of different municipal departments could potentially be involved with program development and implementation and will benefit from reading this manual. Table 1-1 identifies the municipal agencies and personnel who may be involved in implementing the storm water management program. This manual is also intended for use by State and Federal employees assisting municipalities to meet their NPDES storm water program objectives.

TABLE 1-1. AGENCIES AND PERSONNEL INVOLVED IN Storm water MANAGEMENT PROGRAM DEVELOPMENT/IMPLEMENTATION

Municipal Agencies	City/County Personnel	Other Members of Community
Building Department City/County Attorney's Office Department of Environmental Management Engineering Department Fire Department Health Department Planning Department Police Department Public Works Department Site Plan Review Department Water and Sewer Department Zoning Department	Council members or other elected officials Emergency response teams Engineers and environmental planners Financial officers Inspectors Public health officers Public outreach personnel Public works directors Site/building inspectors Site plan reviewers Treatment works operators Zoning board members	Community representatives Educators Environmental advocates

ORGANIZATION OF THIS MANUAL

This manual, organized in a two-volume set, provides specific guidance on how to implement particular aspects of the storm water management program. The manual does not track all requirements of the two-part permit application; rather, it addresses certain elements of the storm water management program (developed under Part 2 of the application) that could be problematic for municipalities to implement, such as illicit detection and removal procedures, public education efforts, and ongoing monitoring programs. Case studies from municipalities around the country have been provided at the end of each chapter. Wherever possible, worksheets, pictures, maps, and charts have been included to help illustrate a particular process.

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Chapters, in each volume, are organized as follows:

Volume I: (Planning and Administration)

- **Chapter 1:** Provides an overview of the NPDES storm water program, reviews the topics addressed by the manual, outlines the storm water management program planning process, and examines the relationship between the NPDES program and other urban runoff management programs.
- **Chapter 2:** Helps municipalities establish priorities for storm water management activities to ensure the greatest return on their investment. The chapter also provides methods for ranking problems (i.e., pollutant sources and receiving waters) and appropriate controls.
- **Chapter 3:** Offers hands-on guidance for fulfilling certain administrative requirements, including procedures for developing effective public outreach/public participation programs, financing the storm water management program, and completing required annual reports.
- **Chapter 4:** Provides specific policy guidance on how municipalities may develop effective programs to detect and remove illicit discharges into their MS4s.

Volume II: (Technical Approach)

- **Chapter 5:** Updates guidance on developing sampling and monitoring programs/procedures for the detection of illicit entries into storm water drainage systems;
- **Chapter 6:** Updates information on storage and/or treatment facilities for urban storm water;
- **Chapter 7:** Provides matrices of source control (or nonstructural) and structural BMPs indicating applicability, effectiveness, advantages, and disadvantages of particular controls;
- **Chapter 8:** Compiles guidance on operation and maintenance required for structural BMPs and residuals management practices;
- **Chapter 9:** Develops methodology for evaluating and designing wetland systems for urban storm water pollution control.

DIFFERENCE BETWEEN THIS MANUAL AND OTHER PUBLICATIONS

A number of guidance materials address municipal storm water permit application requirements and urban runoff management as listed in this chapter references, including the following EPA publications:

- *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (April 1991). (EPA 1991a)

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- *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (November 1992). (EPA 1992a)

This manual differs from most of the other publications because rather than focusing on completing municipal permit application requirements, it provides guidance on how to develop and implement a long-term, cost-effective storm water management program. Specifically, this document will help municipalities to set priorities for successful program implementation. While the manual concentrates on NPDES requirements, it also encourages municipalities to consider a broad range of related storm water/watershed management programs (e.g., nonpoint source programs or coastal zone nonpoint pollution control programs). This holistic approach to storm water management provides a framework that allows a municipality to integrate its storm water program effectively with other watershed protection efforts at the local, State, and Federal levels. This manual is part of a family of literature available from EPA, states, and other sources. Where information is already provided in other publications, the manual will direct the reader to those documents.

OVERVIEW OF PART 1 AND PART 2 PERMIT APPLICATION REQUIREMENTS

Before outlining the seven-step planning process of storm water management program development, it is important to review briefly the municipal permit application requirements at 40 CFR (EPA 1991b) Part 122.26(d). The regulations established a two-part application requirement for municipalities operating large or medium MS4s.

Part 1 of the application required municipalities to gather information about existing watershed conditions and storm water management activities. In addition, they were to examine existing legal authorities to enforce their storm water management programs. Part 1 also required that field screening of major outfalls be conducted to characterize storm water discharges and detect illicit connections in the storm sewer system. The deadlines for submitting Part 1 permit application for large municipal system (>250,000 population) and medium municipal system (100,000 to 250,000 population) were November 18, 1991 and May 18, 1992, respectively.

Part 2 of the application required municipalities to elaborate on information provided in Part 1. Applicants were to establish adequate legal authority, provide additional information on pollutant sources, collect quantitative data from selected sampling points, and analyze fiscal needs versus available resources. Once existing conditions had been assessed and monitoring data collected, municipalities were required to propose a comprehensive storm water management program. The deadlines for submitting Part 2 permit application for large municipal system and medium municipal system were November 16, 1992 and May 17, 1993, respectively. Figure 1-1 summarizes the key elements that required for application of Part 1 and Part 2 storm water permit.

DEVELOPING A WATER MANAGEMENT PROGRAM: THE PLANNING PROCESS

As noted above, this manual delineates a basic seven-step planning process that will help municipalities design cost-effective and sensible storm water management programs. For municipalities that have already completed Parts 1 and 2 of the NPDES municipal permit application, this planning process may suggest ways to improve or enhance the proposed storm water management program. The flow chart appearing in Figure 1-2 has been developed to give municipalities a sense of how each step in the planning process logically leads to the next and ultimately of how the process feeds back into itself, thereby forming a cycle.

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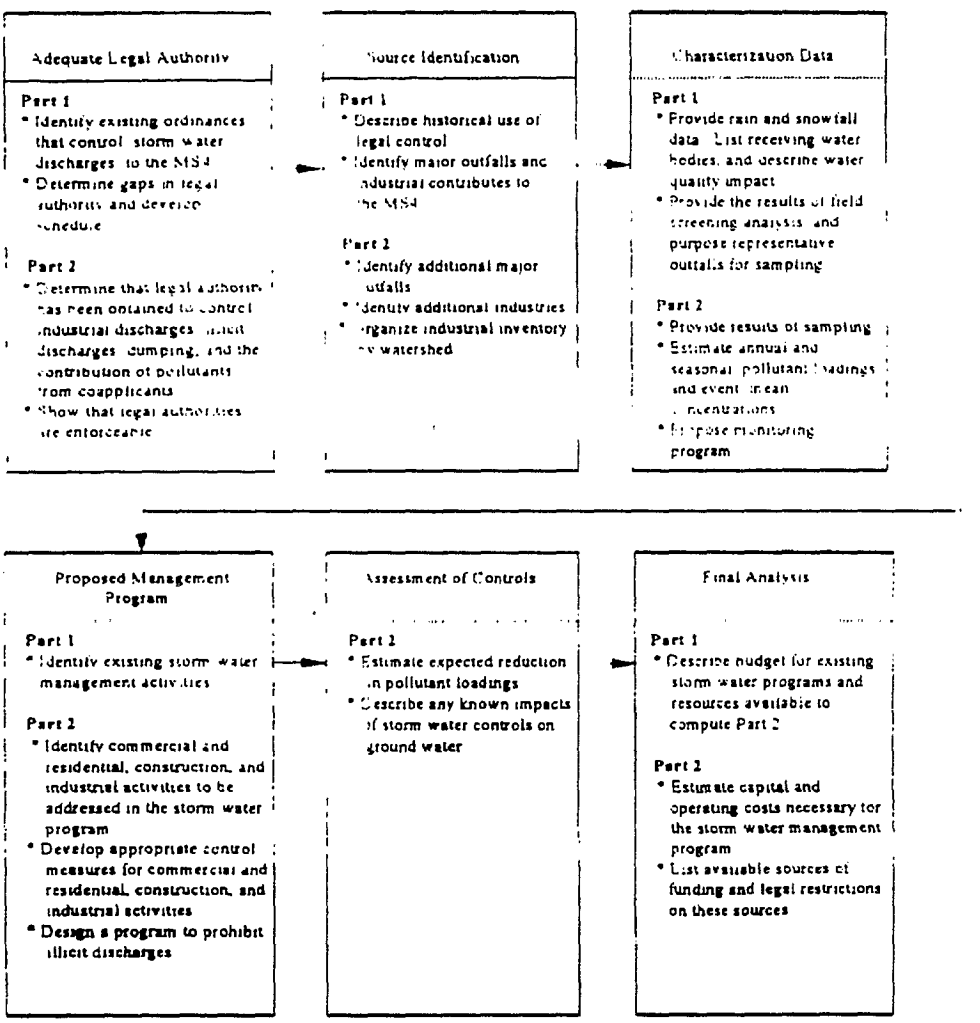

FIGURE 1-1. PART 1 AND PART 2 STORM WATER APPLICATION REQUIREMENTS

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After the flow chart, a brief description of each planning step is provided. Other useful guidance materials are listed under the Reference section at the end of this chapter

- For detailed guidance on Steps 1 and 2 (assessing existing conditions and setting goals), refer to *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Storm water Discharges From Municipal Separate Storm Sewer Systems* (April 1991) and *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Storm water Discharges From Municipal Separate Storm Sewer Systems* (November 1992).

- Steps 3 and 4, which describe methods for ranking pollutants sources and impaired watersheds and for ranking control measures, are addressed in Chapter 2.

- Step 5, which identifies storm water management program administrative requirements, is further discussed in Chapter 3 (guidance for developing public outreach/public participation programs) and Chapter 4 (guidance for developing an illicit detection/removal program).

- Step 6, which addresses data collection programs, is further discussed in Chapter 5.

- Step 7, which addresses evaluating the effectiveness of the program, is elaborated upon at the end of Chapter 3. Other useful guidance materials are listed under the Reference section at the end of this chapter

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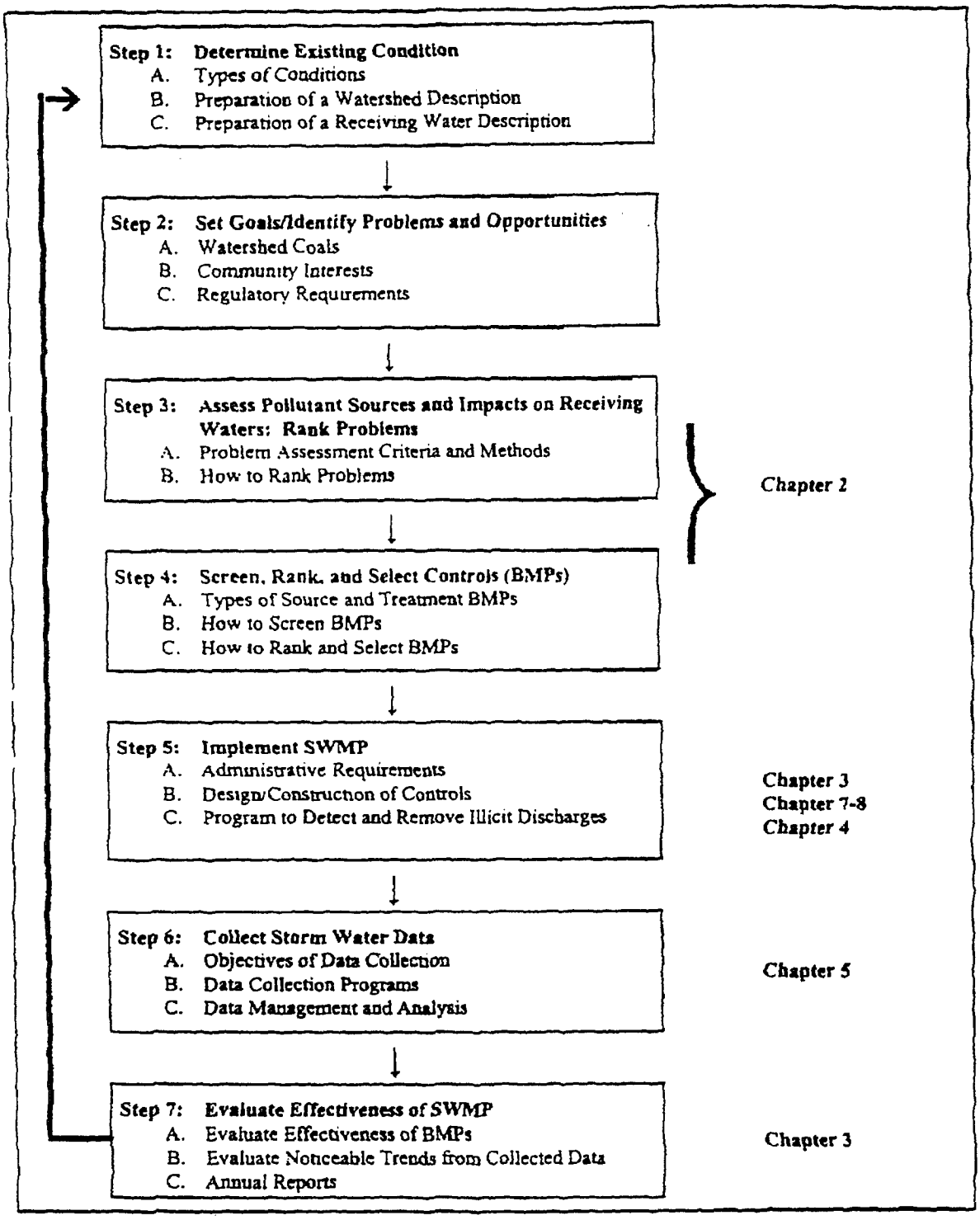

FIGURE 1-2. THE SEVEN STEP STORM WATER MANAGEMENT PROGRAM PLANNING PROCESS

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THE SEVEN-STEP STORM WATER MANAGEMENT PROGRAM PLANNING PROCESS

Step 1: Define Existing Conditions

Types of Conditions

The municipality must assess existing water resource conditions to set its initial program goals. Much of this information was collected during Parts 1 and 2 of the municipal permit application. Guidance on how to begin to assess existing conditions may be found in the *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer System*. Existing conditions that should be assessed for the SWMP include those identified below.

Pollutant Sources

Municipalities must identify areas or sources known or suspected to contain significant concentrations of pollutants, including industrial sites (those required to obtain permits under the NPDES program), commercial areas, residential areas, and construction activities. In some cases, these areas of concern may be defined on a categorical basis (e.g., all service stations), while in other cases, the area of concern may be more site-specific (e.g., a particular service station). A significant nonpollutant source of concern is excessively high flow, which results in bank erosion, channel scouring, and sediment deposition.

Receiving Waters

Understanding the characteristics of receiving waters is essential for storm water management program development. Municipalities should evaluate available data on the physical, chemical, and biological conditions of receiving waters—and examine existing uses versus designated uses for particular resources—to determine which waterbodies and which specific areas demand highest priority. A wide range of information should be available from State and Federal agencies and local universities. Similarly, the planning and public works department should have relevant information on receiving waters in its possession.

Watershed Characteristics

In addition to identifying pollutants sources and their impacts on receiving waters, municipalities should assess other aspects of the watershed, such as land use and development patterns (e.g., general program, zoning, subdivision requirements), physical characteristics (e.g., soils, slope, subsurface conditions, climate), and characteristics of the drainage system (e.g., physical storm drain characteristics, base flow characteristics, and water quality objectives). Again, such information should be available from existing sources, including local, State, and Federal agencies.

Institutional Considerations

In Phase I, municipalities have assessed their institutional issues for developing and implementing a storm water management program. However, the items to consider in this phase are funding mechanisms, available staffing, legal authority to carry out storm water management program activities, and the institutional ability in marshalling joint efforts for storm water management among different municipal agencies. Municipalities should consider existing municipal programs that either affect storm water quality (e.g., road maintenance) or that may be expanded to address storm water concerns (e.g., pretreatment, fire inspections).

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Community Character

To ensure the political and financial support of SWMP activities, municipalities must work in conjunction with community members to determine what issues are important to them and which programs they would be likely to support. The factors to consider include municipal demographics; types of community organizations; environmental, land use, and aesthetic issues; and the local business climate.

Existing Programs and Controls

Many cities and counties already have programs that, to one degree or another, address storm water management. The SWMP will be more cost-effective if municipalities can incorporate these existing programmatic measures or controls into those now envisioned for an expanded comprehensive SWMP. The existing programs to consider include those that currently manage pollutant sources and those that currently manage other activities of parties responsible for pollutant sources.

Preparation of a Watershed Description

Once municipalities have gathered together available data about sources of pollution and the status of receiving waters, these data need to be organized to facilitate decisionmaking for storm water management activities. As discussed in EPA's Part 2 guidance manual, municipalities are required to prepare a map-based watershed description to obtain a visual sense of the topography in their city, drainage areas, locations of industries, and existing control measures and to pinpoint major sources of pollution. Much of the data listed in Table 1-2, which municipalities are required to collect under Parts 1 and 2 of the permit application, can be plotted on a base map to form a watershed description.

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TABLE 1-2. TYPES OF DATA TYPICALLY INCLUDED IN A WATERSHED PROFILE

Environmental	Potential Sources/Existing Structural Controls
• Topography • Land use • Recreational areas (beaches, boating areas) • Designated water uses • Soils and surface/bedrock geology • Vegetation • Natural resources • Temperature • Precipitation • Hydrology	• Landfills • Illicit connections • Waste handling areas • Salt storage facilities • Underground tanks • NPDES industrial activities • Pollution control facilities • Retention/detention ponds • Flood control structures
Infrastructure	**Municipal**
• Roads and highways • Storm drainage systems • Sanitary sewer systems • Treatment facilities • Other utilities (water, electric, gas)	• Population density and projected growth • Zoning • Land ownership • Regulations • Ordinances • Municipal source controls (e.g., street sweeping, catch basin cleaning)

For more information about the sources of watershed mapping and data, as well as methods for analyzing watershed data, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA 1993a.

Preparation of a Receiving Water Description

In addition to preparing a watershed description, municipalities are encouraged to assess receiving water conditions. Effective identification and use of existing water resources data will reduce the schedule program and cost, in some cases by reducing the need for additional sampling and analysis. Municipalities should work closely with States and Regional EPA offices to obtain available data on receiving waters in various States. States must collect receiving water data as required by CWA § 304(1), 305(b), § 314, and § 319 reports. Data should be available from various local departments (e.g., planning, public works, parks and recreation) as well as State and Federal departments (U.S. EPA, United States Geological Survey [USGS], Fish and Wildlife Service, U.S. Department of Agriculture). In some cases, State and Federal agencies may have conducted intensive surveys of a particular watershed or sub-watershed. Municipalities should contact these agencies prior to initiating any data collection efforts on their own or use field data as an initial screening purpose. In addition, volunteer stream monitoring and survey for field verification of stream conditions will be very valuable to the program. Table 1-3 identifies the data that should be collected to prepare a receiving water description.

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TABLE 1-3. TYPES OF DATA TYPICALLY INCLUDED IN A RECEIVING WATER PROFILE

Source Input	Chemical
• CSO data • storm water data • Other NPS data	• Water quality data • Sediment data • Bioconcentration
Physical/Hydrologic	**Biological**
• Physiographic and bathymetric data • Flow characteristics • Tidal elevation in coastal areas • Sediment data	• Fisheries • Benthos data • Biomonitoring data
	Water Quality Standards
	• State water quality standards

For more information about the sources of watershed mapping and data, as well as methods for analyzing watershed data, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA 1993a

Step 2: Set Goals and Identify Problems and Oppertunities:

The primary goal of the Clean Water Act and the NPDES permitting program is to protect the physical, chemical, and biological integrity of our Nation's waters. Toward this end, municipalities are required to develop storm water management programs that will control discharges through their storm sewer systems to the "maximum extent practicable" and to prohibit non-storm water discharges through their MS4s. Within this statutory and regulatory framework, regulated municipalities will define their own set of goals that address all aspects of water quality, including chemical water quality (e.g., toxic substances and conventional pollutants), physical water quality (e.g., temperature, flow, and circulation), habitat quality (e.g., channel morphology, composition, and biotic communities), and biodiversity (e.g, species number and range). Table 1-4 identifies sample goals for a municipal storm water management program.

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TABLE 1-4. EXAMPLES OF SPECIFIC WATER QUALITY, ECOLOGICAL, AND RESOURCE MANAGEMENT GOALS

Parameter	Goal	Reference
Examples of Water Quality Goals		
Dissolved Oxygen	At least 1 mg/l at all times throughout the Chesapeake Bay Dissolved oxygen monthly means concentrations of at least 5 mg/l at all times throughout the Chesapeake Bay, with the exception of subpycnocline waters	Part of quantitative criteria established for dissolved oxygen by the Chesapeake Bay Program
Dissolved Oxygen	3.0 mg/l minimum (for other than early life stages) 4.0 mg/l weekly average minimum 5.0 mg/l minimum for early life stages 4.0 mg/l minimum 5.0 mg/l daily average minimum 5.0 mg/l minimum	EPA water quality criteria Virginia standard Pennsylvania criterion District of Columbia standard Maryland standard
Nutrients	Low enough to prevent nuisance growth of algae, weeds, and slimes	Specific objective under the Great Lakes Water Agreement
Solids (settleable and suspended) and turbidity	Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life	EPA Water Quality Criteria
Mercury	Less than 2.1 ppb/0.025 ppb	Quantitative water quality acute criteria/chronic criteria for priority metal (EPA criteria under development)
Polynuclear Aromatic Hydrocarbons (PAH)	Less than 300 ppb/ND	Preliminary marine water quality criteria under development by EPA
Examples of Living Resource Goals		
Wetlands	No overall net loss	Federal Policy
Wetlands	"...diking, filling, or dredging in existing estuaries and wetlands shall maintain or enhance the functional capacity of the wetland or estuary. Any alteration of coastal wetlands ... shall be limited to very incidental public facilities, restorative measures, nature study, commercial fishing facilities in Bodega Bay, and development in already developed parts of south San Diego Bay..."	Specific objectives set forth in the California Coastal Act
Waterfowl Habitat	Regional land acquisition targets set to meet goals of the Migratory Bird Conservation Act	U.S. Fish and Wildlife Service priority list for land acquisition
Examples of Quality of Life Goals		
Shoreline Access	Substantially expand recreational beach access	So. Carolina's State Comprehensive Outdoor Recreation Program
Park/Recreation Area	Increase urban wildlife programs and public use of opportunities, particularly watchable wildlife programs	U.S. Fish and Wildlife Service "Vision for the Future"

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Step 3: Assess Poll... S...rces and Their Impacts on Receiving Water; Rank Problems:

Once municipa...ed data to determine existing conditions within their jurisdictions, they must determine the mos...ms. During this step, municipalities should consider the following issues: (1) the types of storm ...llution (and their sources) in the watershed, (2) the extent to which these pollution sources affec... water resources, (3) institutional needs and constraints in solving problems, and (4) the deg...ogram goals are being met. Finally, municipalities should take steps to rank their problems using ...aking and analysis methods presented in Chapter 2, which provides additional information on this

Step 4: Screen, Rank, and Select Controls

After municipalities have ranked and targe...ter runoff problems (i.e., particular areas, sources, and waterbodies of concern), efforts can then be focused t...ing those problems in a cost-effective manner. First, the municipality should compile readily available lists of p...lution prevention and treatment practices to assess their relative effectiveness. In most cases, more than one set of BMPs will be identified as feasible to address a particular problem. From the list of feasible alternatives, the municipality will then rank and select its final list of BMPs. Chapter 2 discusses this process of screening, ranking, and finally selecting appropriate BMPs.

Step 5: Implement Storm Water Management Program:

Once priorities have been articulated and a list of BMPs drawn up, the storm water management program team is responsible for moving from planning to implementation as soon as all legal requirements are in place. During this step, near- and long-term program responsibilities must be clearly delineated. All involved persons must be familiar with, and accept their role in, implementing and enforcing the program. Some of the most important aspects of implementing a storm water management program include completing administrative requirements (discussed in Chapter 3), developing a program to detect and remove illicit discharges (discussed in Chapter 4), and knowing exactly when certain BMPs would be effective/appropriate (discussed in Chapter 5).

Step 6: Collect Storm water Quality Data

Although the municipality may ...ly have existing data, additional data will need to be gathered throughout the life of the SWMP. When proposing their monitoring programs under the SWMP, municipalities will have to make important decisions about <u>when</u>, <u>where</u>, and <u>how often</u> to monitor their storm water. Ultimately, the permit writer will establish monitoring conditions for each municipality's permit. Chapter 7 presents detailed guidance for developing municipal in-stream water quality monitoring programs.

Step 7: Evaluate Effectiveness of Storm Water Management Program

The final step, evaluating the effectiveness of the storm water management program, encourages municipalities to reassess decisions previously made and, if necessary, to make alterations in the program plan. As part of this process, the NPDES regulations require that municipalities complete an annual report outlining the effectiveness of their programs on an yearly basis (discussed in Chapter 3).

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DISCUSSION OF RELATED REGULATIONS/STATUTES AND PROGRAMS THAT ADDRESS MUNICIPAL STORM WATER RUNOFF

While this manual focuses on providing guidance for NPDES storm water program implementation, municipalities should carefully consider other related watershed protection programs. By integrating these programs into the storm water programs, municipalities will enhance the overall effectiveness of the SWMP. A knowledge of such programs can save startup costs (e.g., by minimizing the need to collect data that may have previously been collected for other purposes) and long-term costs (e.g., by piggybacking BMP planning and implementation activities with other watershed protection efforts). Furthermore, by working in conjunction with other runoff management programs, municipalities can more efficiently address a broad range of watersheds problems concurrently. Listed below (Table 1-5) and identified in the following paragraphs are related Federal statutes, regulations, and programs that address municipal storm water runoff, pollution prevention, and control

TABLE 1-5. RELATED FEDERAL STATUTES, REGULATIONS, AND PROGRAMS ADDRESSING MUNICIPAL Storm water RUNOFF

- Combined Sewer Overflow Policy
- Nonpoint Source Program (CWA § 319)
- Coastal Zone Nonpoint Source Pollution Control (CZARA § 6217)
- Safe Drinking Water Act
- Clean Lakes Program (CWA § 314)
- 404 Regulations/Wetlands Program
- National Estuary Program
- Federal Emergency Management Agency Regulations
- Pollution Prevention Act of 1990

Combined Sewer Overflow Policy

Combined sewer systems are designed to carry both storm water and sanitary sewage. When wet weather flows exceed the carrying capacity of the system, these combined systems discharge the excess flow through designated overflow points. This event is known as a combined sewer overflow (CSO). Such combined sewer discharges, if not treated before overflowing into receiving waters, can cause significant water resource effects and threaten human health. NPDES permits for CSOs include prohibition of CSOs during dry-weather flow conditions, compliance of all wet-weather CSOs with the technology-based requirements of the CWA and applicable State water quality standards, and minimization of water quality impacts from wet-weather generated overflows.

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Relationship to SWMP Implementation

Municipalities that own/operate both storm sewer systems and combined sanitary/storm sewer systems are required to comply with many of the same NPDES permit program requirements, including the following:

- Receiving water quality assessment
- Monitoring
- Public education programs
- Enforcement

(EPA 1994)

Nonpoint Source (NPS) Program (CWA §319)

Under § 319 states perform nonpoint source assessments of navigable waters of the United States. They must identify impaired and threatened waters, the activities causing impairment, and controls and programs necessary to address impairments. In addition, States must develop Nonpoint Source Assessment Reports and Nonpoint Source Management Programs that include an inventory of BMPs, a schedule containing annual milestones for program implementation and certification of adequate legal authority to be eligible for Federal funding. Under this program, many States have also developed State Priority Ranking Systems and undertaken monitoring programs to track progress

Relationship to SWMP Implementation

Program information may be used by municipalities completing their storm water management programs for the following purposes:

- Assessing wetland boundaries
- Assessing the water quality of receiving waters
- Identifying major sources of impairment of receiving waters
- Identifying and implementing effective controls
- Prioritizing implementation of SWMP components
- Identify Total Maximum Daily Loads (TMDLs).

(EPA 1989a and 1990a)

Coastal Zone Nonpoint Source Pollution Control (CZARA § 6217, EPA 1993b)

The Coastal Zone Act Reauthorization Amendments of 1990 require States with existing coastal zone management programs to establish coastal NPS programs that must be approved by the National Oceanic and Atmospheric Administration (NOAA) and U.S. EPA. This program is limited to NPS pollution control in coastal areas and the contribution of inland sources of pollution to degraded coastal water quality. To secure an approved coastal nonpoint program, States are required to do the following:

- Coordinate existing State programs, including State and local water quality plans and programs under § 208, § 303, § 319, and § 320 of the CWA

- Submit State coastal zone boundaries and § 6217 management areas to NOAA for review and modification, if necessary

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- Implement State NPS control programs in conformance with management measures defined under CZARA § 6217(g) (referenced below) and additional measures where coastal water quality remains impaired.
- Provide technical and other assistance to local governments and the public for implementing additional management measures
- Provide opportunities for public participation in all aspects of the programs and ensure that there will be administrative coordination among various State, regional, and local agencies
- Develop enforceable policies and mechanisms to implement the Coastal Nonpoint Pollution Control Program.

Relationship to SWMP Implementation

There are many similarities between nonpoint source program goals (under § 319 and CZARA § 6217) and NPDES program goals. Both programs address storm water runoff from areas of industrial activity, as well as new development, pollution prevention, and watershed management. However, these programs target different classes and sources of discharges. For example, municipalities subject to NPDES permit application requirements are not subject to requirements under nonpoint source control programs, including CZARA § 6217; small municipalities (under population 100,000) without NPDES storm water permits are currently covered under CZARA § 6217 and § 314.

The distinction between point and nonpoint source programs becomes more problematic in relationship to industrial activities. While certain industrial activities are covered under the NPDES program (40 CFR 122.26(b)(14), many other activities fall under the purview of CZARA § 6217. For example, construction activity that disturbs five or more acres or that is part of a larger common program of development or sale is covered under the NPDES program, whereas construction disturbing fewer than five acres is covered under CZARA.

Safe Drinking Water Act

The Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act (SDWA) outlines requirements for watershed protection of surface drinking water supplies from urban runoff and nonpoint source pollutants. Municipalities using surface waters for drinking water supplies are required by U.S. EPA or the approved State agency to develop a watershed protection program for such surface waters that includes the following: a watershed description, identification of physical watershed characteristics and a description of activities potentially affecting water quality, a program to control pollutant sources (including implementation of appropriate BMPs), and an ongoing program to conduct monitoring.

Relationship to SWMP Implementation

The NPDES storm water management program and the Safe Drinking Water Act have many overlapping requirements, and municipalities are urged to share information between these two programs. Activities common to both include:

- Identifying critical areas and watersheds
- Determining watershed characteristics

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- Identifying activities detrimental to surface water quality
- Implementation of control practices to address pollution sources.

(EPA 1986 and 1990b)

Clean Lakes Program

The Clean Lakes Program sets goals for defining the cause and extent of pollution problems in the lakes of each State. Emphasis is placed on developing watershed assessments and effective technology that considers all point and nonpoint sources that affect lake quality

Relationship to SWMP Implementation

Information developed under this program that may be useful to municipalities implementing SWMPs include:

- Identification of environmental conditions
- Description of the lake's sources of pollution and abatement actions to reduce the pollution caused by these sources
- Monitoring data on receiving waters
- Alternative BMPs for pollution control.

(EPA 1993c)

404 Regulations/Wetlands Program

The Army Corps of Engineers and EPA jointly implement section 404 of the Clean Water Act, which regulates the discharge of dredged and fill material into waters of the United States, including most wetlands, and establishes a permit program to ensure that such discharges comply with environmental requirements.

Relationship to SWMP Implementation

Information available through this regulation may assist the municipality by helping to:

- Identify wetlands and delineate boundaries. (Corps of Engineers Delineation Manual 1987)
- Enforce SWMP restrictions on discharging fill materials
- Develop water quality standards specifically for wetlands.

(EPA 1989b, 1993c, and 1995)

National Estuary Program (NEP)

The National Estuary Program (NEP) focuses on point and nonpoint pollution in geographically targeted, high-priority, estuarine watersheds. Under this program, EPA assists State, regional, and local governments in developing estuary-specific comprehensive conservation and management programs that recommend corrective actions to restore and maintain estuarine water quality and to protect fish populations and other designated uses of these targeted waters.

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Relationship to SWMP Implementation

Information obtained under the NEP may be helpful to the municipalities in their efforts to:

- Assess pollutant sources/loadings in particular watersheds
- Monitor trends in receiving water quality
- Implement public outreach elements of the program.

(EPA 1992b)

Federal Emergency Management Agency Regulations (FEMA)

FEMA works closely with local communities to identify flood hazard areas and flooding risks Flood plain maps are also available through the agency

Relationship to SWMP Implementation

Municipalities developing storm water management programs may use this information to

- Effectively place structural controls
- Determine floodplains boundaries

(FEMA 1992 and 1993)

Pollution Prevention Act of 1990

The Pollution Prevention Act of 1990 established a national policy specifying that pollution prevention should be emphasized over pollution control or treatment. With this policy, Congress defined a pollution prevention hierarchy to be followed by all pollution reduction programs:

- Prevent or reduce at the source whenever feasible
- Where prevention is unfeasible, recycle in an environmentally safe manner
- Where prevention or recycling is not feasible, treat in an environmentally safe manner
- As a last resort, dispose of (or otherwise release to the environment) materials in an environmentally safe manner.

Relationship to SWMP Implementation

Management practices set forth in EPA's pollution prevention policy include public education, household hazardous waste collection, location and elimination of illicit connections to separate storm systems, reduction of roadway sanding and salting, and reduction of pesticide, herbicide, and fertilizer use. Many of these measures are required or suggested elements of the storm water management program and can, therefore, be implemented in conjunction with one another.

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SUMMARY

Chapter 1 provided an overview of the NPDES storm water program and briefly summarized the remaining chapters. In particular, this chapter introduced the storm water management program planning, a seven-step process that involves establishing goals, collecting data, establishing priorities, and implementing the program. This planning process incorporates the requirements of Parts 1 and 2 of the NPDES municipal storm water permit application. Finally, this chapter examined the relationship between the NPDES program and programs addressing urban runoff management.

Chapter 2 will provide guidance for municipalities as they attempt to establish priorities for storm water management activities. The chapter will describe methods for ranking "problems" (i.e., pollutant sources and receiving waters) and ranking appropriate controls

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CHAPTER 2

ASSESSING STORM WATER RUNOFF PROBLEMS AND DEVELOPING SOLUTIONS: HOW TO SET PRIORITIES

Step 3: Assess Pollutant Sources and Impacts on Receiving Waters: Rank Problems

A. Problem Assessment Criteria and Methods
B. How to Rank Problems

Step 4: Screen, Rank, and Select Controls (BMPs)

A. How to Screen BMPs
B. How to Rank and Select BMPs

INTRODUCTION

The MPDES regulations require that municipalities develop storm water management programs to control storm sewer system discharges to the maximum extent practicable. In order to develop an effective storm water implementation program, the municipalities should know what their biggest storm water runoff problems are and which solutions are most cost effective.

This chapter[1] is designed to help municipalities answer these questions by identifying sources of information to recognize the existing conditions of a watershed, suggesting ways to identify and prioritize sources of water quality problems, and evaluating the effectiveness of potential control measures. Municipalities have already complied some of this information as part of the application requirements. However, other watershed information was not included in the applications and will involve additional data collection activities. Using information available on watershed conditions will enable municipalities to set priorities for conducting storm water management activities. As information is gathered and analyzed, a municipality may find it will need to modify SWMP planning and implementation activities. This chapter also emphasizes the use of water quality models to determine this information. However, there are non-computer based methods for determining the benefits and impact of different pollution prevention alternatives.

[1]Chapter 2 has been adapted in part from U.S. EPA, Office of Research and Development. *Urban Runoff Pollution Prevention and Control Planning.* September 1993a.

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This chapter consists of 3 primary sections. The first section addresses methods for assessing problems and ranking them in order of importance. The second section of the chapter offers methods for evaluating and selecting controls to solve these problems. The criteria used to assess problems (e.g., consideration of public opinion, costs, goals) will often be similar, if not identical, to those used for selecting control measures. The third section includes case studies of municipalities assessing storm water runoff problems and evaluating/selecting and evaluating/selecting appropriate BMPs.

As mentioned in Chapter 1, Steps 1 and 2 (setting goals and assessing existing conditions) are not extensively discussed in this manual because they were covered in the application guidance manuals; *Guidance Manual for the Preparation of Part I of the NPDES Permit Application for Discharges from Municipal Separate Storm Sewer Systems* (April 1991) and *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer Systems* (November 1992a). Readers should refer to these manuals for detail on Steps 1 and 2. This chapter addresses Steps 3 and 4. Step 3, assessing receiving waters and sources of any impaired conditions, is described below. Step 4 is discussed later in this chapter. Step 6, which addresses data collection programs, is discussed in Chapter 5.

STEP 3: ASSESS POLLUTANT SOURCES AND IMPACTS ON RECEIVING WATERS: RANK PROBLEMS

To determine the need for, and appropriate level of, pollution prevention and control measures under their SWMPs, municipalities need to assess and rank existing watershed conditions. To assess watershed conditions, a municipality must gather information concerning the physical, chemical, and biological integrity of the water bodies in its jurisdiction. This type of information can be accessed through numerous sources, including Federal, State, and local sources. Some of these sources are a biennial report (known as the Clean Water Act § 305(b) report) on water quality conditions; the State's listing of impaired water bodies (known as Clean Water Act § 304(1) listings) prepared by the State for submittal to EPA; State Nonpoint Source Assessments (known as Clean Water Act § 319 listings); State Water Quality Assessment (known as Clean Water Act § 314 listings) Fish and Wildlife Service biological surveys; United States Geological Survey (USGS) sources, including maps, water quality and quantity data, and aerial photographs; water quality data compiled by State environmental agencies; Geographic Information System (GIS) data compiled by State or Federal agencies (e.g., EPA, Department of Agriculture, and Department of the Interior); as well as information available by local park departments, health departments, public works departments, and local universities.

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Information concerning watershed conditions that may have been collected as part of the application requirements includes the following

Part 1

- Major outfalls and industrial contributions to the MS4
- Topographic map
- Rain and snowfall data
- List of receiving water bodies, with a description of water quality impacts
- Results of field screening analysis
- Existing storm water management activities

Part 2

- Runoff sampling results
- Estimate of annual and seasonal pollutant loadings and event mean concentrations
- Estimate of expected reduction in pollutant loadings.

Using the information collected from the sources listed above, a municipality must identify the watershed conditions in its jurisdiction. When identifying the problems, a municipality must consider the chemical, physical, and biological conditions of a water body and determine the degree to which flow volumes and/or associated pollutants led to impaired conditions. For example, when eutrophication occurs in a lake, excess nutrients are of concern. The municipality, in turn, needs to assess the problem, which in this case may be too much fertilizer reaching the water body through runoff. Another example may involve storm water flow resulting in bank erosion and/or changing the strata of the streambed. In large part, the traditional water quality program has focused on chemical impairments. However, in developing a storm water program, municipalities will also need to consider physical and biological impairments

Once the problems have been identified, they need to be assessed. While many different types of problem assessments may be conducted as part of the storm water management program, to simplify the process this chapter focuses on four major types:

- Resource Assessments. Evaluating the extent to which these pollution sources adversely affect water resources
- Pollutant Source Assessments: Assessing the sources of urban runoff pollution in the watershed
- Institutional Assessments: Assessing existing BMPs, costs, public opinion, and technical feasibility
- Goals and Objectives Assessments: Evaluating whether program goals and objectives are being met.

Municipalities may establish criteria (such as those presented in Table 2-1) for assessing problems. Methods for assessing the problems can also be explored. A discussion of the most commonly used methods of problem assessment is presented under each of the four headings. Finally, methods for ranking problems using both quantitative and qualitative measures are explained.

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Once storm ... runoff problems have been fully assessed and ordered, municipalities will begin to screen and select BMPs (dis... second section of this chapter).

Resource Assess.

The critical element fo... rm water runoff problems is assessing storm water effects on receiving water physical, chemical, and t... erity and determining locations where preventive and corrective measures are needed.

Criteria To Consider

In assessing receiving waters, mu... onsider the importance or value of a resource (with respect to such issues as aquatic habitat, rec... lic water supplies), the current and desired uses of a resource, and the degree to which a resource ... esource values are reflected in a State's water quality standards.

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TABLE 2-1. CRITERIA FOR ASSESSING POLLUTION PROBLEMS

Resource
- Existing use of the affected resource (type, status, and level of use)
- Designated use of receiving water
- Type and severity of impairment
- Relative value of resource affected

Pollutant Source
- Type of pollutant
- Pollutants typically associated with the source
- Source magnitude/pollutant loading
- Transport mechanisms to water resource (direct pipe, overland flow, or ground water)

Institutional
- Available resources and technologies
- Problems and opportunities
- Potential for solving identified problems
- Implementability of controls
- Applicable and adequate regulations
- Multi-agency responsibilities
- Costs of controls and program implementation
- Funding sources and limitations
- Public perception

Goals and Objectives
- Water resource goals (water use objectives)
- Technology-based goals
- Land use objectives

Adapted in part from U.S. EPA, 1987a.

Municipalities should consider the following when evaluating which receiving waters need to be addressed by storm water control activities:

- Extent to which the waterbody is meeting its designated use
- Level of waterbody impairment due to pollution (chemical integrity), loss of aquatic habitat, or riparian or terrestrial area modification (physical integrity)
- Relative value of resource from functional perspective, for instance, for aquatic habitat (biological integrity), recreation, and water supply
- Threat of waterbody impairment, habitat destruction, or terrestrial area destruction if no action is taken (i.e., new impairments are anticipated)
- Feasibility of implementing corrective or protective (e.g., pollution preventative) measures and achieving demonstrable results in the watershed

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- Availability of information necessary to target waterbodies and watersheds and to develop and implement effective management strategies.

Methods for Assessing Water Resources and Receiving Waters

Water resource assessments address the effect of storm water flow and associated pollutants on the water bodies of interest. Water resource assessments frequently involve taking the results of the pollutant source assessments described in the following part of this chapter and determining the effect of these pollutant sources on water resources. Water resource assessments may include chemical water quality assessments, as well as aquatic life assessments, sediment quality evaluations, and assessments of any other relevant conditions, such as streambed strata. The methods to perform water quality assessments can range from simple evaluations, involving the comparison of measured concentrations to water quality standards, to detection modeling, to more complex, mathematically based computer models. It is more than likely that sufficient State and local data exist to assess the chemical quality of the waters. It is less likely that local, State, and Federal agencies have data on the physical and biological integrity of the water body of concern. Nonetheless, the municipality should work with the permit writer to access any available information. If necessary, municipal staff, perhaps with the assistance of local universities, can conduct biological assessments. EPA (1989) has issued a valuable guide to biological assessments entitled, *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA/444/4-89-001)

Some municipalities may choose to use receiving water models to assess existing water quality conditions and to simulate future conditions of the water resource under various pollution prevention and control scenarios. These models can also be used to differentiate the impacts of sources from one another, thereby enabling the decision maker to make decisions concerning control options. Receiving water models can also be used to assess the impacts of alternative BMPs. These models receive input from runoff model results, field-measured parameters, and the values of parameters found in the literature. The level of complexity of the receiving water model chosen should parallel that of the model used to assess urban runoff flows and loads. Some commonly used receiving water models include the following:

- The Enhanced Stream Water Quality Model (QUAL2E)
- The Water Quality Analysis Simulation Program (WASP4)
- The Exposure Analysis Modeling System II (EXAMSII).

These models are available from U.S. EPA's Center for Exposure Assessment Modeling, Environmental Research Laboratory, in Athens, Georgia. For further information, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA, 1993a.

Pollutant Source Assessments

Using the Federal, Regional, State, or local sources discussed above, it can be determined which physical and chemical conditions are threatening the water bodies and/or their designated uses. Previous studies on water quality have indicated that certain pollutants are associated with a discrete number of sources. Some of these sources are more easily controlled at a local level than others. For example, controlling runoff from gas stations can be more practically controlled at the local level than can atmospheric deposition.

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GUIDANCE MANUAL FOR IMPLEMENTING MUNICIPAL STORM WATER MANAGEMENT PROGRAMS

August 17, 1994

CHAPTERS 1 - 4



U.S. Environmental Protection Agency
Municipal Support Division

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CHAPTER 1

CHAPTER 1
INTRODUCTION

INTRODUCTION

Urbanization and industrial activities around the country have significantly altered the natural landscape of our Nation's watersheds. This, in turn, has adversely affected both the quantity and the quality of storm water runoff and has contributed to the chemical, physical, and biological impairment of receiving waters. Studies, such as the Nationwide Urban Runoff Program (NURP) study (EPA, 1983), have shown that storm water from urban and industrial areas is commonly contaminated by heavy metals, synthetic organics, pesticides, fuels, waste oils, and pathogens.

Congress, recognizing the importance of controlling these discharges, passed amendments to the Clean Water Act (CWA) in 1987 requiring that the U.S. Environmental Protection Agency (EPA) issue regulations addressing storm water discharges under the National Pollutant Discharge Elimination System (NPDES) program. Promulgated on November 16, 1990, the NPDES regulations establish permit application requirements for operators of certain municipal separate storm sewer systems (MS4), as well as of storm water discharges "associated with industrial activity." Regulated municipalities include those cities and counties operating medium and large MS4s (serving a population of 100,000 or greater) and other MS4s specifically designated by the permitting authority.

According to CWA mandate, municipalities regulated under the NPDES program must, at a minimum, achieve technology-based requirements (i.e., must reduce pollutant loadings in MS4s to the "maximum extent practicable" [MEP] and must effectively prohibit non-storm water discharges through their MS4s) as a first step toward achieving loading reductions consistent with applicable water quality standards. While MEP was not explicitly defined by Congress, EPA interpreted it to mean that municipalities will develop and implement comprehensive storm water management programs. These programs, proposed by the regulated municipalities under Part 2 of the permit application, are required to address a number of storm water control measures, including methods to detect and remove illicit discharges entering municipal storm sewer systems, as well as appropriate best management practices (BMPs) to address discharges from industrial, commercial, and development activities.

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At this time, all regulated Phase I[1] municipalities should have submitted both Parts 1 and 2 of the municipal storm water permit application and will soon begin implementing the storm water management programs they have proposed.

PURPOSE OF THIS MANUAL

The purpose of this manual is to provide hands-on guidance for municipalities on how to best implement their storm water management programs. As mentioned above, most municipalities have already proposed these programs under Part 2 of the application. Upon approval by the permitting authority, these programs will then be incorporated into the municipality's permit and will serve as the blueprint for the municipality's storm water management activities. Permit requirements, however, cannot specify all the procedures necessary to put storm water management programs into effect. Municipalities will need to take steps to ensure that storm water management programs are implemented in a practical, cost-effective manner. As noted throughout this manual, the storm water program is a watershed protection program. Storm water sources include a host of source categories, many of them associated with residential, commercial, and industrial land uses. Thus, a host of controls is available for this diverse set of sources. An effective Storm Water Management Plan (SWMP) program will consider all sources and make decisions on establishing control priorities on an holistic, watershed basis.

This manual is intended to help municipalities through this implementation process. A basic seven-step planning process described in this chapter provides a framework for effective decision-making and long-term planning. Municipalities are encouraged to revisit decisions made during Parts 1 and 2 of the permit application process to reassess their overall planning strategies, selected controls, policies, and programmatic measures. In addition, this manual is intended to help municipalities transform their storm water management program elements from words into action. For example, many municipalities pledged to develop "public outreach programs" to promote awareness about the effects of storm water runoff. But how should such programs be structured? What are the most cost-effective methods for educating

[1]Pursuant to Section 402(p)(2) of the Clean Water Act, Phase I of the storm water program covers the following: A) a discharge with respect to which a permit has been issued under Section 402 before February 4, 1987, B) a discharge associated with industrial activity, C) a discharge from a municipal separate storm sewer system serving a population of 100,000 or more, and D) a storm water discharge that the administrator or State determines may be contributing to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. Phase II of the storm water program potentially could cover any sources not covered under Phase I. A request for public comment on Phase II targeting and control options appeared in the *Federal Register* on September 9, 1992.

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community members? What are the advantages of pursuing a public outreach program versus a public participation event? This manual will help municipalities answer such questions and provide guidance on implementing storm water management program activities into the future.

Finally, this manual emphasizes a watershed protection approach, an integrated, holistic strategy for more effectively restoring and protecting aquatic ecosystems and protecting human health. This approach represents a renewed effort by EPA to focus on hydrologically defined drainage basins—watersheds—rather than on areas defined solely by political boundaries. For a given watershed, regulated municipalities are encouraged to consider not only the water resource (e.g., stream, lake, estuary, or aquifer) but all the land from which water drains to that resource. As water drains off the land, it carries with it the effects of human activities throughout the watershed. Consequently, to protect water resources, it is important to address the condition of land areas within the watershed. By concentrating on natural resources and systems, it is possible to detect and take remedial action for such problems as declines in living resources and habitat loss, as well as to identify the more commonly recognized problems associated with elevated pollutant concentrations. This manual provides guidance for municipalities to implement their storm water management programs within a watershed protection framework.

INTENDED AUDIENCE

This manual is intended to provide guidance for regulated municipalities as they begin implementing their storm water management programs. Regulated municipalities include cities and counties operating municipal separate storm sewer systems that serve populations of 100,000 or more, as well as certain municipalities specifically designated by the permitting authority. Individuals from a variety of different municipal departments could potentially be involved with program development and implementation and will benefit from reading this manual. Table 1-1 identifies the municipal agencies and personnel who may be involved in implementing the storm water management program. This manual is also intended for use by State and Federal employees administering the NPDES storm water program.

ORGANIZATION OF THIS MANUAL

This manual provides specific guidance on how to implement particular aspects of the storm water management program. The manual does not track all requirements of the two-part permit application;

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TABLE 1-1. AGENCIES AND PERSONNEL INVOLVED IN STORM WATER MANAGEMENT PROGRAM DEVELOPMENT/IMPLEMENTATION

Municipal Agencies	City/County Personnel	Other Members of Community
Building Department City/County Attorney's Office Department of Environmental Management Engineering Department Fire Department Health Department Planning Department Police Department Public Works Department Site Plan Review Department Water and Sewer Department Zoning Department	Council members or other elected officials Emergency response teams Engineers and environmental planners Financial officers Inspectors Public health officers Public outreach personnel Public works directors Site/building inspectors Site plan reviewers Treatment works operators Zoning board members	Community representatives Educators Environmental advocates

rather, it addresses certain elements of the storm water management program (developed under Part 2 of the application) that could be problematic for municipalities to implement, such as illicit detection and removal procedures, public education efforts, and ongoing monitoring programs. Case studies from municipalities around the country have been provided at the end of each chapter. Wherever possible, worksheets, pictures, maps, and charts have been included to help illustrate a particular process. Chapters are organized as follows:

- **Chapter 1:** Provides an overview of the NPDES storm water program, reviews the topics addressed by the manual, outlines the storm water management program planning process, and examines the relationship between the NPDES program and other urban runoff management programs.

- **Chapter 2:** Helps municipalities establish priorities for storm water management activities to ensure the greatest return on their investment. The chapter also provides methods for ranking problems (i.e., pollutant sources and receiving waters) and appropriate controls.

- **Chapter 3:** Offers hands-on guidance for fulfilling certain administrative requirements, including procedures for developing effective public outreach/public participation programs, financing the storm water management program, and completing required annual reports.

- **Chapter 4:** Provides specific guidance on how municipalities may develop effective programs to detect and remove illicit discharges and illegal dumping into their MS4s.

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- **Chapter 5:** Provides matrices of source control and structural BMPs indicating applicability, effectiveness, advantages, and disadvantages of particular controls.

- **Chapter 6:** Provides guidance on operation and maintenance required for structural BMPs and residuals management practices.

- **Chapter 7:** Offers detailed guidance on developing in-stream MS4 water quality monitoring programs.

- **Chapter 8:** Presents appendices, including (A) BMP Fact Sheets, (B) Fact Sheets on Other Federal Regulations Affecting Storm Water Management, (C) Case Studies, (D) Storm Water Contacts Lists, (E) References, (F) Glossary, (G) List of Hazardous Substances and Reportable Quantities, (H) List of Emergency Planning and Community Right-to-know Act (EPCRA) Title III Section 313 Water Priority Chemicals.

DIFFERENCE BETWEEN THIS MANUAL AND OTHER PUBLICATIONS

A number of guidance materials address municipal storm water permit application requirements and urban runoff management (see Chapter 1 References), including the following EPA publications:

- *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (April 1991). EPA-505/8-91-002.

- *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (November 1992). EPA-833-B-92-002.

This manual differs from most of the other publications because rather than focusing on completing municipal permit application requirements, it provides guidance on how to plan and implement a long-term, cost-effective storm water management program. Specifically, the manual will help municipalities set priorities for successful program implementation. While the manual concentrates on NPDES requirements, it also encourages municipalities to consider a broad range of related storm water/watershed management programs (e.g., nonpoint source programs or coastal zone pollution control programs). This holistic approach to storm water management provides a framework that allows a municipality to integrate its storm water program effectively with other watershed protection efforts at the local, State, and Federal levels. This manual is part of a family of literature available from EPA and other sources. Where information is already provided in other publications, the manual will direct the reader to those documents.

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OVERVIEW OF PART 1 AND PART 2 PERMIT APPLICATION REQUIREMENTS

Before outlining the seven-step planning process of storm water management program development, it is important to review briefly the municipal permit application requirements at 40 CFR Part 122.26(d). The regulations established a two-part application requirement for municipalities operating large or medium MS4s.

Part 1 of the application required municipalities to gather information about existing watershed conditions and storm water management activities. In addition, they were to examine existing legal authorities to enforce their storm water management programs. Part 1 also required that field screening of major outfalls be conducted to characterize storm water discharges and detect illicit connections in the storm sewer system.

Part 2 of the application required municipalities to elaborate on information provided in Part 1. Applicants were to establish adequate legal authority, provide additional information on pollutant sources, collect quantitative data from selected sampling points, and analyze fiscal needs versus available resources. Once existing conditions had been assessed and monitoring data collected, municipalities were required to propose a comprehensive storm water management program.

Deadlines for submitting Parts 1 and 2 of the permit applications were as follows:

- Large Municipal Systems with a Population of 250,000 or More: Part 1 - November 18, 1991; Part 2 - November 16, 1992
- Medium Municipal Systems with a Population of 100,000 To 250,000; Part 1 - May 18, 1992; Part 2 - May 17, 1993.

Figure 1-1 briefly summarizes the application requirements for Part 1 and Part 2.

DEVELOPING A WATER MANAGEMENT PROGRAM: THE PLANNING PROCESS

As noted above, this manual delineates a basic seven-step planning process that will help municipalities design cost-effective and sensible storm water management programs. For municipalities that have already completed Parts 1 and 2 of the NPDES municipal permit application, this planning process may suggest ways to improve or enhance the proposed storm water management program. The flow chart

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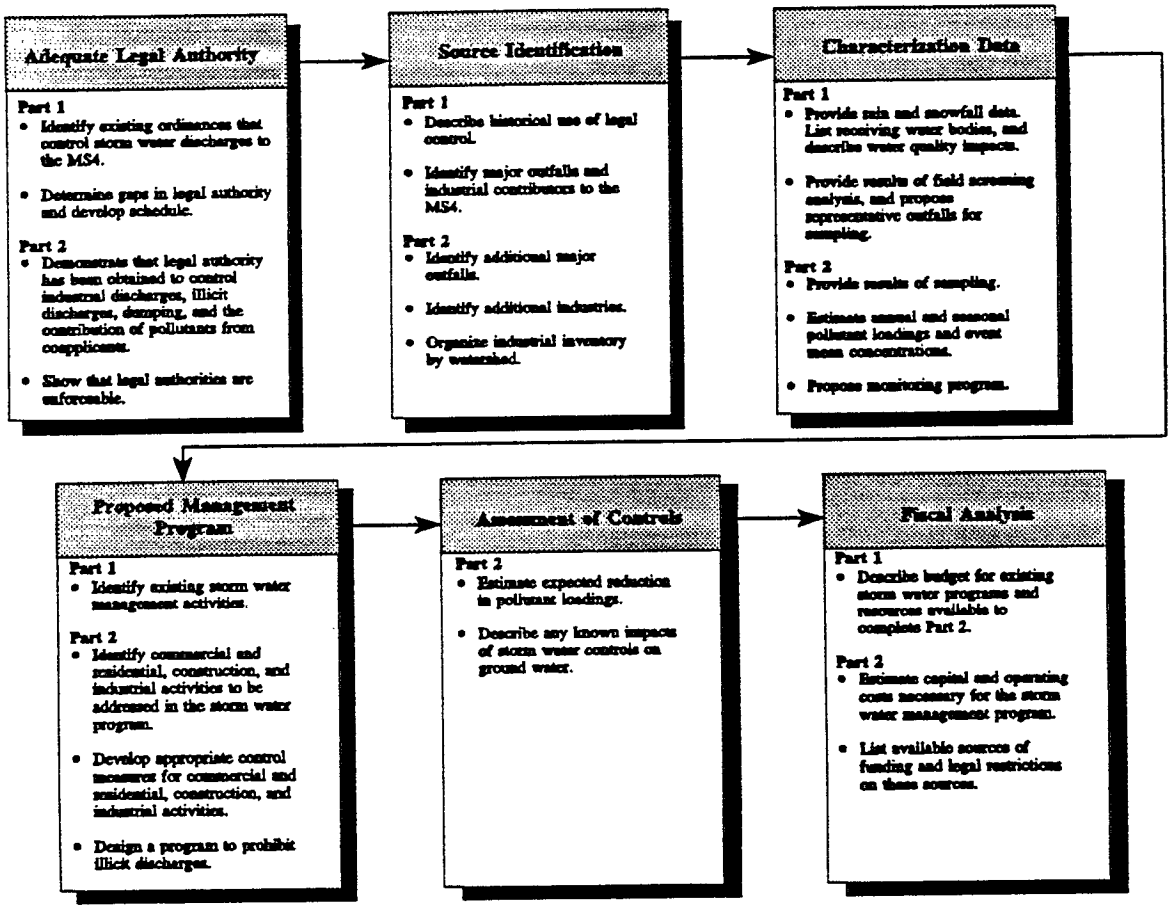

FIGURE 1-1. PART 1 AND PART 2 STORM WATER APPLICATION REQUIREMENTS

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appearing in Figure 1-2 has been developed to give municipalities a sense of how each step in the planning process logically leads to the next and ultimately of how the process feeds back into itself, thereby forming a cycle.

After the flow chart, a brief description of each planning step is provided. Other useful guidance materials are listed under the Reference section at the end of this chapter.

- For detailed guidance on Steps 1 and 2 (setting goals and assessing existing conditions), refer to *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Storm Water Discharges From Municipal Separate Storm Sewer Systems* (April 1991) and *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Application for Storm Water Discharges From Municipal Separate Storm Sewer Systems* (November 1992).

- Steps 3 and 4, which describe methods for ranking pollutants sources and impaired watersheds and for ranking control measures, are addressed in Chapter 2.

- Step 5, which identifies storm water management program administrative requirements, is further discussed in Chapter 3 (guidance for developing public outreach/public participation programs) and Chapter 4 (guidance for developing an illicit detection/removal program).

- Step 6, which addresses data collection programs, is further discussed in Chapter 7.

- Step 7, which addresses evaluating the effectiveness of the program, is elaborated upon at the end of Chapter 3. Other useful guidance materials are listed under the Reference section at the end of this chapter.

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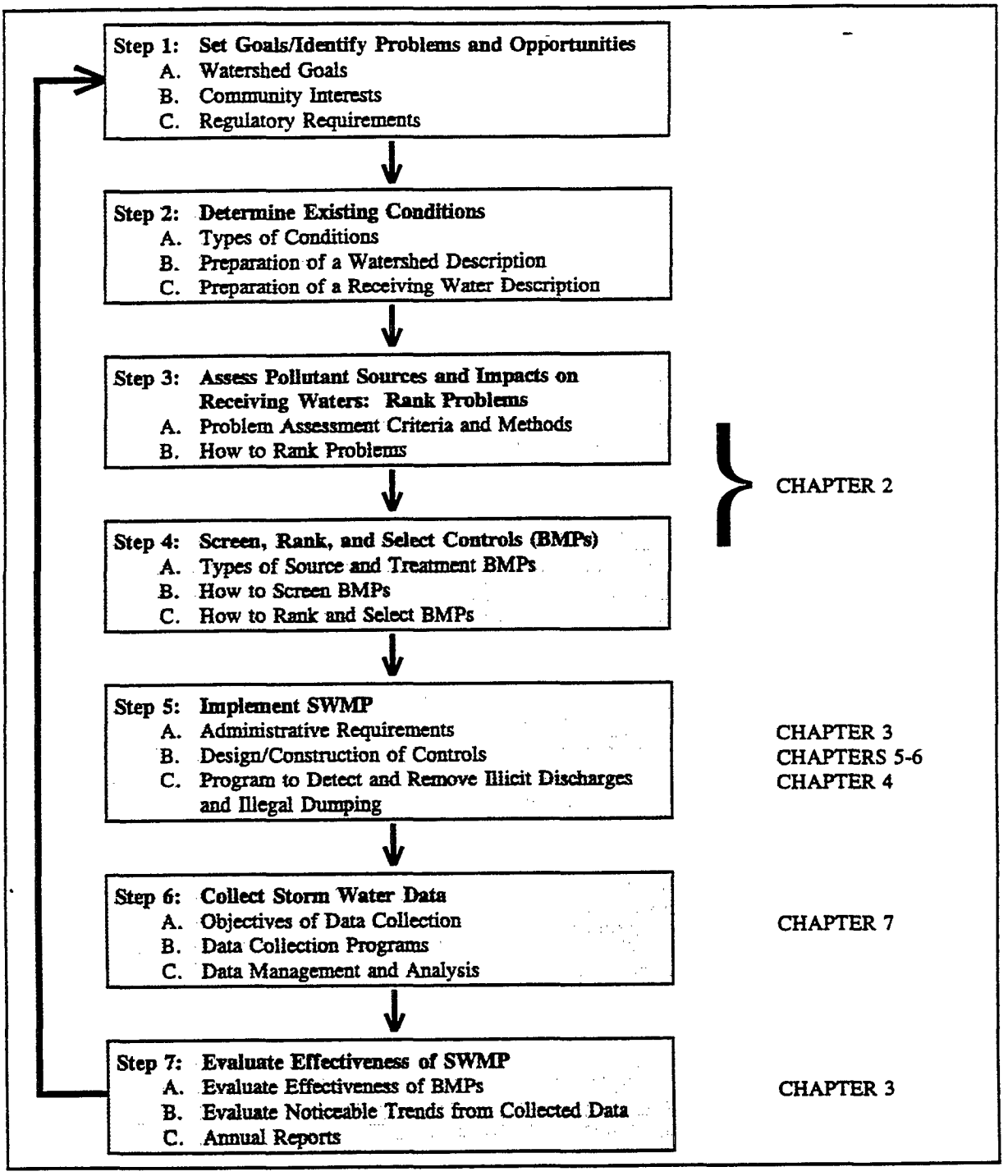

FIGURE 1-2. THE SEVEN-STEP STORM WATER MANAGEMENT PROGRAM PLANNING PROCESS

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THE SEVEN-STEP STORM WATER MANAGEMENT PROGRAM PLANNING PROCESS

Step 1: Set Goals/Identify Problems and Opportunities

The primary goal of the Clean Water Act and the NPDES permitting program is to protect the physical, chemical, and biological integrity of our Nation's waters. Toward this end, municipalities are required to develop storm water management programs that will control discharges through their storm sewer systems to the "maximum extent practicable" and to prohibit non-storm water discharges through their MS4s. Within this statutory and regulatory framework, regulated municipalities will define their own set of goals that address all aspects of water quality, including chemical water quality (e.g., toxics and conventional pollutants), physical water quality (e.g., temperature, flow, and circulation), habitat quality (e.g., channel morphology, composition, and biotic communities), and biodiversity (e.g, species number and range). Table 1-2 identifies sample goals for a municipal storm water management program.

Step 2: Define Existing Conditions

Types of Conditions

Once initial program goals have been articulated, the municipality must assess existing water resource conditions. Much of this information was collected during Parts 1 and 2 of the municipal permit application. Guidance on how to begin to assess existing conditions may be found in the *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges from Municipal Separate Storm Sewer System.* Existing conditions that should be assessed for the SWMP include those identified below.

Pollutant Sources

Municipalities must identify areas or sources known or suspected to contain significant concentrations of pollutants, including industrial sites (those required to obtain permits under the NPDES program), commercial areas, residential areas, and construction activities. In some cases, these areas of concern may be defined on a categorical basis (e.g., all service stations), while in other cases, the area of concern may be more site-specific (e.g., a particular service station). A significant nonpollutant source of concern is excessively high flow, which results in bank erosion, channel scouring, and sediment deposition.

Receiving Waters

Understanding the characteristics of receiving waters is essential for storm water management program development. Municipalities should evaluate available data on the physical, chemical, and biological conditions of receiving waters—and examine existing uses versus designated uses for particular resources—to determine which waterbodies and which specific areas demand highest priority. A wide range of information should be available from State and Federal agencies and local universities. Similarly, the planning and public works department should have relevant information on receiving waters in its possession.

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TABLE 1-2. EXAMPLES OF SPECIFIC WATER QUALITY, ECOLOGICAL, AND RESOURCE MANAGEMENT GOALS

Examples of Water Quality Goals		
Parameter	**Goal**	**Reference**
Dissolved Oxygen	At least 1 mg/l at all times throughout the Chesapeake Bay Dissolved oxygen monthly means concentrations of at least 5 mg/l at all times throughout the Chesapeake Bay, with the exception of subpycnocline waters	Part of quantitative criteria established for dissolved oxygen by the Chesapeake Bay Program
Dissolved Oxygen	3.0 mg/l minimum (for other than early life stages) 4.0 mg/l weekly average minimum 5.0 mg/l minimum for early life stages 4.0 mg/l minimum 5.0 mg/l daily average minimum 5.0 mg/l minimum	EPA water quality criteria Virginia standard Pennsylvania criterion District of Columbia standard Maryland standard
Nutrients	Low enough to prevent nuisance growth of algae, weeds, and slimes	Specific objective under the Great Lakes Water Agreement
Solids (settleable and suspended) and Turbidity	Settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life	EPA Water Quality Criteria
Mercury	Less than 2.1 ppb/0.025 ppb	Quantitative water quality acute criteria/chronic criteria for priority metal (EPA criteria under development)
Polynuclear Aromatic Hydrocarbons (PAH)	Less than 300 ppb/ND	Preliminary marine water quality criteria under development by EPA
Examples of Living Resource Goals		
Wetlands	No overall net loss	Federal Policy
Wetlands	"...diking, filling, or dredging in existing estuaries and wetlands shall maintain or enhance the functional capacity of the wetland or estuary. Any alteration of coastal wetlands...shall be limited to very incidental public facilities, restorative measures, nature study, commercial fishing facilities in Bodega Bay, and development in already developed parts of south San Diego Bay..."	Specific objectives set forth in the California Coastal Act
Waterfowl Habitat	Regional land acquisition targets set to meet goals of the Migrating Bird Conservation Act	U.S. Fish and Wildlife Service priority list for land acquisition
Examples of Quality of Life Goals		
Shoreline Access	Substantially expand recreational beach access	South Carolina's State Comprehensive Outdoor Recreation Plan
Park and Recreation Area	Increase urban wildlife programs and public use of opportunities, particularly watchable wildlife programs	U.S. Fish and Wildlife Service "Vision for the Future"

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Watershed Characteristics

In addition to identifying pollutants sources and their impacts on receiving waters, municipalities should assess other aspects of the watershed, such as land use and development patterns (e.g., general plan, zoning, subdivision requirements), physical characteristics (e.g., soils, slope, subsurface conditions, climate), and characteristics of the drainage system (e.g., physical storm drain characteristics, base flow characteristics, and water quality objectives). Again, such information should be available from existing sources, including local, State, and Federal agencies.

Institutional Considerations

Municipalities must assess their institutional capabilities for developing and implementing a storm water management program. The items to consider are existing funding mechanisms, available staffing, legal authority to carry out stormwater management program activities, and the institutional interest in marshalling joint efforts for storm water management among different municipal agencies. Municipalities should consider existing municipal programs that either affect storm water quality (e.g., road maintenance) or that may be expanded to address storm water concerns (e.g., pretreatment, fire inspections).

Community Character

To ensure the political and financial support of SWMP activities, municipalities must work in conjunction with community members to determine what issues are important to them and which programs they would be likely to support. The factors to consider include municipal demographics; types of community organizations; environmental, land use, and aesthetic issues; and the local business climate.

Existing Programs and Controls

Many cities and counties already have programs that, to one degree or another, address storm water management. The SWMP will be more cost-effective if municipalities can incorporate these existing programmatic measures or controls into those now envisioned for an expanded comprehensive SWMP. The existing programs to consider include those that currently manage pollutant sources and those that currently manage other activities of parties responsible for pollutant sources. Examples of such programs may be found on page 1-16.

Preparation of a Watershed Description

Once municipalities have gathered together available data about sources of pollution and the status of receiving waters, these data need to be organized to facilitate decisionmaking for storm water management activities. As discussed in EPA's Part 2 guidance manual, municipalities are required to prepare a map-based watershed description to obtain a visual sense of the topography in their city, drainage areas, locations of industries, and existing control measures and to pinpoint major sources of pollution. Much of the data listed in Table 1-3, which municipalities are required to collect under Parts 1 and 2 of the permit application, can be plotted on a base map to form a watershed description.

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TABLE 1-3. TYPES OF DATA TYPICALLY INCLUDED IN A WATERSHED PROFILE

Environmental	Potential Sources/Existing Structural Controls
• Topography • Land use • Recreational areas (beaches, boating areas) • Designated water uses • Soils and surface/bedrock geology • Vegetation • Natural resources • Temperature • Precipitation • Hydrology	• Landfills • Illicit connections • Waste handling areas • Salt storage facilities • Underground tanks • NPDES industrial activities • Pollution control facilities • Retention/detention ponds • Flood control structures
Infrastructure	**Municipal**
• Roads and highways • Storm drainage systems • Sanitary sewer systems • Treatment facilities • Other utilities (water, electric, gas)	• Population density and projected growth • Zoning • Land ownership • Regulations • Ordinances • Municipal source controls (e.g., street sweeping, catch basin cleaning)

For more information about the sources of watershed mapping and data, as well as methods for analyzing watershed data, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA CERI, 1993.

Preparation of a Receiving Water Description

In addition to preparing a watershed description, municipalities are encouraged to assess receiving water conditions. Effective identification and use of existing water resources data will reduce the schedule program and cost, in some cases by reducing the need for additional sampling and analysis. Municipalities should work closely with States and Regional EPA offices to obtain available data on receiving waters in various States. States must collect receiving water data as required by CWA sections 304(1), 305(b), and 319 reports. Data should be available from various local departments (e.g., planning, public works, parks and recreation) as well as State and Federal departments (U.S. EPA, United States Geological Survey [USGS], Fish and Wildlife Service, U.S. Department of Agriculture). In some cases, State and Federal agencies may have conducted intensive surveys of a particular watershed or sub-watershed. Municipalities should contact these agencies prior to initiating any data collection efforts on their own. Table 1-4 identifies the data that should be collected to prepare a receiving water description.

Step 3: Assess Pollutant Sources and Their Impacts on Receiving Waters; Rank Problems

Once municipalities have gathered data to determine existing conditions within their jurisdictions, they must determine the most critical problems. During this step, municipalities should consider the following issues: (1) the types of storm water runoff pollution (and their sources) in the watershed, (2) the extent to which these pollution sources affect the receiving water resources, (3) institutional needs and constraints in solving problems, and (4) the degree to which program goals

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TABLE 1-4. TYPES OF DATA TYPICALLY INCLUDED IN A RECEIVING WATER PROFILE

Source Input	Chemical
• CSO data • Storm water data • Other NPS data	• Water quality data • Sediment data • Bioconcentration
Physical/Hydrologic	**Biological**
• Physiographic and bathymetric data • Flow characteristics • Tidal elevation in coastal areas • Sediment data	• Fisheries • Benthos data • Biomonitoring data
	Water Quality Standards
	• State water quality standards

For more information about the sources of watershed mapping and data, as well as methods for analyzing watershed data, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA CERI, 1993.

are being met. Finally, municipalities should take steps to rank their problems using the decisionmaking and analysis methods presented in Chapter 2, which provides additional information on this step.

Step 4: Screen, Rank, and Select Controls (BMPs)

After municipalities have ranked and targeted storm water runoff problems (i.e., particular areas, sources, and waterbodies of concern), efforts can then be focused on solving those problems in a cost-effective manner. First, the municipality should compile readily available lists of pollution prevention and treatment practices to assess their relative effectiveness. In most cases, more than one set of BMPs will be identified as feasible to address a particular problem. From the list of feasible alternatives, the municipality will then rank and select its final list of BMPs. Chapter 2 discusses this process of screening, ranking, and finally selecting appropriate BMPs.

Step 5: Implement SWMP

Once priorities have been articulated and a list of BMPs drawn up, the program team is responsible for moving from planning to implementation. During this step, near- and long-term program responsibilities must be clearly delineated. All involved persons must be familiar with, and accept their role in, implementing and enforcing the plan. Some of the most important aspects of implementing a storm water management program include completing administrative requirements (discussed in Chapter 3), developing a program to detect and remove illicit discharges (discussed in Chapter 4), and knowing exactly when certain BMPs would be effective/appropriate (discussed in Chapter 5).

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Step 6: Collect Storm Water Quality Data

Although the municipality may already have existing data, additional data will need to be gathered as part of the NPDES permit application process and throughout the life of the SWMP. When proposing their monitoring programs under the SWMP, municipalities will have to make important decisions about when, where, and how often to monitor their storm water. Ultimately, the permit writer will establish monitoring conditions for each municipality's permit. Chapter 7 presents detailed guidance for developing municipal in-stream water quality monitoring programs.

Step 7: Evaluate Effectiveness of SWMP

The final step, evaluating the effectiveness of the storm water management program, encourages municipalities to reassess decisions previously made and, if necessary, to make alterations in the program plan. As part of this process, the NPDES regulations require that municipalities complete an annual report outlining the effectiveness of their programs on an yearly basis (discussed in Chapter 3).

DISCUSSION OF RELATED REGULATIONS/STATUTES AND PROGRAMS THAT ADDRESS MUNICIPAL STORM WATER RUNOFF

While this manual focuses on providing guidance for NPDES storm water program implementation, municipalities should carefully consider other related watershed protection programs. By integrating these programs into the storm water programs, municipalities will enhance the overall effectiveness of the SWMP. A knowledge of such programs can save startup costs (e.g., by minimizing the need to collect data that may have previously been collected for other purposes) and long-term costs (e.g., by piggybacking BMP planning and implementation activities with other watershed protection efforts). Furthermore, by working in conjunction with other runoff management programs, municipalities can more efficiently address a broad range of watersheds problems concurrently. Listed below (Table 1-5) and identified in the following paragraphs are related Federal statutes, regulations, and programs that address municipal storm water runoff, pollution prevention, and control.

Combined Sewer Overflow Policy

Combined sewer systems are designed to carry both storm water and sanitary sewage. When wet weather flows exceed the carrying capacity of the system, these combined systems discharge the excess flow through designated overflow points. This event is known as a combined sewer overflow (CSO). Such combined sewer discharges, if not treated before overflowing into receiving waters, can cause significant water resource effects and threaten human health. NPDES permits for CSOs include prohibition of CSOs

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TABLE 1-5. RELATED FEDERAL STATUTES, REGULATIONS, AND PROGRAMS ADDRESSING MUNICIPAL STORM WATER RUNOFF

- Combined Sewer Overflow Policy
- Nonpoint Source Program (CWA §319)
- Coastal Zone Nonpoint Source Pollution Control (CZARA §6217)
- Safe Drinking Water Act
- Clean Lakes Program (CWA 314)
- 404 Regulations/Wetlands Program
- National Estuary Program
- Federal Emergency Management Agency Regulations
- Pollution Prevention Act of 1990

Chapter 8, Appendix B, presents a summary fact sheet for each of these statutes, regulations, and programs, along with a list of contact telephone numbers. Given below are brief descriptions of programs that have components related to the NPDES municipal storm water program.

during dry-weather flow conditions, compliance of all wet-weather CSOs with the technology-based requirements of the CWA and applicable State water quality standards, and minimization of water quality impacts from wet-weather generated overflows.

Relationship to SWMP Implementation

Municipalities that own/operate both storm sewer systems and combined sanitary/storm sewer systems are required to comply with many of the same NPDES permit program requirements, including the following:

- Receiving water quality assessment
- Monitoring
- Public education programs
- Enforcement.

SOURCE: *Combined Sewer Overflow Control Policy*, 4/19/94

Nonpoint Source (NPS) Program (CWA §319)

This program requires States to perform nonpoint source assessments of navigable waters of the United States. They must identify impaired and threatened waters, the activities causing impairment, and controls and programs necessary to address impairments. In addition, States must develop Nonpoint Source Assessment Reports and Nonpoint Source Management Plans that include an inventory of BMPs, a schedule containing annual milestones for program implementation, certification of adequate legal authority, and available Federal and State funding sources to be used. Under this program, many States

have also developed State Priority Ranking Systems and undertaken monitoring programs to track progress.

Relationship to SWMP Implementation

Program information may be used by municipalities completing their storm water management programs for the following purposes:

- Assessing wetland boundaries
- Assessing the water quality of receiving waters
- Identifying major sources of impairment of receiving waters
- Identifying and implementing effective controls
- Prioritizing implementation of SWMP components
- Identify Total Maximum Daily Loads (TMDLs).

SOURCE: *Selecting Priority Nonpoint Source Projects*, EPA 506/2-89/003, pp. vi, 1, and *NATIONAL GUIDANCE, Wetlands and Nonpoint Source Control Programs*, U.S. EPA Office of Water Regulations and Standards, Office of Wetlands Protection, June 1990.

Coastal Zone Nonpoint Source Pollution Control (CZARA §6217)

The Coastal Zone Act Reauthorization Amendments of 1990 require States with existing coastal zone management programs to establish coastal NPS programs that must be approved by the National Oceanic and Atmospheric Administration (NOAA) and U.S. EPA. This program is limited to NPS pollution control in coastal areas and the contribution of inland sources of pollution to degraded coastal water quality. To secure an approved coastal nonpoint program, States are required to do the following:

- Coordinate with existing State programs, including State and local water quality plans and programs under sections 208, 303, 319, and 320 of the CWA
- Submit State coastal zone boundaries and section 6217 management areas to NOAA for review and modification, if necessary
- Implement management measures in conformity with section 621 7(g) of the guidance (referenced below) and additional measures where coastal water quality remains impaired.
- Provide technical and other assistance to local governments and the public for implementing additional management measures

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- Provide opportunities for public participation in all aspects of the programs and ensure that there will be administrative coordination among various State, regional, and local agencies
- Develop enforceable policies and mechanisms to implement the Coastal Nonpoint Pollution Control Program.

Relationship to SWMP Implementation

There are many similarities between nonpoint source program goals (under 319 and CZARA 6217) and NPDES program goals. Both programs address storm water runoff from areas of industrial activity, as well as new development, pollution prevention, and watershed management. However, these programs target different classes of discharges. For example, municipalities subject to NPDES permit application requirements are not subject to requirements under nonpoint source control programs, including CZARA §6217; small municipalities (under population 100,000) are currently covered under CZARA §6217. However, pursuant to §122.26(b)(4)(iii), the permitting authority is authorized to require an NPDES permit for any city under 100,000 that may currently be covered by CZARA §6217.

The distinction between point and nonpoint source programs becomes more problematic in relationship to industrial activities. While certain industrial activities are covered under the NPDES program (40 CFR 122.26(b)(14), many other activities fall under the purview of CZARA §6217. For example, construction activity that disturbs five or more acres or that is part of a larger common plan of development or sale is covered under the NPDES program, whereas construction disturbing fewer than five acres is covered under CZARA.

SOURCE: *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, U.S. EPA, January 1993.

Safe Drinking Water Act

The Surface Water Treatment Rule (SWTR) of the Safe Drinking Water Act (SDWA) outlines requirements for watershed protection of surface drinking water supplies from urban runoff and nonpoint source pollutants. Municipalities using surface waters for drinking water supplies are required by U.S. EPA or the approved State agency to develop a watershed protection plan for such surface waters that includes the following: a watershed description, identification of physical watershed characteristics and

a description of activities potentially affecting water quality, a program to control pollutant sources (including implementation of appropriate BMPs), and an ongoing program to conduct monitoring.

Relationship to SWMP Implementation

The NPDES storm water management program and the Safe Drinking Water Act have many overlapping requirements, and municipalities are urged to share information between these two programs. Activities common to both include:

- Identifying critical areas and watersheds
- Determining watershed characteristics
- Identifying activities detrimental to surface water quality
- Implementation of control practices to address pollution sources.

SOURCE: *Surface Water Treatment Rule,* EPA 570/9-91-300, June 1991, and *Safe Drinking Water Act 1986 Amendments,* EPA 570/9-86-002.

Clean Lakes Program

The Clean Lakes Program sets goals for defining the cause and extent of pollution problems in the lakes of each State. Emphasis is placed on developing watershed assessments and effective technology that considers all point and nonpoint sources that affect lake quality.

Relationship to SWMP Implementation

Information developed under this program that may be useful to municipalities implementing SWMPs include:

- Identification of environmental conditions
- Description of the lake's sources of pollution and abatement actions to reduce the pollution caused by these sources

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- Monitoring data on receiving waters
- Alternative BMPs for pollution control.

SOURCE: *A Commitment to Watershed Protection, A Review of the Clean Lakes Program,* EPA 841-R-93-001.

404 Regulations/Wetlands Program

The Army Corps of Engineers and EPA jointly implement section 404 of the Clean Water Act, which regulates the discharge of dredged and fill material into waters of the United States, including most wetlands, and establishes a permit program to ensure that such discharges comply with environmental requirements.

Relationship to SWMP Implementation

Information available through this regulation may assist the municipality by helping to:

- Identify wetlands and delineate boundaries *(Corps of Engineers Wetland Delineation Manual,* 1987)
- Enforce SWMP restrictions on discharging fill materials
- Develop water quality standards specifically for wetlands.

SOURCE: *EPA WETLANDS FACT SHEETS #7, #9, #13, and #24* and *HIGHLIGHTS OF SECTION 404, FEDERAL REGULATORY PROGRAM TO PROTECT WATERS OF THE UNITED STATES*, EPA Office of Wetland Protection, October 1989, and *THE SECTION 404 PROGRAM,* EPA Office of Wetland Protection, 6-9/89.

National Estuary Program (NEP)

The National Estuary Program (NEP) focuses on point and nonpoint pollution in geographically targeted, high-priority, estuarine watersheds. Under this program, EPA assists State, regional, and local governments in developing estuary-specific comprehensive conservation and management plans that recommend corrective actions to restore and maintain estuarine water quality and to protect fish populations and other designated uses of these targeted waters.

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Relationship to SWMP Implementation

Information obtained under the NEP may be helpful to the municipalities in their efforts to:

- Assess pollutant sources/loadings in particular watersheds
- Monitor trends in receiving water quality
- Implement public outreach elements of the program.

SOURCE: *The National Estuary Program After Four Years, A Report to Congress*, pp. 2-4, EPA 502/9-92/007, April 1992.

Federal Emergency Management Agency Regulations (FEMA)

FEMA works closely with local communities to identify flood hazard areas and flooding risks. Flood plain maps are also available through the agency.

Relationship to SWMP Implementation

Municipalities developing storm water management programs may use this information to:

- Effectively place structural controls
- Determine floodplains boundaries.

SOURCE: *Disaster Assistance Programs - A Guide to Federal Aid in Disasters*, Federal Emergency Management Agency, DAP 19/July March 1993, and *Answers to Questions About The National Flood Insurance Program*, Federal Emergency Management Agency, FIA-2/March 1992.

Pollution Prevention Act of 1990

The Pollution Prevention Act of 1990 established a national policy specifying that pollution prevention should be emphasized over pollution control or treatment. With this policy, Congress defined a pollution prevention hierarchy to be followed by all pollution reduction programs:

- Prevent or reduce at the source whenever feasible
- Where prevention is unfeasible, recycle in an environmentally safe manner

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- Where prevention or recycling is not feasible, treat in an environmentally safe manner
- As a last resort, dispose of (or otherwise release to the environment) materials in an environmentally safe manner.

Relationship to SWMP Implementation

Management practices set forth in EPA's pollution prevention policy include public education, household hazardous waste collection, location and elimination of illicit connections to separate storm systems, reduction of roadway sanding and salting, and reduction of pesticide, herbicide, and fertilizer use. Many of these measures are required or suggested elements of the storm water management program and can, therefore, be implemented in conjunction with one another.

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SUMMARY

Chapter 1 provided an overview of the NPDES storm water program and briefly summarized the remaining chapters. In particular, this chapter introduced the storm water management program planning, a seven-step process that involves establishing goals, collecting data, establishing priorities, and implementing the program. This planning process incorporates the requirements of Parts 1 and 2 of the NPDES municipal storm water permit application. Finally, this chapter examined the relationship between the NPDES program and programs addressing urban runoff management.

Chapter 2 will provide guidance for municipalities as they attempt to establish priorities for storm water management activities. The chapter will describe methods for ranking "problems" (i.e., pollutant sources and receiving waters) and ranking appropriate controls.

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CHAPTER 2

CHAPTER 2

ASSESSING STORM WATER RUNOFF PROBLEMS AND DEVELOPING SOLUTIONS: HOW TO SET PRIORITIES

Step 3: Assess Pollutant Sources and Impacts on Receiving Waters: Rank Problems
- A. Problem Assessment Criteria and Methods
- B. How to Rank Problems

Step 4: Screen, Rank, and Select Controls (BMPs)
- A. How to Screen BMPs
- B. How to Rank and Select BMPs

INTRODUCTION

The NPDES regulations require that municipalities develop storm water management programs to control storm sewer system discharges to the maximum extent practicable. But how do municipalities know what their biggest storm water runoff problems are? How do they know which solutions are most cost effective?

This chapter[1] is designed to help municipalities answer these questions by identifying sources of information to recognize the existing conditions of a watershed, suggesting ways to identify and prioritize sources of water quality problems, and evaluating the effectiveness of potential control measures. Municipalities have already complied some of this information as part of the application requirements. However, other watershed information was not included in the applications and will involve additional data collection activities. Using information available on watershed conditions will enable municipalities to set priorities for conducting storm water management activities. As information is gathered and analyzed, a municipality may find it will need to modify SWMP planning and implementation activities. This chapter also emphasizes the use of water quality models to determine this information. However, there are non-computer based methods for determining the benefits and impacts of different pollution prevention alternatives.

[1]Chapter 2 has been adapted in part from U.S. EPA, Office of Research and Development. *Urban Runoff Pollution Prevention and Control Planning*. September 1993.

ORGANIZATION OF THE CHAPTER

This chapter consists of 3 primary sections. The first section addresses methods for assessing problems and ranking them in order of importance. The second section of the chapter offers methods for evaluating and selecting controls to solve these problems. The criteria used to assess problems (e.g., consideration of public opinion, costs, goals) will often be similar, if not identical, to those used for selecting control measures. The third section includes case studies of municipalities assessing storm water runoff problems and evaluating/selecting appropriate BMPs.

As mentioned in Chapter 1, Steps 1 and 2 (setting goals and assessing existing conditions) are not extensively discussed in this manual because they were covered in the application guidance manuals; *Guidance Manual for the Preparation of Part 1 of the NPDES Permit Application for Discharges From Municipal Separate Storm Sewer Systems* (April 1991) and *Guidance Manual for the Preparation of Part 2 of the NPDES Permit Applications for Discharges From Municipal Separate Storm Sewer Systems* (November 1992). Readers should refer to these manuals for detail on Steps 1 and 2. This chapter addresses Steps 3 and 4. Step 3, assessing receiving waters and sources of any impaired conditions, is described below. Step 4 is discussed later in this chapter. Step 6, which addresses data collection programs, is discussed in Chapter 7.

STEP 3: ASSESS POLLUTANT SOURCES AND IMPACTS ON RECEIVING WATERS: RANK PROBLEMS

To determine the need for, and appropriate level of, pollution prevention and control measures under their SWMPs, municipalities need to assess and rank existing watershed conditions. To assess watershed conditions, a municipality must gather information concerning the physical, chemical, and biological integrity of the water bodies in its jurisdiction. This type of information can be accessed through numerous sources, including Federal, State, and local sources. Some of these sources are a biennial report (known as the 305(b) report) on water quality conditions; the State's listing of impaired water bodies (known as 304(l) listings) prepared by the State for submittal to EPA; State Nonpoint Source Assessments; Fish and Wildlife Service biological surveys; United States Geological Survey (USGS) sources, including maps, water quality and quantity data, and aerial photographs; water quality data compiled by State environmental agencies; Geographic Information System (GIS) data compiled by State or Federal agencies (e.g., EPA, Department of Agriculture, and Department of the Interior); as well as

information available by local park departments, health departments, public works departments, and local universities.

Information concerning watershed conditions that may have been collected as part of the application requirements includes the following:

Part 1

- Major outfalls and industrial contributions to the MS4
- Topographic map
- Rain and snowfall data
- List of receiving water bodies, with a description of water quality impacts
- Results of field screening analysis
- Existing storm water management activities.

Part 2

- Runoff sampling results
- Estimate of annual and seasonal pollutant loadings and event mean concentrations
- Estimate of expected reduction in pollutant loadings.

Using the information collected from the sources listed above, a municipality must identify the watershed conditions in its jurisdiction. When identifying the problems, a municipality must consider the chemical, physical, and biological conditions of a water body and determine the degree to which flow volumes and/or associated pollutants led to impaired conditions. For example, when eutrophication occurs in a lake, excess nutrients are of concern. The municipality, in turn, needs to assess the problem, which in this case may be too much fertilizer reaching the water body through runoff. Another example may involve storm water flow resulting in bank erosion and/or changing the strata of the streambed. In large part, the traditional water quality program has focused on chemical impairments. However, in developing a storm water program, municipalities will also need to consider physical impairments.

Once the problems have been identified, they need to be assessed. While many different types of problem assessments may be conducted as part of the storm water management program, to simplify the process this chapter focuses on four major types:

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- Resource Assessments: Evaluating the extent to which these pollution sources adversely affect water resources
- Pollutant Source Assessments: Assessing the sources of urban runoff pollution in the watershed
- Institutional Assessments: Assessing existing BMPs, costs, public opinion, and technical feasibility
- Goals and Objectives Assessments: Evaluating whether program goals and objectives are being met.

Municipalities may establish criteria (such as those presented in Table 2-1) for assessing problems. Methods for assessing the problems can also be explored. A discussion of the most commonly used methods of problem assessment is presented under each of the four headings. Finally, methods for ranking problems using both quantitative and qualitative measures are explained.

Once storm water runoff problems have been fully assessed and ordered, municipalities will begin to screen and select BMPs (discussed in the second section of this chapter).

Resource Assessments

The critical element for ranking storm water runoff problems is assessing storm water effects on receiving water physical, chemical, and biological integrity and determining locations where preventive and corrective measures are needed.

Criteria To Consider

In assessing receiving waters, municipalities need consider the importance or value of a resource (with respect to such issues as aquatic habitat, recreational use, and public water supplies), the current and desired uses of a resource, and the degree to which a resource is impaired. Water resource values are reflected in a State's water quality standards. Municipalities should consider the following when evaluating which receiving waters need to be addressed by storm water control activities:

- Extent to which the waterbody is meeting its designated use
- Level of waterbody impairment due to pollution (chemical integrity), loss of aquatic habitat, or riparian or terrestrial area modification (physical integrity)

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TABLE 2-1. CRITERIA FOR ASSESSING POLLUTION PROBLEMS

Resource
- Existing use of the affected resource (type, status, and level of use)
- Designated use of receiving water
- Type and severity of impairment
- Relative value of resource affected

Pollutant Source
- Type of pollutant
- Pollutants typically associated with the source
- Source magnitude/pollutant loading
- Transport mechanisms to water resource (direct pipe, overland flow, or ground water)

Institutional
- Available resources and technologies
- Problems and opportunities
- Potential for solving identified problems
- Implementability of controls
- Applicable regulations
- Multi-agency responsibilities
- Costs of controls
- Funding sources and limitations
- Public perception

Goals and Objectives
- Water resource goals (water use objectives)
- Technology-based goals
- Land use objectives

Adapted in part from U.S. EPA, 1987.

- Relative value of resource from functional perspective, for instance, for aquatic habitat (biological integrity), recreation, and water supply

- Threat of waterbody impairment, habitat destruction, or terrestrial area destruction if no action is taken (i.e., new impairments are anticipated)

- Feasibility of implementing corrective or protective (e.g., pollution preventative) measures and achieving demonstrable results in the watershed

- Availability of information necessary to target waterbodies and watersheds and to develop and implement effective management strategies.

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Methods for Assessing Water Resources and Receiving Waters

Water resource assessments address the effect of storm water flow and associated pollutants on the water bodies of interest. Water resource assessments frequently involve taking the results of the pollutant source assessments described in the following part of this chapter and determining the effect of these pollutant sources on water resources. Water resource assessments may include chemical water quality assessments, as well as aquatic life assessments, sediment quality evaluations, and assessments of any other relevant conditions, such as streambed strata. The methods to perform water quality assessments can range from simple evaluations, involving the comparison of measured concentrations to water quality standards, to detection modeling, to more complex, mathematically based computer models. It is more than likely that sufficient State and local data exist to assess the chemical quality of the waters. It is less likely that State and Federal agencies have data on the physical and biological integrity of the water body of concern. Nonetheless, the municipality should work with the permit writer to access any available information. If necessary, municipal staff, perhaps with the assistance of local universities, can conduct biological assessments. EPA has issued a valuable guide to biological assessments entitled, *Rapid Bioassessment Protocols for Use in Streams and Rivers* (EPA/444/4-89-001) 1989.

Some municipalities may choose to use receiving water models to assess existing water quality conditions and to simulate future conditions of the water resource under various pollution prevention and control scenarios. These models can also be used to differentiate the impacts of sources from one another, thereby enabling the decisionmaker to make informal decisions concerning control options. Receiving water models can also be used to assess the impacts of alternative BMPs. These models receive input from runoff model results, field-measured parameters, and the values of parameters found in the literature. The level of complexity of the receiving water model chosen should parallel that of the model used to assess urban runoff flows and loads. Some commonly used receiving water models include the following:

- The Enhanced Stream Water Quality Model (QUAL2E)
- The Water Quality Analysis Simulation Program (WASP4)
- The Exposure Analysis Modeling System II (EXAMSII).

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These models are available from U.S. EPA's Center for Exposure Assessment Modeling, Environmental Research Laboratory, in Athens, Georgia. For further information, refer to *Urban Runoff Pollution Prevention and Control Planning*, EPA, 1993.

Pollutant Source Assessments

Using the Federal, Regional, State, or local sources discussed above, it can be determined which physical and chemical conditions are threatening the water bodies and/or their designated uses. Previous studies on water quality have indicated that certain pollutants are associated with a discrete number of sources. Some of these sources are more easily controlled at a local level than others. For example, controlling runoff from gas stations can be more practically controlled at the local level than can atmospheric deposition.

This section presupposes that municipalities are already aware, or can gain ready access to, information identifying the pollutants of concern. In still other cases, municipalities may be able to anticipate pollutants that may be of concern in the years ahead based on, for example, a knowledge of growth patterns. The purpose of this section is to help municipalities determine which sources they want to control based on impacts to water bodies. In heavily industrialized watersheds, for example, municipalities may want to control industrial sources by using detention ponds to filter runoff. In residential areas, municipalities may want to focus on non-structural measures, such as public education campaigns encouraging used oil recycling. In choosing a source to focus on, municipalities need to consider pollutant loading estimates for storm water runoff and to calculate such estimates on a sub-watershed basis.

Criteria To Consider

To evaluate which sources should be addressed first, municipalities will want to consider the range of pollutant characteristics and sources, the size of each source, the distance between the source and the receiving water, and the mode of pollutant transport. In keeping with the watershed approach, impacts should not be confined to exceedances of chemical criteria. Rather, flow impacts on the physical regime and biological community structure need also be considered. "High-tech" tools useful in evaluating criteria for assessing pollutant sources include geographic information systems (GIS) and urban runoff models. However, high-tech technologies are not essential to step 3. Hand-drawn maps and desk top

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calculators can be just as effective in problem assessment and solution identification. The criteria a municipality would consider when determining which sources to address include an estimate of pollutant loadings from the source and an estimated impact of that source on water quality conditions. Sources can be identified in an incremental fashion by targeting areas of the watershed first, then by further focusing on individual sources or source categories (e.g., large parking lots, service stations) within the sub-watershed. Other important criteria to consider include the use of environmental indicators. The discussion below relates the goals of storm water management programs to the use of environmental indicators to meet the goals.

Environmental Goals and Indicators for Storm Water Management Programs

The "seven-step" planning process for storm water management programs must identify both the overall and project-specific environmental goals for the program. Overall environmental goals include those identified in local watershed strategies, basin-wide plans, local ordinances, community local master plans, and State water quality standards, especially the narrative statements. Project-specific goals include specific actions that will be taken to ensure that the environmental goals will be met. Such specific actions can involve pollutant loadings reductions, bank stabilization, elimination of hydraulic disturbances, increasing the effectiveness of buffers, and other common activities. Environmental indicators are used to measure the progress in meeting the overall environmental goals. Tracking of the completion of the project-specific goals must also be done.

EPA has identified four overall environmental goals and specific objectives for the nation's surface and ground waters (Table 2-2). The two ultimate overall environmental goals are to (1) Protect and Enhance Human Health, and (2) Conserve and Enhance Ecosystems. These goals will be achieved by Improving Ambient Conditions and Reducing Pollutant Loadings (Table 2-2). There are a variety of types of indicators to consider which apply to all water management programs, including storm water, traditional point sources, CSOs, and nonpoint sources. A source to assist municipalities in targeting the use of indicators for specific management actions is the *Guidance for Specifying Management Measures for Sources of Non Point Pollution in Coastal Waters* (EPA 1993). Despite its title, this document broadly addresses specific actions for all types of storm water management in freshwater.

The following discussion provides a summary of the types of indicators available to meet the overall environmental goals and the specific objectives. We are not suggesting that all of these indicators must

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TABLE 2-2. EPA's ENVIRONMENTAL GOALS, OBJECTIVES, AND INDICATORS

Environmental Goal	Objective	Indicator Type
Protect and Enhance Public Health	Safe Drinking Water	Meet Public Water Supply Designated Use
	Safe Aquatic Recreation	•Beach Closures
		Meet Swimming and Secondary Contact Designated Uses
	Safe Fish and Shellfish Consumption	Tissue Concentrations
		Fish Advisories
Conserve and Enhance Ecosystems	Biologically Healthy Water Resources	Biological Diversity
		Biological Criteria
Improve Ambient Conditions	Ground Water Protection	Ground Water Quality
	Improved Ambient Pollutant Concentrations	Water Quality Standards
		Selected Parameters
	Reduce Contaminated Sediments	Extent of Contaminated Sediment
	No Net Loss of Wetlands	Loss or Gain of Wetland Acreage
Reduce Pollutant Loadings	Reduce Conventional Pollutant Loadings	Water/Effluent Chemistry
	Reduce Toxic Pollutant Loadings	Water/Effluent Chemistry

be measured. Indicators should be selected based upon the overall and specific goals of the project. For example, if contaminated sediments is not suspected to be a problem, then there is no need to routinely sample for sediment toxicity or chemistry. However, sediment toxicity and chemistry may need to be sampled in the future to help diagnose a problem. The Intergovernmental Task Force for Monitoring Water Quality is recommending a core set of parameters be measured in all water management programs followed by more detailed parameters to meet specific needs. Among those core parameters include basic water chemistry and physical measurements (temperature, pH, nutrients, solids), biological community measurements (benthic macroinvertebrates, fish, and/or algae), and physical habitat.

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Human Health Indicators

Indicators for human health protection are fairly straightforward. These would include the measures used by the State to determine whether the designated use for public water supplies are met, as well as the designated uses for swimming and secondary contact use. These would typically include beach closures, if applicable.

Ecosystem Health Indicators

Determining the biological health, or integrity, of the communities inhabiting the surface waters requires more than just chemical and physical sampling. Even toxicological measures usually only account for a portion of the community effects due to other potential impacts such as habitat degradation, cumulative and synergistic effects of toxicants, and the conventional and other non-toxic pollutants. Two categories of indicators should be examined to measure progress towards meeting this goal: biological diversity and biological criteria or condition. Biological diversity measures usually are limited to determining the presence of threatened/endangered or rare species that may appear on State or Federal lists. Consultation with the State regulatory and natural resource agencies, The Nature Conservancy, and the National Biological Survey should reveal whether any "special status" species have been encountered in the area. Correction of storm water impacts could bridge important gaps in the natural range of special status species and reintroduce them into the management area.

Biological criteria, or condition, is monitored and assessed by most State regulatory, or natural resource, agencies. This process requires the collection of at least two assemblages, such as fish and benthic macroinvertebrates (and/or algae) and the results are compared with reference conditions developed by sampling least-impacted conditions within specific ecoregions, or by other means available to State biologists. States are working towards adoption of numeric biological criteria into their State water quality standard similar to that done by the State of Ohio, so measurements of the biological health of the waters should be a standard part of the program.

Ambient Condition Indicators

Improvement of ambient conditions can be measured in a number of ways. Table 2-2 shows the types of pollutants that could be monitored associated with various types of storm water management activities. This table summarizes the information in EPA's coastal zone guidance (EPA 1993), but for more detailed information not in this text, we encourage you to refer to the original document. The traditional approach

for determining the improvement in ambient conditions is to compare the receiving water chemistry with State water quality standards or national criteria. However, this does not provide much information for determining the reduction in the extent of contaminated sediments. Conducting sediment toxicity testing is an effective screening tool for determining whether additional sampling and measurement of sediment chemistry is needed.

Pollutant Loading Indicators

This chapter addresses methods for assessing pollutant sources. It is important to document the reductions in pollutant loadings due to management activities to be sure that these activities resulted in measurable progress towards meeting the ultimate environmental goals. The success or failure of these activities can help us learn more about the effectiveness of best management practices.

Methods for Assessing Pollutant Sources

Once criteria have been developed to evaluate pollutant sources—including consideration of the type, magnitude, and transport mode of the pollutants (existing or potential)—the municipality can assess these sources. Pollutant assessments are frequently aimed at quantifying the source flows and pollutant loads under various conditions. Many municipalities may have already completed this step under their municipal permit application. Described below is one widely used assessment method for pollutants source.

Source Determination and Data Evaluation

Urban runoff pollution sources can be defined by completing a comprehensive watershed description that includes the following: the type(s) of pollution affecting a water resource, the pollutant transport mechanisms, the characteristics of drainage patterns and drainage structures, and the land uses in the program area. (Refer to Chapter 1 and the EPA Part 2 NPDES Guidance Manual.)

Those activities or land uses within a watershed that are, or potentially could be, causing pollution problems need to be identified. Both point source and nonpoint source discharges should be considered. Pollutant types found in the watershed can provide some clues regarding the source(s) of the problems. To isolate sources of pollution, it is helpful to divide the watershed into smaller areas so that individual pollution sources can be identified. Depending on the size of the watershed, a drainage basin can first

be divided into subbasins. If necessary, subbasins can then be divided into individual tributaries, pipe systems, or drainage channels. Table 2-3 lists pollutant types typically associated with certain activities or land uses. This information can be used to identify potential sources. Problem sources can also be identified according to water resource conditions, such as eutrophication of a water body resulting from excessive nutrients, or closures of shellfish beds because of high concentrations of bacteria. In addition, sediments from aquatic systems and storm sewers can provide useful information for tracing and identifying potential sources (Livingston, 1991).

Computer modeling is valuable in quantifying the flows and loads of pollutant sources needed for pollution source assessments. Available models range from simple screening tools to numerical models with varying levels of complexity based on the number of processes incorporated and the level of detail provided. The level of application of a given model may also vary depending on the objectives of the analysis and available resources. Municipalities must keep in mind that modeling can be quite expensive and should only be used when the potential benefits justify their use.

In addition to the magnitude of a pollutant load and the location of a pollution source with respect to its receiving waters, the mode of transport to the receiving water and the degradation of the pollutant should also be considered. Sources with a clear path to a waterway, such as pipes, ditches, and gullies, often cause more adverse effects in a receiving water than similar sources that must travel through natural filters, such as forested or grassy areas, before entering a surface water body. Changes in loads, from the initial source discharge to the point where they affect the receptor, occur because of such factors as travel time, dilution, and decay. The fate and transport of pollutants can be modeled using hydrologic and pollutant buildup-washoff models that account for these factors. The more simple modeling methods (i.e., unit load or statistical) can only empirically estimate these factors, and, thus, the level of uncertainty and error is likely to be higher.

Models available for urban runoff assessments vary widely in their levels of complexity, ranging from simple estimation techniques to sophisticated and expensive computer models. Simple methods are compilations of expert judgement and empirical relationships between physiological characteristics of the watershed and pollutant export that can be solved by a spreadsheet program or hand-held calculator. These methods are often used when data limitations, budget, and time constraints preclude the use of more detailed models. Simple models frequently include information on land use, percent impervious factors, runoff coefficients, size of the drainage area, pollutant loading values, and rainfall data. The

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TABLE 2-3. TYPES OF ACTIVITIES AND ASSOCIATED POLLUTANTS

Categories and Subcategories	Nutrients	pH	Sediment	Organic Enrichment	Bacteria	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Agriculture												
Cropland	✓		✓		✓							✓
Pasture Land Animal Holding Areas Animal Waste Storage Areas	✓		✓	✓	✓							
Hayland	✓			✓	✓							
Wash & Processing Water	✓	✓	✓	✓	✓			✓				✓
Waste Application Areas	✓		✓	✓	✓		✓					
Construction												
Highways, Bridges, Roads	✓		✓		✓	✓		✓	✓	✓	✓	
Land Development	✓		✓		✓			✓		✓	✓	
Urban Land												
Storm Water Sewers, Combined Sewers, Surface Runoff-Pavement	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	
Surface Runoff Turf Areas	✓		✓		✓					✓		✓
Infiltration Wells & Basins	✓				✓	✓	✓	✓	✓	✓		
Land Disposal												
Wastes-Sludge-Septage	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Landfills	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
In-Situ Wastewater System	✓				✓	✓	✓	✓				✓
Hazardous Waste Areas	✓	✓			✓	✓	✓	✓	✓			✓

TABLE 2-3. TYPES OF ACTIVITIES AND ASSOCIATED POLLUTANTS (Continued)

Categories and Subcategories	Nutrients	pH	Sediment	Organic Enrichment	Bacteria	Toxic Organics	Toxic Metals	Oil and Grease	Salts (TDS)	Hydrologic Alterations	Thermal Alterations	Pesticides
Hydrologic Modifications												
Earth Fills, Channelization			✓							✓	✓	
Dam Construction/ Reconstruction	✓	✓	✓	✓						✓	✓	
Other Sources												
Atmospheric Deposition	✓	✓				✓	✓					
Underground Storage Tank Leaks						✓	✓	✓				✓
Illegal Disposals/ Dumping, Release of Contaminants from in-place deposits	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Highway/Bridge Maintenance	✓		✓			✓	✓	✓	✓			✓
Auto Salvage			✓			✓	✓	✓				
Washing & Processing Areas	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Snow Dumping Areas	✓		✓	✓	✓	✓	✓	✓	✓			
Utility R.O.W.S			✓							✓	✓	✓
Surface Runoff from Gasoline Station						✓	✓	✓				
In-place sediments	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Sewer System Leaks, Domestic	✓			✓	✓	✓	✓					
Wild Birds and Mammals	✓			✓	✓	✓	✓					
Natural Vegetation (Leaves, Fallen Trees)	✓	✓	✓	✓						✓		
Marinas & Boat Moorings, Boat Maintenance & Boat Washing	✓		✓	✓	✓	✓	✓	✓				

Source Morehouse, 1988

Federal Highway Administration (FHWA) has made great strides in researching pollutant loadings from highway storm water discharges. FHWA has a number of models and statistical methods that municipalities may find useful in determining the benefits and impacts of various pollution prevention alternatives.

Mid-range models, on the other hand, attempt to compromise between the empiricism of the simpler methods and the complexity of detailed models. Detailed models use storm event or continuous simulation to develop historic time series of stormwater runoff and pollutant loadings and concentrations. These models often consider, among other factors, soil type and percent imperviousness factors. To select the model that will best achieve the project objectives, analysts need to consider the available required input data, watershed pollutant characteristics, and time and resources available (*Compendium of Watershed-Scale Models for TMDL Development*, June 1992).

Several models are available from EPA's Center for Exposure Assessment Modeling in Athens, GA. For more detailed information on urban and nonurban models, refer to the following publications:

- U.S. EPA, Office of Water. *Compendium of Watershed-Scale Models for TMDL Development*. EPA841-R-92-002. June 1992.

- U.S. EPA, Office of Research and Development. *Urban Runoff Pollution Prevention Planning and Development*. EPA/625/R-93/004. March 1993.

- U.S. EPA. *Guide to Nonpoint Source Pollution Control*. 1987b.

Example Models

The following discussion highlights a number of commonly used methods and focuses on models used to predict pollution characteristics in an urban environment. The methods include constant concentration or unit load estimates, preliminary screening procedure, statistical method, rating curve or regression approaches, and hydrologic and pollutant buildup-washoff models.

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Constant Event Mean Concentration or Unit Load Estimates

Constant event mean concentrations or unit pollutant loads can be used to estimate pollutant source loads. They can be obtained from available data or estimated according to the types and sizes of land uses in the watershed. Constant event mean concentrations can be coupled with runoff volume estimates to calculate runoff loads or can be used in hydrologic models to calculate time variable flows and loads. The constant event mean concentration or unit load method is easy to use and can be helpful in identifying which areas within a watershed contribute the largest pollutant loads. Constant event mean concentrations or unit loads can also be estimated using a spreadsheet. Where local resources allow, these calculations can be facilitated using a GIS to keep track of such information as pollutant concentrations from different sources, land use or source boundaries, and quantities of flow produced in individual areas. However, a GIS system is not necessary to prepare load estimates, and municipalities without access to such systems should use other methods.

Where actual measurements are not available, input data can be taken from the literature. For example, the U.S. EPA's Nationwide Urban Runoff Program provides a comprehensive study of storm water runoff from residential, commercial, and light industrial areas throughout the United States and contains a large data base of pollutant concentrations and loads measured during various storm events from 1978 through 1983 (U.S. EPA, *Results of the Nationwide Urban Runoff Program*, 1983). The Metropolitan Washington Council of Governments has published a manual entitled *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs* (1987). It recommends a simple method for calculating pollutant export from urban development sites. Included in this manual are recommended concentration values for phosphorus, nitrogen, COD, BOD_5, lead, zinc, and copper from new suburban sites, older urban areas, and a central business district.

Other data bases of storm water pollutant concentrations and loads include Driver and Tasker (1990), Tasker and Driver (1988). These data can be used as inputs to source load estimation techniques, such as the constant concentration or unit load method.

Preliminary Screening Procedure

Simple equations can be used to estimate annual average loading contributions of urban runoff for BOD, suspended solids, volatile solids, total phosphate phosphorus, and total nitrogen. Pollutant loadings can

be estimated based on the relative contribution of pollutants from each land use; however, the equations are not location-specific and are only useful for screening purposes.

Statistical Method

The statistical method of modeling urban runoff assumes that event mean concentrations (EMC) are distributed log-normally and characterizes EMCs by their median values and their coefficients of variation. The U.S. EPA's statistical method (Driscoll et al., 1989) includes statistical properties of rainfall, area, runoff coefficients, median EMCs, and coefficients of variation of EMCs of various pollutants. The FHWA has implemented U.S. EPA's statistical method for various locations in the United States (Driscoll, 1989, and Woodward-Clyde Consultants, 1990).

Regression-Rating Curve Approaches

Rating curve or regression models, such as the 31 storm-runoff-load models developed by the USGS for metropolitan areas throughout the United States (Driver and Tasker, 1990, and Tasker and Driver, 1988), use site-specific rainfall, runoff, and water quality data, such as the data collected for U.S. EPA's Nationwide Urban Runoff Program and similar studies, to relate concentrations and loads of pollutants to flow rates and volumes (see Driver and Tasker, 1990).

Hydrologic and Pollutant Buildup-Washoff Models

Hydrologic and pollutant buildup-washoff models address the accumulation of pollutants during dry-weather periods and runoff of these pollutants during rainfall events. Of the many models available, some of the more widely used models that use a buildup-washoff mechanism include:

- Hydrological Simulation Program-Fortran (HSPF) (U.S. EPA, 1981); also described in (U.S. EPA 1991)
- Storm Water Management Model (SWMM) (U.S. EPA, 1988); also described in (U.S. EPA 1991)
- Source Loading and Management Model (SLAMM) (Pitt, 1989).

Institutional Assessments

In ranking urban runoff related problems, it is also essential to assess institutional constraints/capabilities for the regulators, owners, and the public.

Criteria To Consider

To assess institutional constraints/capabilities, municipalities may want to consider the following: applicable regulations, preferences of the local authorities and regulatory agencies, funding sources and limitations, multi-agency responsibilities and overlaps, and public acceptance of the program. The criteria a municipality would consider when considering which sources to target or which receiving waters to address include:

- Potential for solving the identified problem
- Degree to which existing resources, technology, or (municipal, State, Federal) programs could be used
- Potential for adverse effects due to a particular action
- Willingness of municipal agencies to take steps (use their tools and resources) to help address this problem
- Potential for combined action (involving government agencies, citizens, interest groups, or nongovernmental organizations) in conducting storm water management activities
- Extent to which there are existing programs/activities to support measures required under the SWMP
- Implementability of controls in a particular area
- Level of public support for a) protecting a given resource, b) developing a particular program measure, or c) funding recommended controls
- Availability of funds to undertake a particular project
- Extent to which regulatory/permit requirements are satisfied.

Methods for Assessing Institutional Constraints/Capabilities

The institutional issues of a program are assessed by evaluating the program's potential and limitations and by reviewing the requirements of involved agencies and the public. One major institutional issue that

must be addressed by an urban runoff program is determining the responsibilities of each involved party. This is especially true for programs involving multiple agencies. Interviews and meetings with all interested parties can be conducted to help develop institutional criteria. Questionnaires can be prepared and distributed to help identify concerns. Complaints, either filed with local authorities or available through public interaction programs, can help develop urban runoff pollution prevention and control programs to be implemented later.

Issues related to the control of the program, such as enforcement, maintenance, permitting, and funding, can affect the program's emphasis and the selection of its corrective measures. Another institutional issue involves the limitations of available technology. Implementability of controls may also be considered, particularly in areas involving limited access to private properties. In addition, the potential for eliminating or reducing an urban runoff problem or improving affected water resources can be considered. Public questions and concerns can be influential during the decision-making processes. Applicable regulations and permit conditions may force the sequencing of corrective measures so that those addressing compliance with the regulations or permit conditions are implemented first.

Goals and Objectives Assessments

Finally, municipalities should evaluate storm water runoff problems with respect to current and future goals.

Criteria To Consider

Municipalities will generally want to focus on those problems where preventive or corrective measures would provide the greatest benefit. One goal, for example, might be to increase the use of public beaches by decreasing bacteria counts and aesthetic nuisances associated with storm water events. Application of goals and objectives criteria could identify where corrective measures would provide the greatest benefit, perhaps at beaches only slightly degraded and needing only minimal cleanup before they are restored, or at beaches in heavily populated areas where many people could benefit from restoration of the water body. Criteria a municipality may consider when considering which sources to target or which receiving waters to address include:

- Potential for achieving water resource goals as described in the water quality standard
- Potential for realizing short-term benefits, thereby building good will and commitment to long-term objectives
- Consistency with other land use objectives
- Consistency with programmatic goals of SWMP
- Opportunity to maximize efforts by coordinating activities with other agencies.

Methods for Assessing Attainment of Goals and Objectives

The relative importance of an urban runoff problem may be assessed by comparing that problem to the program's water resource and technology-based goals and objectives. By considering pollution problems in connection with the program's goals and objectives, the program team can identify and focus on the urban runoff problems most important in attaining the overall aims of the program. The assessments conducted on pollutant sources, water resources, and institutional aspects provide input to these determinations.

How to Rank Storm Water Runoff Problems

Municipal storm water pollution problems can be numerous, and funding to correct these problems is usually limited. It is desirable, therefore, that a priority list of sources or impacts be developed to allow for targeting of limited resources. Ranking is a subjective process that requires the judgement of decision-makers. A ranking methodology can range from simple, descriptive methods (qualitative) to numerically complex (quantitative) methods, depending on the requirements of the urban runoff program objectives and the constraints of program funding. Ranking methods can be applied to a variety of geographic areas, ranging from counties or communities with multiple watersheds or individual water bodies or pollution sources.

A ranking methodology is developed for a specific study area to encourage a phased approach and to ensure the optimal allocation of available resources. Several methodologies can be used to rank pollution problems for control, depending on the complexity of the watershed, water resources, and their problems.

Criteria such as those presented in Table 2-1 can be used in problem ranking. Ranking should be conducted following consultation with involved parties, including local, State, and Federal agencies, local environmental groups, and concerned citizens.

Qualitative Rankings

The simplest approach is to use qualitative rankings, such as high, moderate, or low, to prioritize pollution problems. Table 2-4 provides an example of such a ranking system. The assigned ratings must then be interpreted to determine which areas should receive the highest priority as appropriate controls are developed. The use of rating points or categories can allow all the criteria to be evaluated on an equivalent basis. For each problem, the ranking criteria can be assigned relative ratings of 1 to 10, with a higher rating indicating a higher priority. In Table 2-4, the criteria used to gauge which area should receive highest priority for storm water management include imperviousness of the site, land use, runoff coefficient, annual runoff volume.

Quantitative Rankings

To perform numerical ranking, a rating is assigned to each ranking criterion for each problem. The assigned ranking for a criterion can then be multiplied by its relative weight for each pollution problem. All of the products (Criterion Ranking × Relative Weight) should be summed for a given problem. This procedure is then repeated for all problems being evaluated. The sums thus assigned should be compared, and the problems with the highest sums should receive the highest priority during implementation of urban runoff controls. An example of numerical ranking is given on page 2-23.

An important point for municipalities to consider when using the rankings is that the ultimate goal is to address their specific water quality problems. For example, in a given municipality, stream scouring may be a bigger problem than eutrophication. In this case, the municipality would weigh runoff volume heavier than nutrients in runoff.

STEP 4: SCREEN, RANK, AND SELECT CONTROLS

Once particular waterbodies and sources have been targeted for action (based on the criteria discussed in Step 3), the municipality's task is to determine the most cost-effective solutions to solve the identified problems. This section discusses the tools needed to prioritize and rank solutions or control measures in relationship to program goals.

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TABLE 2-4. ESTIMATED NONPOINT SOURCE LOADINGS USING CONSTANT CONCENTRATIONS

Source Area	Description and Location	Area (acres)	% Impervious	Land Use	Runoff Coeff.	Annual Runoff Volume (MG)	Annual FCOL Loading org x 10^{12} (rank)	Annual NO_3-N Loading lbs (rank)	Qualitative Ranking
A	Main St and Freeport Outlet Stores	3.3	85	Commercial[a]	0.73	2.7	1.7 (12)	14 (11)	Low
B	Commercial development at I-95 Interchange, Main St, and Pine St	30.6	50	Commercial	0.45	15.7	9.8 (1)	82 (1)	High
C	A portion of Freeport Crossing Outlets, Main St, Varney Rd, and Kar Klean	13.9	60	Commercial	0.61	9.7	6.0 (3)	51 (4)	High
D	Main St, Varney Rd, a portion of Linwood Rd, and adjacent residential development	21.0	10	Multifamily Residential[b]	0.13	3.1	2.0 (10)	24 (8)	Low
E1	South LL Bean parking lot	6.5	85	Industrial[c]	0.73	5.4	2.8 (7)	28 (7)	Medium
E2	Northern LL Bean parking lot	5.5	80	Industrial	0.69	4.3	2.2 (8)	23 (9)	Medium
F	Independence Way, Eastland Shoe warehouse, Horsefeathers Restaurant, and Main St	14.1	20	Commercial	0.21	3.4	2.1 (9)	18 (10)	Low
G	Somerset Condominiums, Summer St, Upper West St, and Freeport Place Condominiums	38.0	20	Single[d] and Multifamily Residential	0.21	9.1	5.9 (4)	73 (3)	High
H	Municipal Garage, Main St, and town office parking lot	15.0	60	Industrial Commercial	0.53	9.1	4.7 (5)	48 (5)	High
I	Downtown Village area along Main St, between Morse and West St, including Oak	19.2	75	Commercial	0.65	14.2	8.8 (2)	75 (2)	High

Source: Metcalf & Eddy, 1992

[a] FCOL Conc. = 16,000 org/100 ml, NO_3-N Conc. = 0.63 mg/l
[b] FCOL Conc. = 17,000 org/100 ml, NO_3-N Conc. = 0.96 mg/l
[c] FCOL Conc. = 14,000 org/100 ml, NO_3-N Conc. = 0.63 mg/l
[d] FCOL Conc. = 37,000 org/100 ml, NO_3-N Conc. = 0.96 mg/l

EXAMPLE: NUMERICAL RANKING SYSTEM

The following is an example of a numerical ranking system for prioritizing pollution sources. A hypothetical application of this weighted ranking methodology uses the following criteria: water body importance (as reflected by stream or lake size), type of use (ranging from urban drainage to recreational contact), status of use (impaired versus denied), level of use (low, moderate, or high), pollutant loads (not actual loads but estimates for comparative purposes), and implementability of controls (based on institutional factors, existing ordinances, or technical considerations). The criteria used for this example are similar to those identified in Table 2-1. Other criteria may be just as valid. The relative importance of the ranking criteria is designated by assigning each criterion a weight appropriate for the site-specific conditions of the watershed under consideration. The sum of all weights used to rank the problems equal 100. Next, for each problem, the criteria are ranked using a suggested range of 1 to 9, with a higher numerical ranking indicating a higher need for corrective action. This listing allows relative comparisons to be made among problems with respect to a single criterion.

This numerical ranking method for prioritizing pollution problems is illustrated in the hypothetical urban watershed (below) which consists of three streams and several types of land use (Figure 2-1). Information describing the system is presented in Tables 2-5 and 2-6. Typical sources for these data include site-specific pollutant loading data, model results, and literature values from such projects as the NURP study. For this example, the three "use" criteria are clustered together as subcriteria of a "beneficial use" criterion. There are, thus, four prioritization criteria of equal weight: stream size, beneficial use, pollutant load, and ability to implement (Table 2-7).

Ranking for "stream size" is determined according to the total drainage area of each of the three streams. Consistent with the goals for the hypothetical watershed, Stream C is ranked highest with respect to "type of use" because of its recreational uses in the city park, Stream B receives the lowest ranking because it is used mainly as an urban drain, and Stream A is ranked between the other two streams because it is used to support aquatic life. With respect to "status of use," Stream A ranks highest because although somewhat impaired, it has the potential to be improved by control of pollution sources. Stream B receives a low ranking for use status because its water quality is poor and its function as part of an urban drainage system has long been accepted. Stream C also receives a low ranking for use status since the water is of high quality. Rankings for "level of use" reflect the number of people using or affected by each stream.

Mass pollutant loadings are calculated based on runoff coefficients (functions of the amount of impervious area), runoff concentrations of pollutants, and the amount of land use type in each stream's drainage area. Each stream is ranked based on the proportion of pollutant load from its watershed (in this example, total suspended solids is used). The watershed of Stream B is judged to be easiest to implement controls because it is predominantly industrial. Based on the method presented in this example, the watershed of Stream C should receive priority during implementation of controls, followed by the watershed of Stream A and then that of Stream B.

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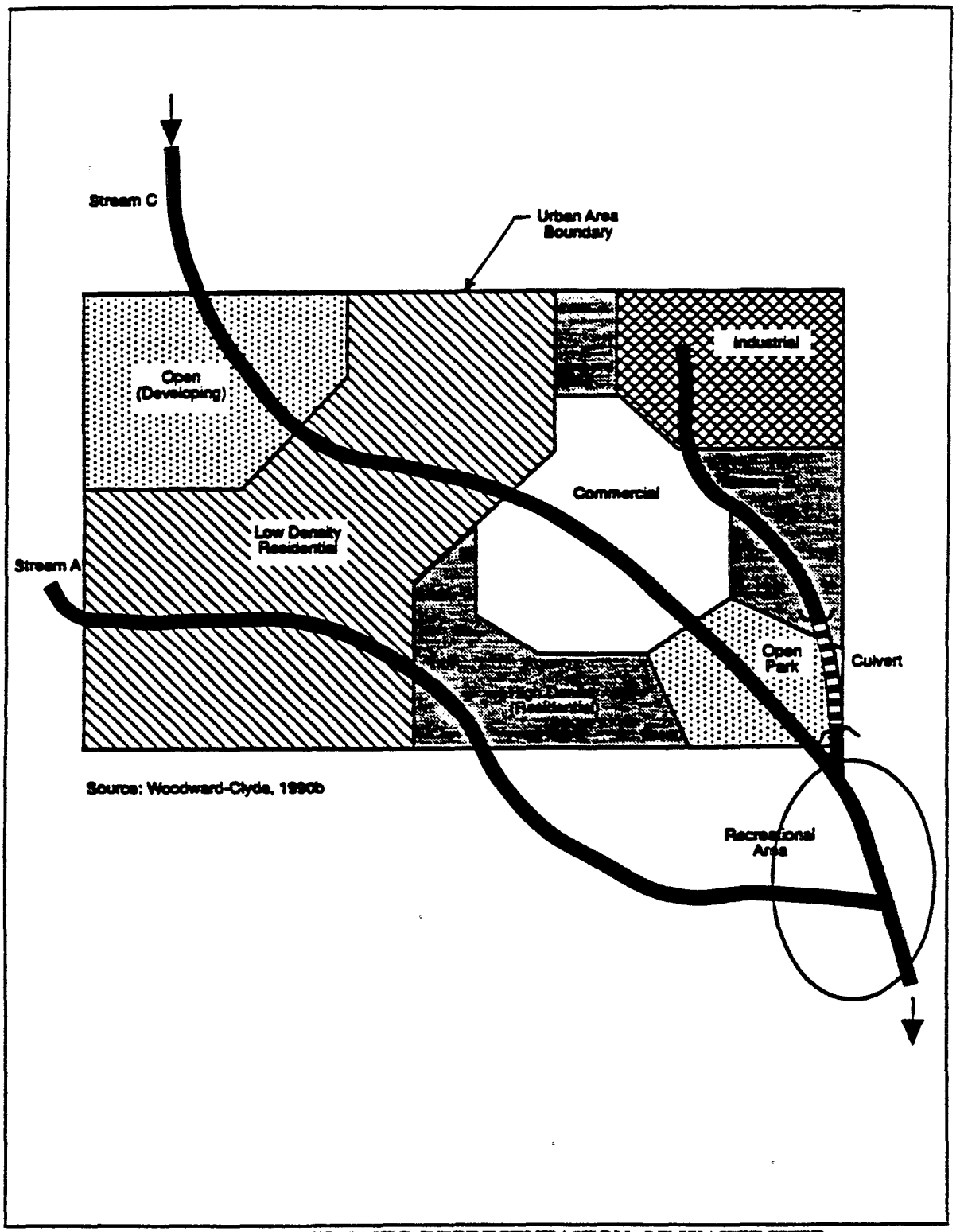

FIGURE 2-1. SCHEMATIC REPRESENTATION OF WATERSHED

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TABLE 2-5. CHARACTERISTICS OF THE TARGETED AREAS AND ESTIMATED CONCENTRATION LOADS

Land Use Category	Runoff Coefficient	Average Concentration in Runoff (mg/l)				Drainage Area (acres)			
		Total Suspended Solids	Oil and Grease	Total Phosphorus	Copper	Stream A	Stream B	Stream C	Urban Total
Industrial	0.6	120	20	0.20	0.05	0	150	0	150
Commercial	0.8	80	15	0.20	0.05	10	80	110	200
Residential (High Density)	0.4	90	10	0.40	0.04	100	100	50	250
Residential (Low Density)	0.2	100	5	0.60	0.03	200	0	200	400
Open - Developing	0.1	150	0	0.80	0.01	0	0	150	150
Open - Urban Park	0.1	50	0	0.80	0.01	0	0	50	50
Total Urban Area						310	330	580	1,200
Upstream Drainage Area						600	0	20,000	20,600
Total Drainage Area						910	330	20,560	21,800

Source: Woodward & Clyde, 1990

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TABLE 2-6. ESTIMATED TOTAL SUSPENDED SOLID LOADS FOR TARGETED AREAS

Land Use Category	Total Suspended Solids Load (lbs per inch of rain)			
	Stream A	Stream B	Stream C	Urban Total
Industrial	0	150	0	2,452
Commercial	10	80	1,598	2,906
Residential (High Density)	100	100	409	2,043
Residential (Low Density)	200	0	908	1,816
Open - Developing	0	0	511	511
Open - Urban Park	0	0	57	57
Watershed Total	1,870	4,431	3,482	9,784
Watershed Rank Value	1.7	4.1	3.2	9.0

Source: Woodward & Clyde, 1990

TABLE 2-7. PRIORITIZATION ANALYSIS FOR URBAN AREA TARGETING

Urban Watershed	Stream Size	Beneficial Use			Pollutant Load (TSS)	Ability to Implement	Target Score
		Type	Status	Level			
Weights	25	10	10	5	25	25	100
Watershed A	4	5	7	4	1.7	5	4.08
Watershed B	2	2	2	1	4.1	7	3.73
Watershed C	8	8	2	6	3.2	3	4.85
Total Urban Watershed	8	8	5	8	9.0	2	6.45

Target Score = Weighted Average of Rank Points = Sum(Rank Score * Weight)/Sum(Weights)
TSS: Total Suspended Solids

Source: Woodward & Clyde, 1990

Selecting BMPs for preventing and controlling storm water runoff pollution is a two-step process. First, a comprehensive list of BMPs should be compiled and screened to eliminate those that are inappropriate for the program. The appropriate BMPs are then assessed to select those that will ultimately be implemented in the SWMP.

The construction of facilities to collect and treat urban runoff may be prohibitively expensive. Therefore, the emphasis of storm water pollution control should be on developing a cost-effective approach that

includes nonstructural controls and low-cost structural controls. Nonstructural controls include both regulatory controls (e.g., pollution prevention measures and land use controls) and source controls (e.g., controls that reduce pollutant buildup or lessen its availability for wash-off during rainfall). Low-cost structural controls include the use of facilities that reduce pollutant loads through infiltration or biological degradation. Given below is a list of the types of controls and BMPs available to municipalities for managing their storm water runoff (discussed in detail in Chapter 5).

EXAMPLES OF SOURCE CONTROL AND TREATMENT BMPs
Regulatory Controls • Land use regulations • Comprehensive runoff control regulations • Land acquisition
Source Controls • New development controls • Illicit discharge controls • Illegal dumping controls • Materials management controls (fertilizers, chemical storage and use) • Street/storm sewer maintenance controls • Spill prevention and cleanup • Public education/pollution prevention
Treatment Controls • Detention facilities • Infiltration practices • Vegetative practices • Filtration practices • Water quality inlets • Retrofitting existing flood control facilities

How to Screen BMPs

The goal of the BMP screening process is to reduce the list of BMPs to a more manageable number to be considered for implementation. Because this is an initial step, the methods used are generally qualitative and require that good engineering judgement be exercised.

For the purposes of screening, BMPs are divided into two general categories: structural and nonstructural. Structural BMPs, such as detention ponds and infiltration practices, are designed to address specific pollutants from known sources. In contrast, nonstructural BMPs, which include regulatory practices (such as those that limit impervious areas or protect natural resources) and source controls (such as street sweeping or solid waste management) are typically implemented throughout an entire community, watershed, or special area to be protected. Municipal storm water management programs will, in most cases, rely on a combination of both structural and nonstructural practices. Methods for screening these

two types of BMPs are outlined below. Chapters 5 and 6 present detailed guidance on implementing structural and nonstructural BMPs.

Nonstructural Practices

Nonstructural BMPs are a good solution when limited funds are available. In addition, these BMPs can perform an auxiliary role to a structural BMP. Many low-cost techniques can lead to significant improvements in water quality. Urban storm water management programs typically include a number of nonstructural BMPs. For example, an urban runoff management plan for the Santa Clara Valley identified more than 100 separate potential nonstructural BMPs used throughout the county (Woodward-Clyde, 1989). To reduce the large number of available BMPs, municipalities must screen these regulatory and source control BMPs for their appropriateness to the watershed. The case study at the end of Chapter 2 discusses the Santa Clara Valley program and the BMP screening and selection method.

One screening method involves applying screening criteria to each nonstructural practice to determine its applicability to the conditions in the watershed. The screening criteria will be specific to the watershed and will depend on the goals of the program. Typical criteria include:

- Pollutant Removal: Different regulations and source control practices are designed to address different pollutants and, therefore, the program team should ensure that the screened list of controls includes those practices designed to address the pollutants of primary concern. Certain source control measures (e.g., development of a public information program) may not be measured in terms of reduction in pollutants loads. Therefore, municipalities may want to use alternate measures, such as the level of public participation in recycling programs or the number of community outreach activities completed.

- Existing Government Structure: Some practices implemented throughout the country require a specific government structure. For example, a strong county government may be important for implementing a specific regulatory control. However, the role of county governments can vary from one section of the country to another. Practices requiring specific government structures that do not exist in the area of concern could, therefore, be eliminated from the list.

- Legal Authority: For regulatory controls to be effective, municipalities must have the legal authority to implement and enforce regulations. Municipal boards and officials may lack this authority and may be required to obtain it through local action.

- Public or Municipal Acceptance: It may be difficult to implement some practices because of resistance from the public or an involved municipal agency. An improved communications strategy or other appropriate measures may improve the perception of these practices.

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- Technical Feasibility: Some of the municipal BMPs described may require large expenditures, extensive efforts, and long-term operation and maintenance costs. Therefore, they may not be suitable for implementation in small municipalities that lack the required resources.

Additional screening criteria may also be used, as shown in the Santa Clara Valley case study at the end of Chapter 2.

Another method of screening involves the use of a comparative summary matrix, an example of which is presented in Figure 2-2. This matrix was developed for screening nonstructural control practices in coastal areas; however, it is at least in part applicable to inland areas as well. In this matrix, various regulatory and source control practices are listed and compared for their ability to meet various criteria. The criteria listed generally include ability to remove specific pollutants, such as nutrients and sediments, maintenance requirement, longevity, community acceptance, secondary environmental impacts, costs, and site requirements. Other criteria are also listed, and some of these are only applicable in coastal areas. For each practice and criterion, an assessment of effectiveness is indicated, with the solid circle indicating high effectiveness and the open circles indicating low effectiveness. This type of matrix may provide a basis for making an initial assessment of practices and their applicability to the program.

Structural Practices

Because structural practices generally are more site-specific and have more restrictions on their use than nonstructural practices, the initial screening step for these practices can be more precise than the initial screening step for nonstructural practices. Table 2-8 outlines some of the more important criteria for screening structural BMPs, including their pollutant removal efficiencies, land requirements, the drainage area that each BMP can effectively treat, the desired soil conditions (e.g., soils favorable for infiltration), ground water elevation, and costs. By using these criteria and the information obtained in the data collection and analysis and problem identification and ranking steps, the program team can narrow the choice of BMPs to a list that can be further assessed in the BMP selection step.

The initial screening criteria for structural practices include the following:

- Pollutant Removal: It is important for the municipality to ensure that the BMPs selected address the primary pollutants of concern to the level of removal desired.

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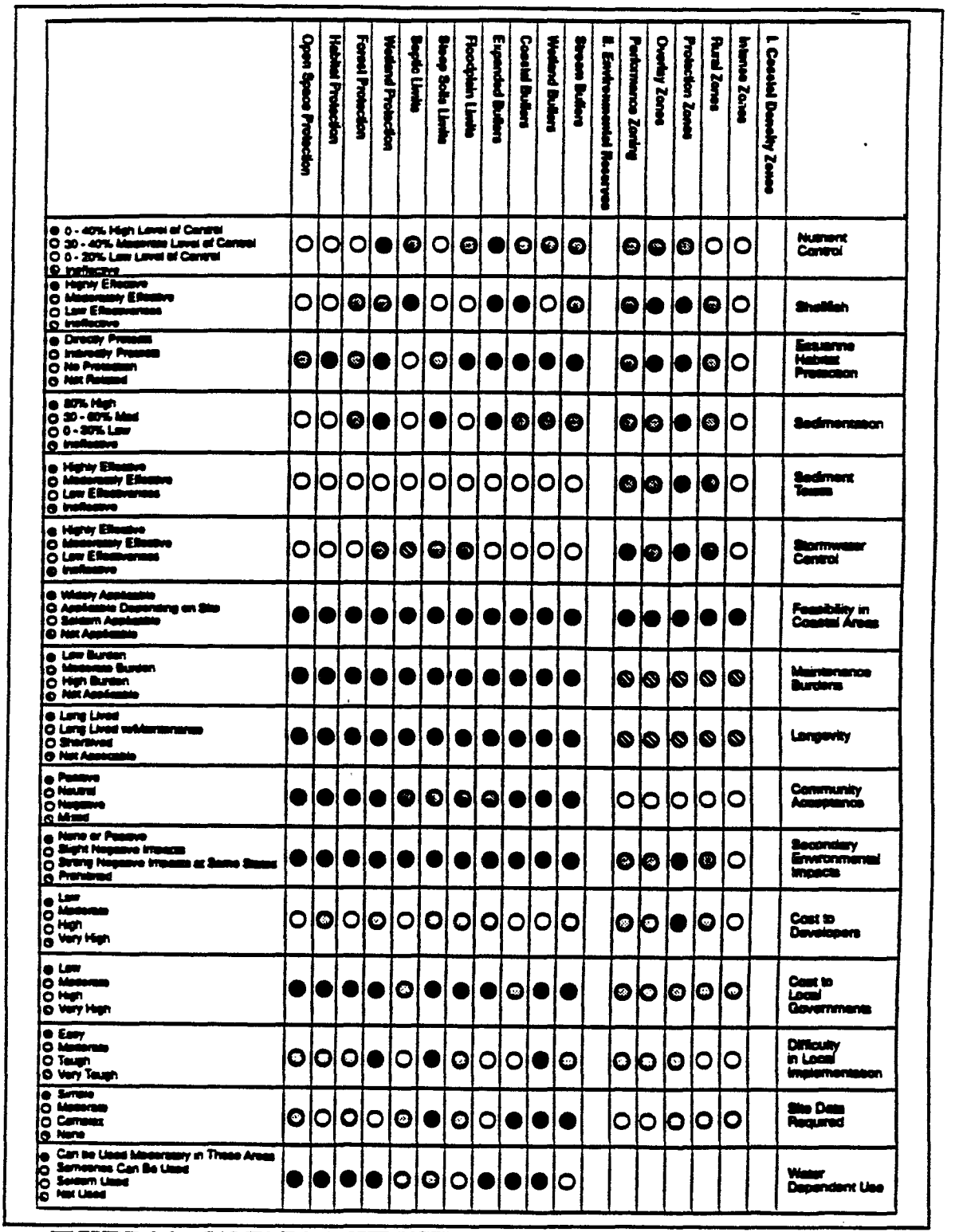

FIGURE 2-2. SAMPLE NONSTRUCTURAL CONTROL SCREENING MATRIX

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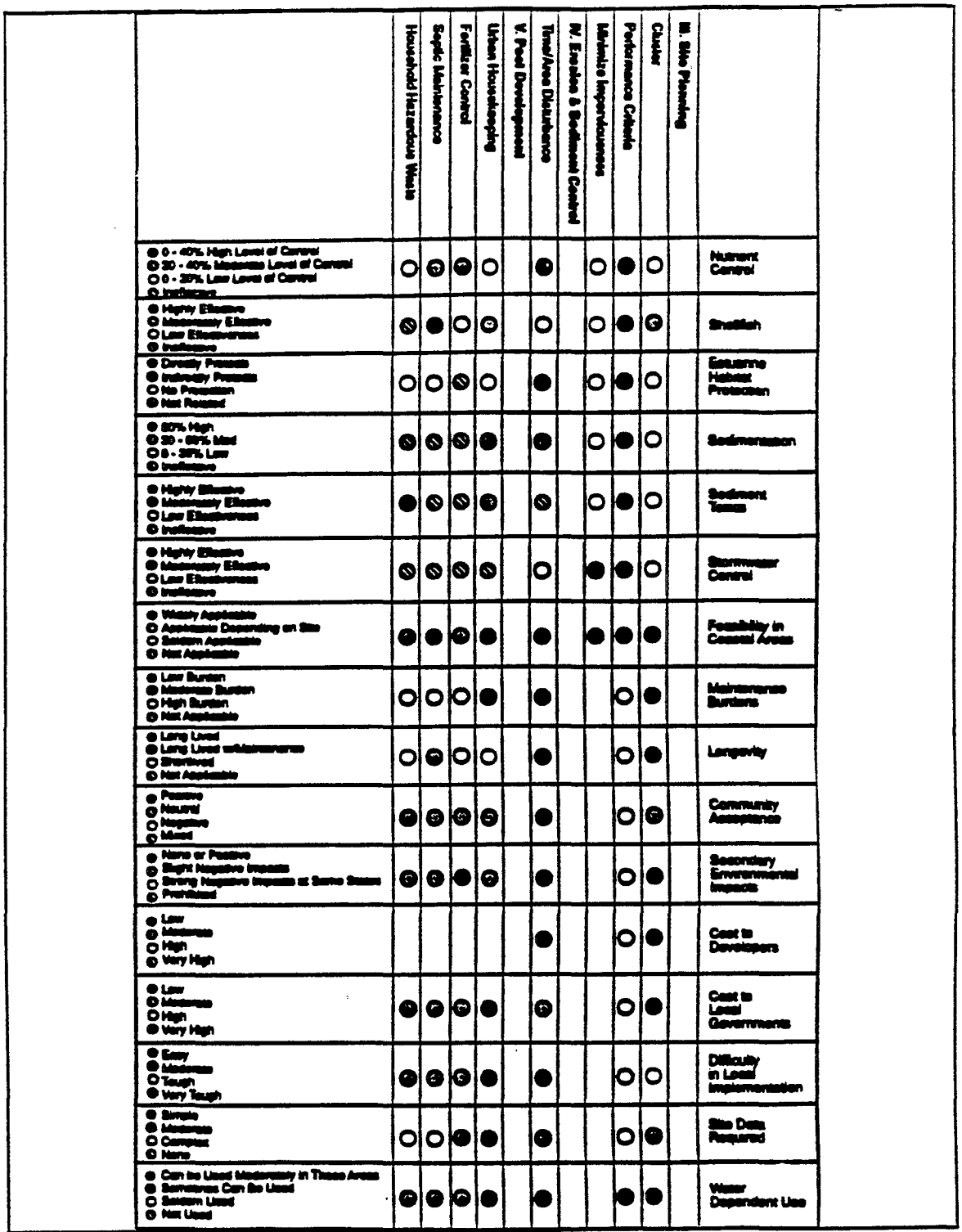

FIGURE 2-2. SAMPLE NONSTRUCTURAL CONTROL SCREENING MATRIX (Continued)

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TABLE 2-8. STRUCTURAL BMP INITIAL SCREENING CRITERIA

Structural BMPs	Pollutant Removal (1)					Land Requirements	Drainage Area (2)	Desired Soil Conditions	Ground Water Elevation
	Suspended Solids	Nitrogen	Phosphorus	Pathogens	Metals				
Detention Facilities									
Extended Detention Basins	Medium-High	Low-Medium	Low-Medium	--	Low-Medium	Large	Medium-Large	Permeable	Below Facility
Wet Ponds	Medium-High	Low-Medium	Low-Medium	--	Low-Medium	Large	Medium-Large	Impermeable	Near Surface
Constructed Wetlands	Medium-High	Low	Low-Medium	--	Medium-High	Large	Large	Impermeable	Near Surface
Infiltration Facilities									
Infiltration Basins*	Medium-High	Medium-High	Medium-High	High	Medium-High	Large	Small-Medium	Permeable	Below Facility
Infiltration Trenches/ Dry Wells*	Medium-High	Medium-High	Low-Medium	High	Medium-High	Small	Small	Permeable	Below Facility
Porous Pavement	High	High	Medium	High	High	N/A	Small-Medium	Permeable	Below Facility
Vegetative Practices									
Grassed Swales	Medium	Low	Low	--	Low-Medium	Small	Small	N/A	N/A
Filter Strips	Medium-High	Medium-High	Medium-High	--	Medium	Varies	Small	N/A	N/A
Filtration Practices									
Filtration Basins	Medium-High	Low	Medium	--	Medium-High	Large	Medium-Large	Permeable	Below Facility
Sand Filters	High	Low	--	--	Medium-High	N/A	Small-Medium	N/A	N/A
Water Quality Inlets	Low-Medium	Low	Low	--	Low	N/A	Small	N/A	N/A

(1) Low = 0-30%; Medium = 30-65%; High = 65-100%
(2) Small = 0-10 acres; Medium = 10-40 acres; Large = >40 acres
N/A = Not applicable
* Potential for failure high, especially when not designed and installed properly.

Sources: Schueler, 1987; Woodward-Clyde, 1991.

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- Land Requirements: Large land requirements for some of the above-ground structural BMPs can often restrict their use in highly developed urban areas.

- Drainage Area: The structural BMPs listed in Table 2-8 are used primarily to treat runoff from watersheds extending to 50 or 60 acres. Drainage areas above this size might have to be treated by locating BMPs in sub-watersheds.

- Soil Characteristics: Structural BMPs have differing requirements for soil conditions. Infiltration facilities generally require permeable soils, while detention BMPs generally require impermeable soils. The municipality must become familiar with soil conditions in the watershed.

- Ground Water Elevation: The ground water elevation in the watershed can be a limiting factor in siting and implementing structural BMPs. Generally, high ground water elevation can restrict the use of infiltration facilities.

- Public Acceptance: It may be difficult for a municipality to implement a structural BMP that meets with general public approval. Public acceptance of the BMP is an important consideration in the screening step.

- Technical Feasibility: Some of the municipal BMPs described may require large expenditures, extensive efforts, and long-term operation and maintenance costs. Therefore, they may not be suitable for implementation in small municipalities that lack the required resources.

Of the screening criteria listed, the pollutant removal, land requirements, and drainage area served are usually absolute restrictions. Soil condition and ground water elevation, on the other hand, impose restrictions that can potentially be overcome by importing needed soil or constructing facilities with clay liners to restrict ground water inflow. These modifications, however, can add significantly to BMP costs.

BMP Selection Process

Having screened the initial list of BMPs, municipalities can now rank and select a final set of BMPs using the decision-making process (Figure 2-3) described below. This process evaluates the relative merits of each BMP or group of BMPs. Because of the complexity of urban runoff control problems, a number of factors must be taken into account in assessing alternative plans. These are presented in Figure 2-3 as inputs to the decision process and include analysis tools and decision factors. The analysis tools are those used to assess and rank the existing pollution problems (see beginning of Chapter 2). The decision factors are the criteria used to compare the alternatives. All of these inputs are then used to evaluate the alternatives using one or more decision analysis methods. The following discussion discusses each input

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to the decision analysis, then describes the various decision analysis methodologies that may be used to select BMPs for ultimate inclusion in the SWMP.

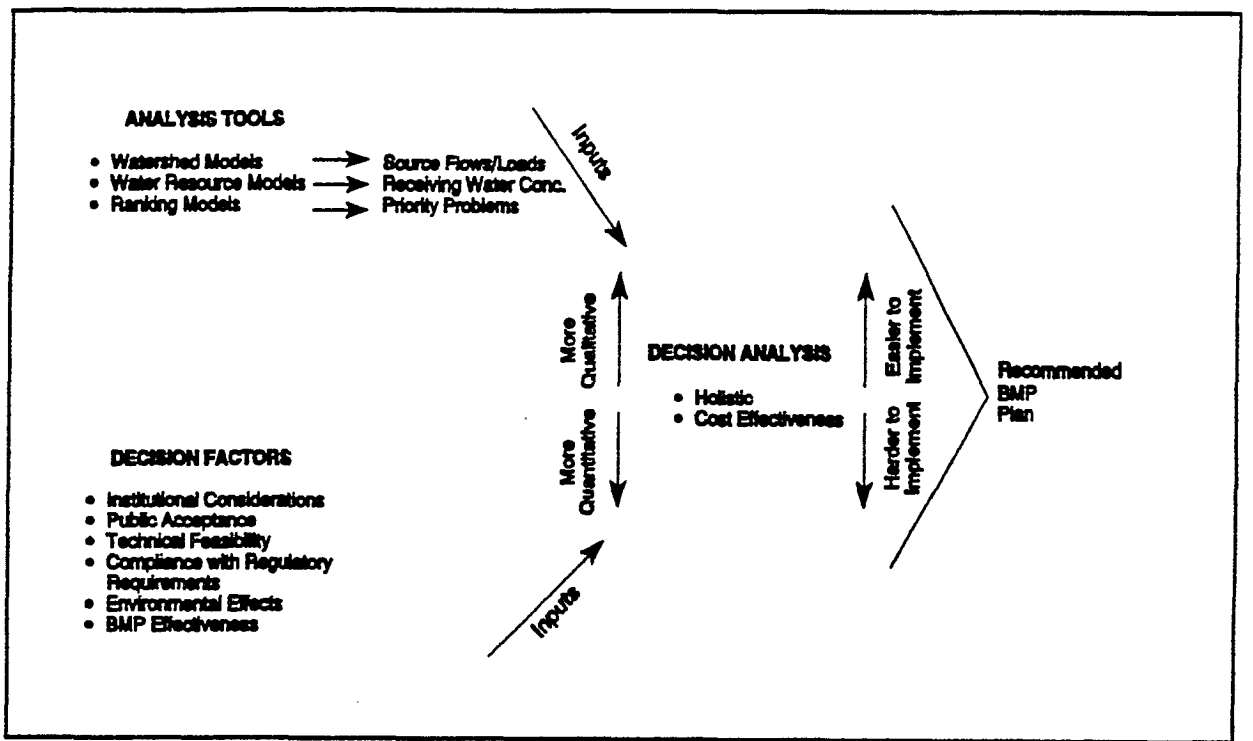

FIGURE 2-3. CONCEPTUAL DIAGRAM OF BMP SELECTION METHOD

Analysis Tools

These tools were described in detail during the discussion of Step 3. They can consist of watershed models, receiving water models, and ranking models. The analysis tools are used to project future conditions, given the alternatives being investigated. For example, the total pollutant loads for each alternative may be calculated (whether using a unit load method or complex models, such as SWMM). This will serve as one item of input information as the alternatives are being compared. Similarly, the impacts to receiving waters may be assessed using these tools, so that the impacts can be compared when making a decision.

Criteria for Decisionmaking

An important step in BMP plan selection is to determine the decision factors of importance. The selection of these criteria is site-specific and needs to be determined by the program team based on the

characteristics of the watershed and the financial and personnel resources available. Typical decisionmaking criteria are discussed below. Note that they are similar to the problem assessment criteria use in Step 3.

Institutional Considerations

To evaluate and select appropriate BMPs, municipalities may want to consider a number of institutional factors, including existing governmental structures, legal authority, and implementation responsibilities. If the proper legal authority does not exist, an analysis for attaining this authority must be undertaken (as required under Part 2 of the application). In addition to these considerations, the team should investigate existing urban runoff programs in the community, region, or State. Often, cost savings are realized and total program efforts reduced by taking advantage of material and data compiled from existing programs. It should be noted that these decision factors are similar to the assessment criteria used to rank pollution problems. Factors to consider when ranking BMPs are:

- Degree to which existing technologies or programs (municipal, State, Federal) could be used
- Availability of tools (technical methods and measures) to address adverse side effects of a particular action
- Extent to which legal authority exists to implement the BMP.

Public Acceptance

In many instances, the public will be responsible for at least a portion of the funding required to implement the recommended plan. Public reaction to aspects of the storm water management program should, therefore, be assessed through the use of public meetings. Measuring public acceptance can be difficult, but is often important to the overall success of a program. The main factors to consider are:

- Level of public support to address problems
- Level of public support for implementing a particular BMP
- Public perception of the value of the resource.

Technical Feasibility

Cost is one of the most important factors to consider when selecting BMPs. Municipalities should consider the costs associated with both the development and implementation of nonstructural BMPs and the construction and operation of structural BMPs. Total costs should be reflected in addition to capital and operation and maintenance costs for each alternative. The benefits associated with the implementation of a control plan are usually more difficult to determine. For example, if an urban runoff control plan is designed to reduce the discharge of fecal coliform to a closed shellfish area, there will be monetary benefits when these beds are reopened. These benefits are difficult to quantify but should not be neglected when selecting BMPs. The factors to consider are:

- Relative costs for a particular BMP
- Availability of funds (capital) to initiate the project
- Availability of funds to operate and maintain BMPs over time.

Construction Issues

In evaluating and selecting BMPs (particularly structural BMPs), municipalities should consider various aspects of construction, including site requirements, the extent of disruption, and the degree of construction difficulty. When relying on complex structural controls, there are difficulties inherent in construction and future maintenance that need to be overcome. Construction issues are not as important when assessing source control and regulatory control practices. However, for structural controls, they can often be very important. The factors to consider include:

- Land requirements
- Soil requirements
- Ground water elevation.

Compliance With Regulatory Requirements of the SWMP

BMPs should also be assessed on their capacity to meet the regulatory requirements of the SWMP. For example, as part of the SWMP, municipalities must prevent illicit discharges from entering the storm sewer system. In addition, they must control discharges into their storm sewer systems from industries. BMPs that work toward achieving these programmatic requirements would be assigned higher priority

than those that do not. Priority considerations and pollution sources should be the focus of the selected alternative. The factors to consider are:

- Extent to which regulatory requirements are satisfied
- Extent to which specific programmatic measures of the SWMP are satisfied.

Environmental Effects

The implementation of pollution control measures for storm water runoff can affect the environment in a number of ways. When evaluating various BMPs, municipalities should consider the potential effects—both positive and negative—that may result from their implementation. The many resources that can be positively affected include water resources, aquatic animal and plant life, wildlife, and wetlands. The negative environmental effects, which can include aesthetic problems, cross-media contamination, the loss of useable land, and wetlands impacts, may also be considered.

The importance of considering BMP side effects is becoming more widely recognized. Indeed, there is a shift away from viewing BMPs simply in terms of their pollution control ability. Incorporating structures into new developments or retrofitting them in existing areas can gain wider acceptance if aesthetic qualities are considered. For example, unvegetated above-ground infiltration basins or extended detention basins are generally not attractive elements of the environment and may serve as insect breeding grounds. However, natural-looking wet ponds or vegetated wetlands can be incorporated into the environment and even improve aesthetics. These are issues that can greatly affect public acceptance. The main factors to consider are:

- Potential for positive effects of BMP on the community (e.g., property value, aesthetics), water resources, aquatic animal and plant life, wildlife, or wetlands
- Potential for negative effects due to BMP, such as aesthetic problems, cross-media contamination, the loss of useable land, wetlands impacts, operation and maintenance costs to the community (taxes).

Secondary environmental impacts from municipal BMPs most often affect wetlands because of the role they play in storm water management. Wetlands are used in the treatment of urban storm water discharges within a storm water management program. The impacts of urban storm water discharges on

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wetlands include degradation of wetland hydrology, wetland water quality, wetland soils, and wetland plants and animals. As a result of urbanization, wetland hydrology is affected by the increased quantity and poor quality of the storm water discharges. The impacts to wetland hydrology include lower wetland response time, change in water levels in the wetland, and a change in the wetland's detention time. The changes in wetland water quality that result from urban storm water runoff are physical and chemical. The physical changes occur in temperature, conductivity, and the level of suspended solids. The chemical changes result from the increased levels of toxics, metals, and nutrients contained in the storm water runoff. Impacts to wetland soils include changes in the pH and redox potential. The combined results of the above impacts negatively affect plants and animals in the wetland. The increased levels of storm water runoff can flood plants and the feeding and breeding grounds of many animals. Also, the toxicity levels in storm water runoff may kill plants and other food for animals within the wetland habitat.

BMP Effectiveness

Estimating the effectiveness of a BMP is one of the most important factors a municipality will consider as part of the BMP selection process. In most cases, determining BMP effectiveness for structural controls is easier than for nonstructural controls. Structural controls (e.g., detention facilities and infiltration basins) may be assessed in terms of their demonstrated capacities to remove pollutants (see Chapter 5), whereas nonstructural controls (e.g., street sweeping, land use regulations, and solid waste management) may be evaluated according to indirect measures, such as the degree to which public awareness is heightened or the number of community outreach programs that are implemented.

Some municipalities may choose quantitative, decision analysis techniques to assess BMPs, whereas others may prefer to use more basic qualitative assessments backed by basic statistics, such as cost-effective data. While qualitative factors may be subjective by their very nature, the need for more quantitative, decision analysis models may be unnecessary during the early steps of BMP selection.

One type of qualitative analysis involves a holistic approach, which relies on the use of certain basic facts, intuition, and professional judgment. One key deciding factor (cost, for example) can guide the process. Given the inherent complexity of assessing alternative urban runoff control plans and the large number of available inputs to the decision, this approach is usually over-simplified. The selection of an appropriate plan from the developed alternatives will generally require an assessment of multiple factors and should be done in as quantitative a manner as is reasonably possible.

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Quantitative approaches include such measures as cost-effectiveness analyses. A cost-effectiveness analysis helps the municipality attain a predetermined goal with the least expensive method possible.

SUMMARY

The process of targeting storm water runoff problems and selecting BMPs to control those problems is difficult and can best be performed by undertaking a systematic assessment process. Because of the qualitative nature of some inputs to these assessments and decisions, subjective comparisons among the alternative plans will likely be necessary. Where cost-benefit issues need to be addressed, or where technically complex cases are encountered, more quantitatively based, analytical tools may be necessary. The process outlined in this chapter acts as a guide for decision making and cannot account for all of the circumstances that might be encountered. Professional judgment and care is needed at each step along the way. Once these choices have been made and BMPs have been selected, the storm water management program is ready to be implemented.

WORKSHEETS

The next two pages contain worksheets developed for the *State of California Storm Water Best Management Practice Handbook (Municipal)*. These worksheets may be useful in setting priorities for selecting municipal source and treatment controls.

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WORKSHEET 1 SOURCE CONTROL BMP							
PROGRAM ACTIVITIES: **PROGRAM ELEMENTS:**							
BMPs	**Meets Regulatory Requirements (1 - 5)**	**Effectiveness of Pollutant Removal (1 - 5)**	**Public Acceptance (1 - 5)**	**Implementable (1 - 5)**	**Institutional Constraints (1 - 5)**	**Costs (1 - 5)**	**Total (30 MAX)**

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WORKSHEET 2 TREATMENT CONTROL BMP								
Pollutants of Concern	BMPs	Area of Application (Ac)	Annual Pollutants Removed (Lb/Yr)	Annual Capital Costs[1] ($/Yr)	Annual O&M Cost[2] ($/Yr)	Annual Admin. Costs ($/Yr)	Total Annual Costs ($/Yr)	Removal Cost[3] ($/Lb)

[1] Annual capital costs based on a 20-year design period.
[2] Annual administration costs are best determined by a given community once a city-wide program is established.
[3] Removal costs are in units ($/Yr)/(Lb/Yr) = $/Lb.

CASE STUDIES

The following case studies provide examples of methods for both assessing storm water runoff problems and evaluating/selecting appropriate BMPs to address those problems.

R0014041

This section summarizes the Virginia Beach, Virginia, Part 2 Storm Water permit application. The example illustrates the overall program priorities considered by Virginia Beach for the initial implementation of its storm water management program.

Program priorities were developed based on a qualitative approach rather than a rigorous quantitative approach using specific evaluation criteria that are assigned values and weights. Priorities, however, were considered by evaluating each activity listed in Table 2-9 using the following guidelines:

- Level of pollution load reduction (if high, then higher priority)
- Cost (if low, then higher priority)
- Public acceptance (if high, then higher priority)
- Type of program (if ongoing program, then higher priority than enhanced ongoing program; if new program, then lower priority than existing program; if program designed to meet a minimum requirement not presently undertaken by city, then a higher priority)
- Type of development (if program for new development, then higher priority than for program for existing development).

Using these guidelines, the first priority programs and the second priority programs were selected and are presented in Table 2-9 under the heading Priorities with either a "1st" priority or a "2nd" priority indication.

Schedule

Figure 2-4 shows an overall schedule for the program activities listed in Table 2-9. Many of the ongoing programs (e.g., BMP Reinspection Program) and some of the new programs (e.g., implementation and enforcement of new storm sewer system ordinance) will be fully implemented during each year of the term of the permit. Other programs will require phased implementation (e.g., development of a slide show for reporting illicit discharges), and still others will be developed during the middle years of the program (e.g., evaluation of any existing major flood control structures for water quality benefits). For some programs, the schedule indicates the number of ponds, structures, and sites to be considered (e.g., ongoing field screening for up to 25 new sites a year) for each year of the permit. The frequency (e.g., once a year) of monitoring and specific inspection programs are also indicated on the schedule.

Program Evaluation

During the term of the permit, the city, principally through the Department of Public Works, will monitor the progress of implementing the components of the comprehensive management program and the representative monitoring program. As part of this process, the city will evaluate the pollution removal/control effectiveness of the various program activities. For commercial and residential areas, the comprehensive storm water management program will be tracked and evaluated in light of the new and existing ordinances related to storm water quality. The expanded BMP data base will be monitored to assure that new data on structural BMPs are being used by the BMP reinspection program to assist in the maintenance schedule for structural controls, including major sediment removal.

R0014042

TABLE 2-9. PROPOSED MANAGEMENT PROGRAM ACTIVITIES*

Activities	Priorities
Program for Commercial and Residential Areas	
• Master Plan for New Development	
- Maintenance of Comprehensive Plan	1st
- Existing Ordinances	1st
- Owl Creek Watershed Protection Program	1st
- Design Guidelines	2nd
• Maintenance of Structural Controls	
- Maintenance of Structures	
– Retention/Detention Ponds	1st
– Ditches/Canals/Waterways	1st
– Oil/Water Separators	1st
– Volume Control BMPs	1st
– Culverts/Structures	1st
- BMP Reinspection Program	1st
- BMP Data Base Expansion	2nd
- Major Sediment Removal	2nd
• Practices for O&M for Streets, Roads, and Highways	
- Erosion and Sediment Control	1st
- Catch Basin and Ditch Cleaning	1st
- Snow and Ice Control	1st
- Litter Control	1st
- Other Programs	1st
• Flood Management Procedures Assessment	1st
• Pesticide, Herbicide, and Fertilizer Application	
- Certification and Licensing	1st
- Training	1st
- Public Education	2nd
• Storm Water Master Plan Continuation	
- Plan Maintenance	1st
- Storm Sewer System Inventory	2nd
Program for Illicit Discharges and Improper Disposal	
• Implementation and Enforcement of Ordinance	1st
• Ongoing Field Screening	
- Sites from Part 1 Investigation	1st
- New sites each year	2nd

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the City of Virginia Beach, Virginia (1992).

R0014043

TABLE 2-9. PROPOSED MANAGEMENT PROGRAM ACTIVITIES (Continued)

Activities	Priorities
Program for Illicit Discharges and Improper Disposal (Continued)	
• Storm Sewer Investigations	
- Mapping and Evaluation	
— Part 1 sites	1st
— New sites	2nd
- Field surveys	
— Part 1 sites	1st
— New sites	2nd
- Source Identification	
— Part 1 sites	1st
— New sites	2nd
• Spill Response and Inspection Program	1st
• Reporting of Illicit Discharges	
- Brochures, Cityline Message and Slide Show	1st
- Hotline and main-in programs	2nd
• Controls to Limit Infiltration	1st
Program for Industrial Facilities	
• Mount Trashmore (Closed Landfill)	
- Inspection/Maintenance of Park	1st
- Monitoring Program for Two Lakes	1st
• Landfill No. 2	
- Inspection	1st
- Monitoring at One Site	2nd
• Other Facilities Data Evaluations	2nd
Program for Construction Sites	
• Site Plan Review	1st
• Inspection/Enforcement	1st
• Training Site Operators	2nd

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ACTIVITIES	YEAR OF PERMIT				
	1	2	3	4	5
COMMERCIAL AND RESIDENTIAL AREAS					
Master Plan for New Development					
Comprehensive Plan					
Existing Ordinances					
Owl Creek Watershed Protection Program					
Design Guidelines					
Maintenance Plan for New Development					
Maintenance of Structures					
BMP Reinspection Program					
Data Base Expansion					
Major Sediment Removal	2 ponds	2 ponds	2 ponds	2 ponds	2 ponds
Practices for O&M for Streets, Roads, and Highways					
Flood Management Procedure Assessment					
Pesticides, Herbicides, and Fertilizer					
Certification/Licensing					
Training (O = developed)	O				
Public Education (O = developed)	O				
Storm Water Master Plan					
Water Quality Model					
Plan Maintenance					
Storm Sewer System Inventory (continuing after 5 years)					
ILLICIT DISCHARGES AND IMPROPER DISPOSAL					
Implementation and Enforcement of Ordinance					
Ongoing Field Screening					
Sites from Part 1 Investigation	30 sites				
New Sites Each Year	25 sites	25 sites	25 sites	25 sites	25 sites
Storm Sewer System Investigations					
Mapping and Evaluation					
Part 1 Sites	30 sites				
New Sites	25 sites	25 sites	25 sites	25 sites	25 sites
Field Surveys					
Part 1 Sites		30 sites	25 sites	25 sites	25 sites
New Sites		25 sites	25 sites	25 sites	25 sites

FIGURE 2-4. CITY OF VIRGINIA BEACH, VIRGINIA PROPOSED STORM WATER MANAGEMENT PROGRAM SCHEDULE*

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the City of Virginia Beach, Virginia (1992)

R0014045

ACTIVITIES	YEAR OF PERMIT				
	1	2	3	4	5
Source Identification					
Part 1 Sites		30 sites			
New Sites		25 sites	25 sites	25 sites	25 sites
Spill Response and Inspection Program					
Reporting of Illicit Discharges					
Brochure, Cityline Message, and Slide Shows (O = developed)	O				
Call-in and Mail-in (O = developed)	O				
Proper Management and Disposal of Toxic Materials					
Support for Ongoing Programs					
Brochure, Cityline Message, and Slide Show (O = developed)	O				
Controls to Limit Infiltration					
INDUSTRIAL FACILITIES					
Mount Trashmore					
Inspection/Maintenance of Park					
Monitoring Program for Two Lakes	twice	twice	twice	twice	twice
Landfill No. 2					
Inspection	4 times	4 times	4 times	4 times	4 times
Monitoring at a Site	once	once	once	once	once
Other Facilities Evaluations					
Evaluate Data					
Site Inspection of Each Site	once	once	once	once	once
CONSTRUCTION SITES					
Site Plan Review					
Inspection/Enforcement					
Training Site Operators (O = developed)	O	once	once	once	once

FIGURE 4-2. CITY OF VIRGINIA BEACH, VIRGINIA PROPOSED STORM WATER MANAGEMENT PROGRAM SCHEDULE (Continued)

R0014046

Criteria for Prioritizing Basins

The primary objective of King County's watershed approach is to protect and maintain the integrity of County stream systems and to prevent their degradation to the degree possible.

King County's philosophy is that stream protection must be accomplished through the evaluation and management of land and water within the entire watershed; that erosion cannot be managed without controlling the high flows that cause erosion; that water pollution cannot be adequately reduced without controlling the runoff and sediment, by which pollutants are transported; and that aquatic habitat cannot be managed without considering all of the chemical, physical, and hydrological elements that define each habitat.

Accordingly, criteria for prioritizing watersheds were developed to give planning urgency to those basins where hazardous conditions, such as landslides and flooding, were most frequent/severe and where water quality and habitat have not been severely affected (and could yet be preserved through proactive planning).

The initial basin planning prioritization was based on a significant body of knowledge gained from the 1987 Basin Reconnaissance program, a field inventory of problems and potential solutions conducted during the rainy seasons of 1985-1986 and 1986-1987. Multidisciplinary teams noted existing problems and features in portions of 29 service area basins. These data were used directly to determine ratings for each basin in four major categories: Existing Problems, Future Problems, Existing Resources, and Urgency/Timeliness. Rating criteria were associated with each major category, as listed in Table 2-10 below.

TABLE 2-10. BASIN PLANNING PRIORITIZATION CATEGORIES AND CRITERIA*

Category	Criteria
Existing Problems	- Landslides - Erosion/Sediment - Flooding
Future Problems	- Land in Unincorporated King County - Subdivision/Plat Activity - Population Growth - Permitted Residential Units
Existing Resources	- Stream Habitat - In-Stream Resources - Wetland Value - Wetland Storage Potential - Water Quality Potential
Urgency/Timeliness	- Other Agency Interest - Opportunity to Integrate with Other Programs

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

Problem counts for each category were generated from the Technical Appendix of each Basin Reconnaissance report (included with the Part 1 permit application). For example, for the Landslides, Erosion/Sedimentation, and Flooding categories, the following ratings were applied: "0" - low (few problems), "1" - moderate (some problems), and "2" - high (many problems). For other criteria, such as Water Quality and Stream Habitat, opposite

scores were assigned: "0" - low quality (many problems), "1" - moderate (some problems), and "2" - high quality (few problems).

Tables 2-11 through 2-14 show the final scores of each basin for each major category. Table 2-15 shows the ranking of basins according to total scores. These rankings form the basis of the proposed basin planning schedule shown in Table 2-16.

By the end of 1992, the County will have completed, or will be substantially underway, with basin plans for 12 of the 37 basins in the surface water management service area. As expected from the ranking criteria, the first basins selected for planning services were predominately rural watersheds. More recently, the Surface Water Management Division has begun the basin planning process in urban or urbanizing basins, such as Miller Creek, Seola Creek, and Salmon Creek. The planning process for these basins will incorporate many of the same management strategies applied to rural basins and will be complemented with new programs being developed and implemented as part of the NPDES program (e.g., drainage mapping, illicit discharge surveys, and source control best management practices).

R0014048

TABLE 2-11. BASIN PRIORITIZATION*

1. Existing Problems (from Basin Reconnaissance)				
	Criteria			
Drainage Basin	Landslide	Erosion/ Sediment	Flooding	Sheet 1 Total
McAleer	1	1	2	4
Lyons	0	1	2	3
Swamp	0	1	2	3
Sammamish	2	2	1	5
North	0	0	0	0
Little Bear	0	1	1	2
Big Bear	0	2	1	3
Thornton	0	0	1	1
Lk Washington	0	2	1	3
Juanita	1	2	2	5
Forbes	0	1	1	2
Evans	1	2	1	4
W Lk Sammamish	1	2	1	4
E Lk Sammamish	1	2	1	4
Coal	1	1	1	3
Tibbetts	2	1	1	4
May	1	2	2	5
N Fk Issaquah	0	1	1	2
E Fk Issaquah	0	1	1	2
Issaquah	1	2	0	3
Lower Cedar	2	2	2	6
Duwamish	0	1	2	3
Black	1	2	0	3
Mill	0	2	2	4
Lower Green	1	2	1	4
Soos	0	1	2	3
Jenkins	0	1	2	3
Covington	0	0	0	0
Middle Green	2	1	1	4
Boeing	2	2	1	5
Middle Puget	1	1	1	3
Lower Puget	2	2	1	5
Salmon	1	1	1	3
Miller	0	1	1	2
Des Moines	0	1	2	3
Hylebos	0	2	2	4
White	0	1	1	2

Note: See narrative for explanation of rating criteria.

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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TABLE 2-12. BASIN PRIORITIZATION*

II. Future Problems					
	Criteria				
Drainage Basin	Land in Unincorp. King Co.	1982-1987 Subdivision/ Plat Activ.	Population Growth	Permitted Residential Units	Sheet 2 Total
McAleer	1	1	0	1	3
Lyons	0	1	0	2	3
Swamp	0	1	1	2	4
Sammamish	1	2	2	1	6
North	0	2	1	2	5
Little Bear	0	1	2	0	3
Big Bear	1	1	2	2	6
Thornton	1	0	0	0	1
Lk Washington	0	2	1	1	4
Juanita	2	2	2	2	8
Forbes	1	2	1	2	6
Evans	2	2	2	1	7
W Lk Sammamish	0	2	1	2	5
E Lk Sammamish	2	2	2	2	8
Coal	1	1	2	0	4
Tibbetts	1	1	1	0	3
May	1	0	1	1	3
N Fk Issaquah	2	0	1	0	3
E Fk Issaquah	1	0	0	0	1
Issaquah	2	0	0	0	2
Lower Cedar	0	1	1	1	3
Duwamish	0	0	0	1	1
Black	0	1	1	2	4
Mill	1	0	1	0	2
Lower Green	1	2	1	2	6
Soos	2	2	2	1	7
Jenkins	2	1	1	1	5
Covington	1	0	0	0	1
Middle Green	0	0	0	1	1
Boeing	2	1	0	2	5
Middle Puget	0	0	0	0	0
Lower Puget	1	2	2	2	7
Salmon	2	0	0	2	4
Miller	2	0	0	1	3
Des Moines	2	0	0	0	2
Hylebos	2	1	2	1	6
White	0	1	0	0	1

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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TABLE 2-13. BASIN PRIORITIZATION*

III. Existing Resources						
	Criteria					
Drainage Basin	Stream Habitat	In-Stream Resources	Wetland Value	Wetland Strg. Pot.	Water Quality	Sheet 3 Total
McAleer	0	0	0	0	1	1
Lyons	0	0	0	0	0	0
Swamp	1	1	1	0	1	4
Sammamish	0	2	1	1	1	5
North	1	2	0	0	2	5
Little Bear	1	2	0	0	2	5
Big Bear	1	2	2	2	2	9
Thornton	0	0	0	0	0	0
Lk Washington	0	0	1	1	0	2
Juanita	1	1	1	0	1	4
Forbes	1	1	1	1	1	5
Evans	1	1	2	2	1	7
W Lk Sammamish	0	1	0	0	1	2
E Lk Sammamish	1	1	2	2	1	7
Coal	0	1	1	0	1	3
Tibbetts	1	2	0	0	1	4
May	1	1	2	1	1	6
N Fk Issaquah	1	1	1	1	1	5
E Fk Issaquah	1	1	1	1	1	5
Issaquah	2	2	2	1	2	9
Lower Cedar	1	1	2	2	1	7
Duwamish	1	1	0	0	0	2
Black	0	2	1	0	0	3
Mill	0	1	1	0	0	2
Lower Green	0	1	2	1	1	5
Soos	1	2	2	2	1	8
Jenkins	2	2	2	2	2	10
Covington	2	2	2	2	1	9
Middle Green	1	2	2	1	1	7
Boeing	0	0	0	0	0	0
Middle Puget	0	0	0	0	0	0
Lower Puget	0	0	2	1	0	3
Salmon	1	1	1	0	1	4
Miller	1	1	1	0	0	3
Des Moines	1	0	1	0	0	2
Hylebos	1	2	2	1	1	7
White	1	2	2	1	1	7

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

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TABLE 2-14. BASIN PRIORITIZATION*

IV. Urgency/Timeliness			
	Criteria		
Drainage Basin	Other Agency Interest	Opp. to Integrate with Other Programs	Sheet 4 Total
McAleer	1	0	1
Lyons	1	1	2
Swamp	1	0	1
Sammamish	0	1	1
North	0	0	0
Little Bear	0	0	0
Big Bear	2	2	4
Thornton	1	0	1
Lk Washington	0	0	0
Juanita	0	0	0
Forbes	0	0	0
Evans	2	1	3
W Lk Sammamish	1	1	2
E Lk Sammamish	1	1	2
Coal	1	0	1
Tibbetts	2	1	3
May	0	0	0
N Fk Issaquah	2	2	4
E Fk Issaquah	2	2	4
Issaquah	2	2	4
Lower Cedar	0	1	1
Duwamish	2	1	3
Black	0	1	1
Mill	2	2	4
Lower Green	0	2	2
Soos	2	2	4
Jenkins	2	2	4
Covington	2	2	4
Middle Green	0	2	2
Boeing	0	0	0
Middle Puget	0	0	0
Lower Puget	1	1	2
Salmon	0	0	0
Miller	0	1	1
Des Moines	2	1	3
Hylebos	1	1	2
White	0	1	1

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

TABLE 2-15. BASIN PRIORITIZATION*

Summation Sheet Ranked According to Total Score					
Drainage Basin	**Existing Problems**	**Future Problems**	**Existing Resources**	**Urgency/ Timeliness**	**Total Sum**
Big Bear	3	6	9	4	22
Jenkins	3	5	10	4	22
Soos	3	7	8	4	22
E Lk Sammamish	4	8	7	2	21
Evans	4	7	7	3	21
Hylebos	4	6	7	2	19
Issaquah	3	2	9	4	18
Juanita	5	8	4	0	17
Lower Cedar	6	3	7	1	17
Lower Green	4	6	5	2	17
Lower Puget	5	7	3	2	17
Sammamish	5	6	5	1	17
Covington	0	1	9	4	14
May	5	3	6	0	14
Middle Green	4	1	7	2	14
N Fk Issaquah	2	3	5	4	14
Tibbetts	4	3	4	3	14
Forbes	2	6	5	0	13
W Lk Sammamish	4	5	2	2	13
E Fk Issaquah	2	1	5	4	12
Mill	4	2	2	4	12
Swamp	3	4	4	1	12
Black	3	4	3	1	11
Coal	3	4	3	1	11
Salmon	3	4	4	0	11
White	2	1	7	1	11
Boeing	5	5	0	0	10
Des Moines	3	2	2	3	10
Little Bear	2	3	5	0	10
North	0	5	5	0	10
Duwamish	3	1	2	3	9
Lk Washington	3	4	2	0	9
McAleer	4	3	1	1	9
Miller	2	3	3	1	9
Lyons	3	3	0	2	8
Middle Puget	3	0	0	0	3
Thornton	1	1	0	1	3

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

TABLE 2-16. PROPOSED BASIN PLANNING SCHEDULE 1992 - 1997*

Basin/Start Year	Current and Future Conditions Report	Draft Basin Plan	WMC Proposed Basin Plan	WMC-approved or Executive Proposed	Expected Adoption
Soos/87	—	Nov 89		July 90	*Jan 92*
Bear/87	—	*Dec 89*		May 91	Oct 92
Hylebos-LPS/88	*July 90*	*Feb 91*		July 91	Jan 93
ELS/88	*Sept 90*	*May 92*	Nov 92	June 93	Sept 93
Issaquah/89	*Oct 91*	Nov 92	Apr 93	Sept 93	Jan 94
Cedar/91	Jan 93	July 93	Jan 94	Sept 94	Jan 95
May 2/92	Aug 93	April 94		Nov 94	May 95
Miller-Salmon-Seola/92	Oct 93	July 94		Feb 95	Aug 95
Green/94	May 95	Feb 96		Dec 96	Jun 97
Duwamish-Black-Mill/94	Feb 95	Oct 95		May 96	Nov 96
Sammamish 94	Dec 95	Sept 96		Apr 97	Oct 97
Boeing-McAleer-Lyon-Thornton/95	Feb 96	Oct 96		May 97	Dec 97
Juanita, E LK Wa. 96	Apr 97	Dec 97		Jul 98	Dec 98
W. Lk. WA, W. Lk. Samm 96	May 97	Dec 97		Jul 98	Dec 98

*Taken verbatim from the Part 2 NPDES Storm Water Permit Application prepared by the King County Surface Water Management Division (1992)

R0014054

This section summarizes the Part 2 storm water permit application prepared by Charlotte, North Carolina. The discussion does not mirror the planning process described in this manual, but rather presents a variation for municipalities to consider.

Step 1 — Develop Criteria to Evaluate Objective Attainment and Planning

The table below, taken verbatim from the Charlotte, North Carolina, Part 2 storm water permit application, summarizes the factors considered in each of the Charlotte Storm Water Quality Management Program (SWQMP) elements. The purpose of the table was to force full consideration of both the pros and cons of each program element and to assist the city in determining the practicability of each measure in formulation of its MEP.

TABLE 2-17. BEST MANAGEMENT PRACTICE SCREENING CRITERIA*

BMP:					
	Criteria Description	**+**	**0**	**-**	**Comments**
1.	Human Risk, Public Safety and Potential Liability				
2.	Environmental Risk and Implications				
3.	Ability to Control Key Targeted Pollutants				
4.	Costs to Implement and Continuing Costs				
5.	Acceptability to the Public, Stakeholders, Staff and Political Leadership				
6.	Equitability to Impacted Persons				
7.	Reliability and Consistency Over Time				
8.	Sustainability in Terms of Maintenance or Program Management				
9.	Ability to be Applied Universally Throughout the Jurisdiction or, on a Specific Watershed Basis				
10.	"Fit with other Charlotte Operations and Programs				
11.	Relationship to other Federal, State, or Local Regulatory Requirements				
12.	Amenity or Multi-use Value				
Totals					

*Excerpted verbatim from the Part 2 Storm Water Permit Application prepared by Charlotte, North Carolina (1992)

Step 2 — Develop List of Possible Control Measures (BMP's)

There are almost an infinite number of variations on programmatic, structural, and nonstructural BMPs. A candidate set of nearly 100 control measures, program elements, and other activities was developed through brainstorming sessions. A preliminary screening was done of these based on engineering judgement and knowledge of what measures were not remotely feasible. Candidate control measures and programs surviving this initial screen were subjected to a more formal consideration using the table in step 1.

Step 3 — Apply the Criteria to Screen the Measures

The criteria were generally applied (along with engineering judgement) to spotlight potential problems with the application of program elements. It was considered too premature to require the use of certain structural BMPs,

though a more formal technical consideration of specific design standards and incorporation into Charlotte design criteria was adopted as a program element.

Step 4 — Preliminarily Analyze a Practical Set of Control Measures

This shortened list was organized and analyzed to determine how each measure will function singularly and in conjunction with other program elements and how and by whom these elements will be implemented. Another part of this analysis is to determine ranges of BMP application to allow for development of alternative programs and to get a feel for cost sensitivity where appropriate.

Step 5 — Estimate Overall Program Costs and Pollution Reduction Effectiveness

In most cases, particularly for nonstructural BMPs, it was very difficult to assign pollution reduction numbers without better data and information. In many cases it was inappropriate. Great care and engineering judgment must then be exercised. The steps generally were to:

- Define such factors as the control measures, phases of implementation, ranges of implementation, equipment, and locations as necessary to define the program as fully as possible; consider pilot applications and data monitoring feedback loops
- Make first order estimates of program costs in each implementation stage or phase.
- Realistically allocate budgets to these programs over the first 5-year permit period and at ultimate development as appropriate.
- Make first order estimates of the program's effectiveness by relying on the experience of other cities.

Step 6 — Obtain Feedback and Revise Program Scope to Maximize Program Cost Effectiveness

There is a need in any comprehensive program development to go back and look at the whole assembled puzzle after suitable examination of each of the pieces and after preliminary coordination with the permit writer. Adjustments were made to the program scope and schedule.

Step 7 — Describe Roles and Responsibilities to Implement the Program

After a preliminary SWQMP strategy was formulated, preliminary roles or responsibilities for each program element were identified. The local organizational structure and current program responsibilities were considered.

Step 8 — Develop Schedule for Implementation Control Program Including Management and Feedback Loops

The end result of this step is the schedule and budget for program implementation. It was considered important to evaluate the success of the programs at every step and build into each program ways to measure that success. This may be through specially designed feedback from the persons implementing the program, through data collection and monitoring, public awareness polls, or other means.

EXAMPLE METHOD FOR SELECTING SOURCE CONTROL BMPs

This section summarizes the *State of California Storm Water Best Management Practice Handbook (Municipal)*, Storm Water Quality Task Force, March 1993. The discussion provides a step-by-step planning example on how to select potential source control BMPs for inclusion in a municipal Storm Water Management Program. It assumes that program goals and priorities and existing conditions (Steps 1-3) have been identified. This example illustrates how source control BMPs may be selected using the Source Control Worksheet #1.

Selection Process

The selection criteria and the scoring system below are similar to other selection processes developed around California. It is recommended, however, that the criteria and/or the scoring be modified to suit the particular community. Modification of the following selection process attributes may be considered:

- **Criteria** — Redefine some of the criteria or add/subtract criteria.
- **Scores** — Modify the scoring to a simple +,0, and -, or 1, 2, and 3.
- **Weighting** — Group the criteria into tiers reflecting their relative importance to specific SWMP goals. By multiplying the scores of the highest tier by some factor (e.g., x2), the first tier scores could be weighted more heavily than the others to reflect this importance.
- **Fatal flaw** — Provide for some fatal flaw in scoring the BMPs (e.g., the BMP is illegal or its implementation is completely unacceptable to the public) that would make implementation impossible. Scoring a fatal flaw as a 0 is one way of highlighting the flaw. Any BMP scoring a 0 against a criterion would be eliminated from consideration, regardless of its overall ranking.

Example

In the following example, municipality Anytown, California, is developing a Storm Water Management Program that includes an element for Residential/Commercial Activities. By following the steps below, the community uses Worksheet 1 to rank the BMPs according to their ability to meet the selection criteria. The worksheet shows the initial results of this hypothetical ranking.

1. The selection process involves consideration of following:
   - Table 2-18, Application of BMPs to SWMP Program Elements
   - Discussion of selection criteria
   - Worksheet 1
   - Source Control BMPs.
2. A review of Table 2-18 shows that for Residential/Commercial Activities, the storm water regulations require the SWMP to have an element addressing Roadway and Drainage Facility Maintenance. The program activity and element are listed at the top of Worksheet 1.
3. Looking across the Roadway and Drainage Facility Maintenance row in Table 2-18, two categories of source control BMPs apply, Material Use Control and Street/Storm Drain Maintenance.
4. The Material Use Control category includes two types of BMPs, Housekeeping Practices and Safer Alternative Products. These are listed on Worksheet 1.
5. Several BMPs are described within each fact sheet. These are also listed on Worksheet 1.

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WORKSHEET 1* SOURCE CONTROL BMP							
PROGRAM ACTIVITIES: *Residential/Commercial*							
PROGRAM ELEMENTS: *Roadway and Drainable Facility Maintenance*							
BMPs	**Meets Regulatory Requirements (1 - 5)**	**Effectiveness of Pollutant Removal (1 - 5)**	**Public Acceptance (1 - 5)**	**Implementable (1 - 5)**	**Institutional Constraints (1 - 5)**	**Costs (1 - 5)**	**Total (30 MAX)**
MATERIAL USE CONTROL:							
Housekeeping Practices							
• Distribute Public Education Material	3	2	5	5	4	5	24
• Train City Employees Regarding Chemical Use	3	3	5	4	4	5	24
Safer Alternative Products							
• Use Organic Soil Amendments	3	5	5	3	5	2	23
• Train City Employees Regarding IPM	3	3	5	4	4	5	24
• Substitute IPM for Pesticides	3	5	5	2	5	5	25
STREET/STORM DRAIN MAINTENANCE:							
Street Cleaning							
• Replace Mechanical Sweepers with Vacuum	3	3	5	3	3	1	18
• Increase Frequency Two Times a Week	3	2	5	3	4	2	19
• Maintain Equipment	3	2	5	5	5	4	24
• Maintain Operation Log	3	1	5	5	5	5	24
Storm Drain Flushing							
• Flushing	3	4	4	2	0	4	17*

*Taken verbatim from the *State of California Storm Water Best Management Practice Handbook*, Storm Water Quality Task Force, March 1993.

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TABLE 2-18. APPLICATION OF BMPs TO SWMP PROGRAM ELEMENTS*

Required Elements of SWMP	Source Control BMPs Chapter 4							
	Planning Management	Material Use Control	Material Exposure Controls	Material Disposal & Recycling	Spill Prevention & Cleanup	Illegal Dumping Controls	Illicit Connection Controls	Street/Storm Drain Maintenance
FOR RESIDENTIAL/COMMERCIAL ACTIVITIES:								
Roadway and drainage facility maintenance		✓						✓
BMP planning for new development and redevelopment projects	✓							✓
Retrofitting existing or proposed floor control projects with BMPs	(See Page 3-9, Chapter 3)							
Municipal waste handling and disposal operations		✓	✓	✓	✓	✓		
Pesticide, herbicide, and fertilizer use controls		✓	✓	✓	✓	✓		
FOR IMPROPER DISCHARGE ACTIVITIES:								
Prevention, detection, and removal of illegal connection to storm drains							✓	
Spill prevention, containment, and response		✓	✓	✓	✓	✓		
Promote proper use and disposal of toxic materials		✓	✓	✓	✓	✓		
Reduce storm water contamination by leaking/overflowing separate sanitary sewers					✓	✓		
FOR INDUSTRIAL ACTIVITIES:								
Inspection and control prioritization and procedures		✓	✓	✓	✓	✓	✓	✓
Monitoring of significant industrial discharges						✓	✓	
FOR CONSTRUCTION AND LAND DEVELOPMENT ACTIVITIES:								
Water quality and BMP assessments during planning	✓	✓	✓	✓	✓	✓		✓
Site inspection and enforcement procedures	✓	✓	✓	✓	✓	✓		✓
Training for developers and contractors	✓							

*Taken verbatim from the *State of California Storm Water Best Management Practice Handbook (Municipal)*, Storm Water Quality Task Force.

6. Using the discussion of selection criteria, the BMPs are ranked against the selection criteria using the scale of 1-5.

7. For the first BMP, Distribute Public Education Materials, the following scores are recorded:
   Meets Regulatory Requirements = 3. Public education meets the intent of the storm water regulations.
   Effectiveness of Pollutant Removal = 2. Effectiveness of source control is high; however, insufficient data exist to support this claim.
   Public Acceptance = 5. Anytown believes that the public education materials are available from other municipalities and agencies to serve as models or to purchase for use as is.
   Implementable = 5. The existing department and staff may be used, and public education materials are available from other municipalities and agencies to serve as models or to purchase for use as is.
   Institutional Constraints = 4. To provide a consistent message to the public, Anytown must coordinate its public education program with the county, which already has in place a hazardous waste disposal program. The county has indicated that it will cooperate fully with Anytown to ensure that the public education material is consistent with the county's program.
   Costs = 5. Given the availability of materials to serve as models or to use directly, production should be relatively inexpensive.

8. Addition of the criteria scores across each row produces a total score, which may be compared to the other totals.

9. The process is continued for each of the source control BMP categories checked in Table 2-18.

As a result of this evaluation, Anytown, California, implemented all the BMPs in the Housekeeping Practices and Safer Alternative Products categories, as well as the maintenance BMPs in the Street/Storm Drain Maintenance category. However, the scores for the other Street/Storm Drain Maintenance BMPs indicated that further study was necessary before their implementation could be proposed. Anytown, California, also found that storm drain flushing was not allowed by the local sewer agency, so this fatal flaw removed this BMP from further consideration.

A Few Points to Remember

- Have several people or one of the storm water committees conduct the selection independently to get a broad perspective on the relative merits of each BMP and to help reach a consensus.
- Keep the selection system as simple as possible and use best professional judgment to interpret and to conduct a reality check on the total scores.
- Remember that differences of a few points in the total score are probably not significant.
- Use the final rankings to plan and prioritize the SWMP. For example, those BMPs with the highest scores may be implemented in the first year of the NPDES permit, while low scoring BMPs may need more time to develop, relegating their implementation to the fifth year or to further study.
- Use the exercise of working through this selection to provide the necessary data to promote the program to other departments, political leaders, regulatory agencies, and the public.

R0014060

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION BMP SELECTION MATRIX

To address storm water and nonpoint source pollution control in areas of new development, the Maine Department of Environmental Protection (ME DEP) has developed a method to select BMPs. The method is based on the following information:

- Development land use type and size
- Receiving water type (e.g., estuary, wetland, river, or stream)
- Watershed priority (either priority or nonpriority)
- Erosion and sediment control target or "level to achieve"
- Storm water quality control target or "level to achieve"
- Erosion and sediment control options and "treatment level codes"
- Storm water quality control target or "treatment level codes."

To implement the BMP selection method, ME DEP has developed a series of eight matrices. There are two matrices for each receiving water type (estuary, wetland, river, and stream). One matrix is applied to development in designated priority watersheds, and the other is applied to development in nonpriority watersheds. A priority watershed list has been developed by ME DEP based on environmental sensitivity, local support for water quality, and importance of the watershed to the State. Example matrices for priority and nonpriority estuary watersheds are shown in Tables 2-19 and 2-20.

Each matrix has two major components, which are broken down by land use type. The first is an erosion and sediment control "level to achieve," and the second is a storm water quality "level to achieve." The "level to achieve" for a given combination of land use and receiving water category is a relative, qualitative measure of the impact of storm runoff pollution. It ranges from 1 to 5, with 1 being the lowest impact and 5 being the greatest impact. For example, a multi-housing development proposed for a priority estuary watershed is given an erosion and sediment "level to achieve" of 2 and a water quality "level to achieve" of 3. By comparison, a small residential development in the same priority watershed is given an erosion control "level to achieve" of 1 and a water quality "level to achieve" of 1. In all cases, the " levels to achieve" for priority watersheds are greater than or equal to those for nonpriority watersheds.

Each matrix also addresses the types of BMPs that can be implemented for pollution control. ME DEP selected a number of BMPs and assigned each a "treatment level code" based on the expected level of pollutant removal. The "treatment level code" is a relative, qualitative measure. It is designed to indicate the relative pollutant removal expected from various BMPs. "Treatment level codes" range from 1 to 3, with 1 providing the lowest level of control and 3 providing the greatest level of control. The BMPs and their treatment level codes are shown in Table 2-21. As indicated, various designs for each BMP are given different treatment level codes. For example, a 50-foot buffer is given a treatment level code of 1, a 125-foot buffer is given a treatment level code of 2, and a 200-foot buffer is given a treatment level code of 3.

For a proposed development to be approved, the sum of treatment level codes for the proposed BMPs must be greater than or equal to the "level to achieve." For example, if a multi-housing unit development is proposed for a priority estuary (erosion "level to achieve" of 2 and water quality "level to achieve" of 3, the developer could implement erosion and sediment controls (treatment level 2) and a combination of a swale (treatment level 1) and an infiltration system (treatment level 2). Additional combinations also could be implemented as long as the total "treatment level" provided is greater than or equal to the total "level to achieve." ME DEP has also recommended that at least one vegetative BMP be implemented unless the site is already 100 percent impervious. The specified vegetative BMPs are buffers, grassed swales with level spreaders, and swales.

R0014061

TABLE 2-19. PRIORITY ESTUARY STORM WATER CONTROL MATRIX*

Land Use Category	Erosion and Sediment Level to Achieve	Erosion and Sediment Controls	Water Quality Level to Achieve	Storm Water Controls
Low Density Residential >2 acres per lot	1	Erosion and Sediment 1	1	Buffer 1
High Density Residential <2 acres per lot	2	Erosion and Sediment 2	3	Buffer 1 or 2 Wet Pond 2 Infiltration 1 or 2 Created Wetland 2
Commercial <1 acre distributed	1	Erosion and Sediment 1	1	Buffer 1
Commercial 1-3 acres distributed	1	Erosion and Sediment 1	2	Buffer 1 or 2 Infiltration 1 Swale 1
Commercial >3 acres disturbed	2	Erosion and Sediment 2	4	Buffer 1 or 2 Infiltration 1 or 2 Created Wetland 2 Wet Pond 2 or 3 Fertilizer Control 1 Shallow Impoundment 1
Intensive Use Open Space (e.g., golf courses, nurseries)	2	Erosion and Sediment 2	5	Buffer 1 or 2 Fertilizer Control 1 Pesticide Control 1 Created Wetland 2 or 3 Wet Pond 2 or 3
Multi-housing Units	2	Erosion and Sediment 2	3	Buffer 1 or 2 Fertilizer Control 1 Pesticide Control 1 Created Wetland 2 Wet Pond 2 Infiltration 1 or 2
Industrial <1 acre disturbed	1	Erosion and Sediment 1	1	Buffer 1 Swale 1
Industrial 1-3 acres disturbed	1	Erosion and Sediment 1	2	Buffer 1 or 2 Swale 1
Industrial >3 acres disturbed	2	Erosion and Sediment 2	5	Buffer 1 or 2 Swale 1 Created Wetland 2 or 3 Wet Pond 2 or 3

*Taken verbatim from *Storm Water Best Management Practices—Second Draft*, prepared by the Maine Department of Environmental Protection (1990)

R0014062

TABLE 2-20. NONPRIORITY ESTUARY STORM WATER CONTROL MATRIX*

Land Use Category	Erosion and Sediment Level to Achieve	Erosion and Sediment Controls	Water Quality Level to Achieve	Storm Water Controls
Low Density Residential >2 acres per lot	1	Erosion and Sediment 1	1	Buffer 1
High Density Residential <2 acres per lot	2	Erosion and Sediment 2	2	Buffer 1 or 2 Infiltration 1
Commercial <1 acre distributed	1	Erosion and Sediment 1	1	Buffer 1
Commercial 1-3 acres distributed	1	Erosion and Sediment 1	1	Buffer 1
Commercial >3 acres disturbed	2	Erosion and Sediment 2	2	Buffer 1 or 2 Infiltration 1 Swale 1 Shallow Impoundment 1
Intensive Use Open Space (e.g., golf courses, nurseries)	2	Erosion and Sediment 2	3	Buffer 1 or 2 Infiltration 1 or 2 Fertilizer Control 1 Created Wetland 2 Wet Pond 2
Multi-housing Units	2	Erosion and Sediment 2	2	Buffer 1 or 2 Infiltration 1
Industrial <1 acre disturbed	1	Erosion and Sediment 1	1	Buffer 1 Swale 1
Industrial 1-3 acres disturbed	1	Erosion and Sediment 1	2	Buffer 1 or 2 Swale 1
Industrial >3 acres disturbed	2	Erosion and Sediment 2	4	Buffer 1 or 2 Swale 1 or 2 Created Wetland 2 or 3 Wet Pond 2 or 3

*Taken verbatim from *Storm Water Best Management Practices—Second Draft*, prepared by the Maine Department of Environmental Protection (1990)

R0014063

TABLE 2-21. BMPs AND TREATMENT LEVEL CODES*

BMPs	Level of Treatment
Erosion and Sediment Control	
• One line of erosion control	1
• Two lines of erosion control	2
Non-grassed Buffers	
• 50 feet	1
• 125 feet	2
• 200 feet	3
Swales	1
Shallow Impoundments	1
Infiltration Systems	
• Single system	1
• Multiple systems	2
Wet Ponds	
• Single pond system holding 2.5 inches of runoff	2
• Double pond system each pond holding 2.5 inches of runoff	3
Created Wetlands	
• Single created wetland	2
• Two created wetlands	3
Street Cleaning	1
Fertilizer Application Control	1
Pesticide Use Control	1
Grassed Swales with Level Spreaders	1
Reverting Land (allowing land that is currently impervious to become a vegetative buffer)	1

*Taken verbatim from *Storm Water Best Management Practices—Second Draft*, prepared by the Maine Department of Environmental Protection (1990)

This BMP selection system is in its early stages of implementation. Its success will depend on the ability to establish "levels to achieve" that will adequately protect the water bodies in new developments. It will also depend on the ability of treatment level codes to quantify the effectiveness of the identified control measures. Thus, the system is a technology-based approach for erosion and sediment control, as well as for storm water pollution control.

Currently, this method is outlined in a state-wide guidance document and is not a regulatory requirement. Municipal officials can incorporate this process at their discretion in subdivision regulations. This method of BMP selection requires extensive up-front work to develop the matrices and BMP levels of treatment. Once these are developed, however, this method provides a simple and direct technology-based approach to BMP selection. It has flexibility in terms of the range of BMPs that can be selected for given types of proposed development and given site constraints.

R0014064

Background

In 1986, the San Francisco Regional Water Quality Control Board developed a Basin Plan for San Francisco Bay that involved regulatory activities to control point and nonpoint source discharges. This was the driving force behind initiating the Santa Clara Valley Nonpoint Source Control Program. This program involves a number of local governments and county agencies and is designed to address water quality problems in Lower South San Francisco Bay. In conducting this project, a 12-step process that closely follows the process outlined in this manual was used. The 12 steps are as follows:

- Initiate Program
- Determine Existing Conditions
- Conduct Field Monitoring
- Define Program Objectives
- Develop Evaluation and Planning Criteria
- Compile Inventory of Candidate Controls
- Apply Criteria to Screen Candidate Controls
- Apply Professional Judgment to Select a Practical set of Controls
- Estimate Overall Program Cost and Effectiveness
- Revise the Previously Defined Control Programs to Balance Cost, Effectiveness, and Other Factors
- Describe the Roles of Various Agencies
- Develop an Implementation Schedule.

Development of the Nonpoint Source Control Plan began in 1986 and has continued through various stages to initial implementation and preliminary assessment of effectiveness.

Watershed Description

Santa Clara County, which incorporates the entire study area, is located at the southern end of San Francisco Bay (see Figure 2-5). The watershed is approximately 690 square miles and consists primarily of the relatively flat Santa Clara Valley. Land use in the watershed is approximately 30 percent residential, 5 percent industrial (predominantly light industry associated with high technology manufacturing), and 62 percent open space. Large cities, San Jose, Sunnyvale, and Santa Clara, account for the majority of urban areas in the watershed.

Overview of Water Quality

To characterize existing water quality in Lower South San Francisco Bay, a comprehensive monitoring program was undertaken. This program included hydrologic monitoring, wet and dry weather water quality monitoring, sediment monitoring, and biological monitoring. The monitoring was conducted primarily to determine the levels of toxic pollutants, such as heavy metals and pesticides, as well as nutrients and bacteria. Data obtained through this monitoring program were incorporated into data bases and used for developing computer models. Watershed loads were estimated using the Storm Water Management Model (SWMM), which was calibrated to the observed data gathered in the monitoring program. The data were also used to compare the relative contributions of point (e.g., waste water treatment plants) and nonpoint source pollution to the bay.

Water quality monitoring results indicated that heavy metal concentrations in receiving waters increase during wet weather due to contaminated runoff as well as resuspension of contaminated sediments. The metals primarily detected were cadmium, chromium, copper, lead, nickel, and zinc. However, copper was the primary metal regularly detected at levels greater than the EPA aquatic life toxic criterion during wet weather. The criteria were

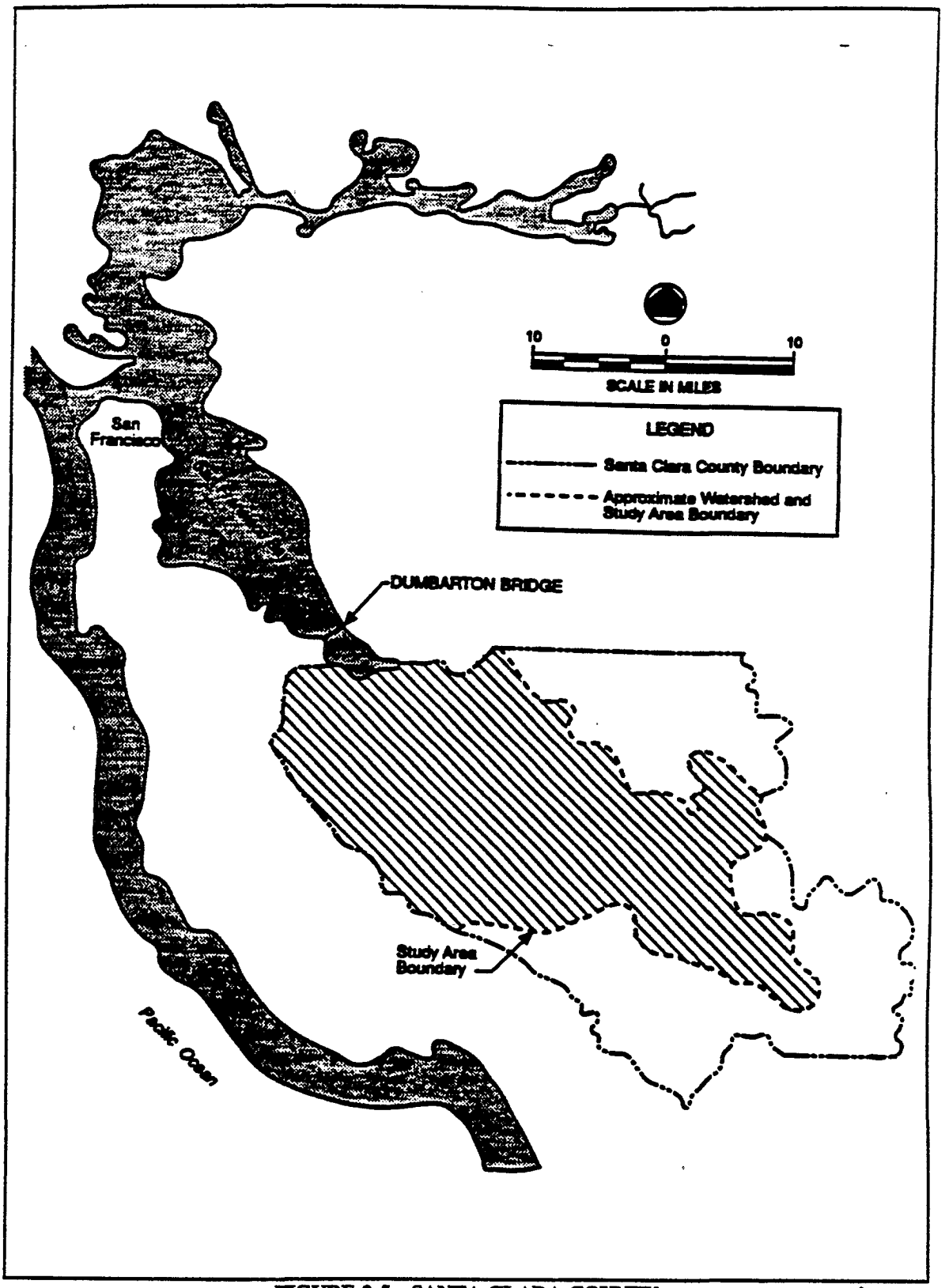

FIGURE 2-5. SANTA CLARA COUNTY

only occasionally exceeded for cadmium, lead, and zinc. Also, during wet weather, hydrocarbons and pesticides were detected in approximately 25 percent of the samples collected, while none was detected during dry weather. The limited bacteria data gathered indicated increased levels (by a factor of about 10) of fecal coliform bacteria during wet weather as compared to dry weather conditions.

In comparing point and nonpoint source contributions to water quality problems in Lower South San Francisco Bay, the monitoring results showed that point sources account for approximately 98 percent of the nutrient load. However, nonpoint sources accounted for 60 to 80 percent of the load for metals and about 98 percent of the total suspended solids on a long-term basis.

Management Practice Screening

Because of the large size of the watershed and the variety of pollutants entering the Lower South San Francisco Bay, the emphasis of the nonpoint source pollution control program was on pollution prevention measures and nonstructural controls that could be implemented across municipal boundaries. Selection of appropriate pollution controls was accomplished through a process consisting of preliminary screening followed by final control measure selection (see Figure 2-6).

To screen the extensive list of potential pollution control practices, the program team first developed a list of important criteria for the selected control measures. The criteria developed for this project were:

- **Pollutants Controlled:** Emphasis is placed on controls for metals, pesticides, oil and grease, bacteria, and sediments.
- **Effectiveness:** Each control measure should contribute enough toward the overall program pollution control to warrant its inclusion.
- **Reliability/Sustainability:** Control measures should be effective over an extended period of time and be able to be properly implemented over time.
- **Implementation Cost:** Emphasis was placed on control measures with low planning, design, land acquisition, construction, and equipment acquisition costs.
- **Continuing Costs:** Emphasis was placed on control measures with low operation, maintenance, repair, support service, and equipment replacement costs.
- **Equitability:** Controls were evaluated regarding the degree to which costs and benefits would be considered to be equitably distributed.
- **Universality:** Controls were evaluated in terms of how universally they would have to be applied to be effective.
- **Public Acceptability:** Control measures were assessed on the expected response of agencies responsible for implementation.
- **Relationship to Regulatory Requirements:** Control measures were evaluated on their consistency with existing and anticipated regulatory requirements.
- **Risk/Liability:** Control measures were evaluated in terms of the risks or liabilities that may occur in implementation.
- **Environmental Implications:** Control measures were evaluated regarding the positive and negative environmental impacts resulting from their use.

Once the control measure criteria were listed and agreed upon, the project team developed a comprehensive list of potential control measures for implementation. The inventory of potential control measures was developed through

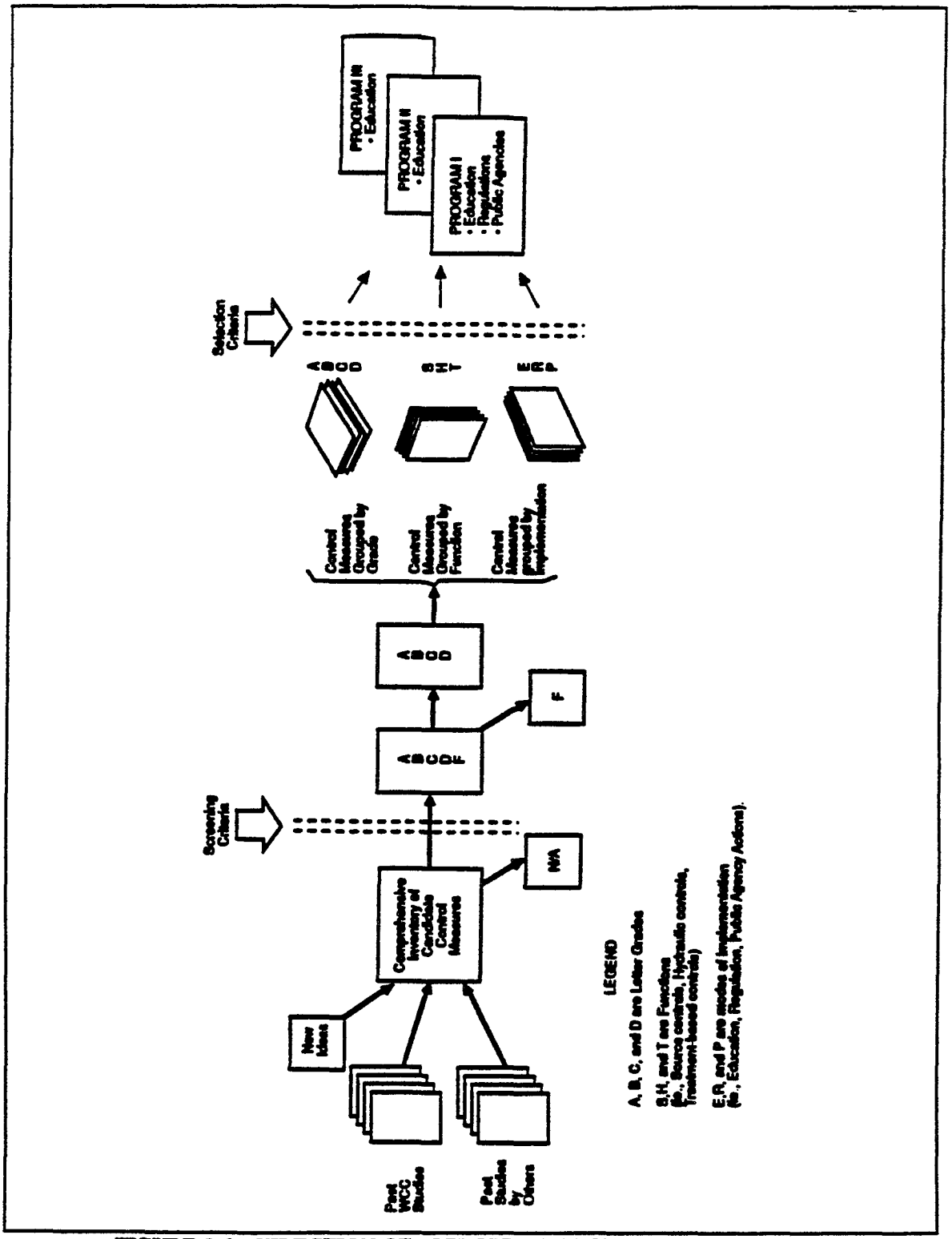

FIGURE 2-6. SELECTION OF APPROPRIATE POLLUTION CONTROLS

R0014068

a review of technical literature and other nonpoint source control programs. In addition, technical and managerial personnel from other State agencies, county agencies, and city public works and planning agencies were interviewed. This review resulted in a list of more than 120 separate control measures to be screened. This initial list was developed to be comprehensive, and no consideration was given to the applicability of the measures. However, once the list had been developed, obviously inappropriate control measures were eliminated. The control measures eliminated from the list at this step were primarily those designed to address specific situations that did not exist in the watershed. This initial screening reduced the list of potential pollution controls to 92.

This list of 92 control measures was then assessed qualitatively using the criteria developed earlier in the program. This was conducted by assigning each of the control measures a letter "grade" (A through F) for its ability to meet the criteria. Those measures receiving an "A" were viewed to meet all or a large number of the assessment criteria, while those receiving an "F" were viewed to meet none or very few of the assessment criteria. In this way, each of the potential control measures was assigned to a category. The control measures that fell into the category of "F" were immediately eliminated from further consideration in the Santa Clara Valley watershed.

R0014069

The Waukegan River/Ravine system is the primary drainage for the urban areas of Waukegan. Significant point and nonpoint source discharges of storm water runoff create considerable water quality problems. Directly related to these water quality concerns are significant erosion and siltation problems occurring in various areas of the river/ravine system.

The Waukegan River/Ravine main channel and tributaries are approximately 12.5 miles. The watershed, primarily in Waukegan, is approximately 7,640 acres and receives storm water runoff from point and nonpoint discharges from an urban area with 80,000 residents. The river/ravine system has the highest population density (8.0 people per acre) of any river in Lake County. The Waukegan River discharges into Lake Michigan just east of the downtown area at a point 6,000 feet from the city's fresh water intake.

The water quality problems identified are siltation, suspended sediments, pesticides, petroleum products, and solid waste. In addition, unstable stream channels result in severe bank erosion, and damaged sewer lines along the stream channel. Stream channel instability has already broken up small sewer lines that enter the main sewer (buried in the floodplain along the stream).

In response to these problems, a number of implementation activities have occurred. The Lake County Storm Water Management Commission developed a model environmental storm water strategy and is implementing a nonpoint source pollution awareness project. This strategy is a watershed-based, multiobjective approach that considers all the environmental values associated with surface water. This comprehensive strategy includes a complete coordinated system addressing program operations, planning design, construction, finance, maintenance, and regulations. In addition, the strategy addresses prevention, remediation, and maintenance.

A specific program to restore this area includes the restoration of urban streambanks through the development of technical and legal procedures for urban stream management and training of local government employees in the bioengineering techniques of vegetative stream stabilization. Also, to improve water quality in the Waukegan River, an aerator was installed and an illicit connection program is proposed.

The purpose of the storm water pollution prevention awareness project is to increase the awareness of urban storm water pollution problems in Lake County, Illinois, through pollution prevention advertisements (e.g., messages, graphics, and photographs) on billboards, buses, and bus stops. The advertisements will address such urban runoff issues as gasoline spills on pavements, storm drains clogged by debris, sediment runoff from construction sites, erosion of urban stream banks, and runoff of phosphate detergents into storm drains. Preventive actions will include storm drain stenciling programs and recycling of motor oil.

An intensive 10-year monitoring and evaluation program has been implemented to demonstrate and evaluate the effectiveness of the storm water best management practices (BMPs) implemented in the Waukegan River watershed. This monitoring effort focuses on the impacts of the storm water pollution control program on urban fisheries and stream habitat.

R0014070

Identification of Water Quality Problems

Physical Setting

Lincoln Creek is a 9 mile high gradient warm water stream in the Milwaukee River South Watershed. The Milwaukee River drains into Lake Michigan. The creek's drainage area, the City of Milwaukee, is mostly urbanized.

Land Use

Lincoln Creek is the largest urban subwatershed in the Milwaukee River South Watershed, draining 12,600 acres. This subwatershed is entirely urban, although there are large areas of recreational and open space land, including a U.S. Army tract, the State's Havenwoods Forest Preserve and Nature Center, the Milwaukee County Lincoln Creek Parkway, and golf courses and municipal parks.

Residential lands dominate the subwatershed. High density residential areas cover 35 percent of the subwatershed and multifamily residential areas cover an additional 15 percent. Industrial areas cover 12 percent and commercial areas 7 percent of the subwatershed. Most of the subwatershed is contained within the city of Milwaukee. However, a small portion is contained within the city of Glendale and includes primarily industrial and multifamily land uses.

Project Area Size

The Lincoln Creek drainage area is about 20 square miles (12,600 acres), and the entire area is urbanized. The breakdown for some of the land uses is high density residential (35%), multifamily residential (15%), industrial (15%), and commercial (7%).

Critical Areas

Critical land uses were identified using the Source Loading and Management Model (SLAMM). Critical areas were those that had the highest annual loads of sediment and lead. Lead was considered an indicator for other toxic pollutants. High density residential, industrial, multifamily residential, and commercial land uses contributed most of the sediment and lead loads. The Lincoln Creek drainage area was the most important source of toxic pollutants in the Milwaukee South Watershed. There are 24,000 feet of eroding streambank, which produces about 430 tons of sediment each year. Construction sites are another critical source of sediments.

Water Resource Condition

The lower portion of Lincoln Creek has the potential to support a warm water sport fishery, while the upper portions have the potential to support a warm water forage fishery. All sections of the creek have the potential to support partial body contact water recreation.

However, none of the potential uses of the creek are being attained. Recent surveys of the creek have found it to be highly degraded. Only two fish species (fathead minnow and sunfish) were found in the middle portions of the creek in 1992 and both species are pollutant tolerant. Lincoln Creek should support a diverse fish community of at least 15 fish species.

Lincoln Creek is almost entirely channelized, with the channel alternating between concrete and earthen sections. Channel modifications and frequent high storm water flows contribute to the low biological activity observed in the creek.

R0014071

Levels of petroleum aromatic hydrocarbons (PAHs), heavy metals, fecal coliform and suspended solids, and other pollutants increase significantly during runoff events. Some pollutants, like PAHs, reach levels high enough to exceed water quality standards. Based on EPA criteria, the bottom sediments are moderately or heavily polluted with heavy metals and PAHs.

Crayfish tissue is highly contaminated with PAHs. Mortality was observed in fathead minnows exposed to Lincoln Creek water for more than 15 days. Traditional acute and chronic bioassays did not indicate any toxicity.

Problems in the creek are caused by poor habitat, increased flows, and high levels of pollutant loading.

BMPs, such as wet detention basins, are proposed in the priority watershed plan to address these problems.

Storm water pollution control objectives for Lincoln Creek include:

1. Restore the forage and sport fish communities by improving the habitat and water quality.

2. Improve the recreational uses.

3. Reduce the loadings of pollutants to the Milwaukee River and Lake Michigan.

Watershed Plan

The implementation plan for Lincoln Creek is part of the Milwaukee River South Priority Watershed Plan, which was implemented in 1991.

One of the recommendations in the watershed plan has been implemented—the preparation of a storm water management plan. The storm water management plan provides detailed information about the management alternatives for Lincoln Creek. Critical land uses are identified by sewershed instead of the whole drainage area. A major effort is put into determining the feasibility of installing the structural practices recommended in the watershed plan and locating sites for installing the wet detention basins.

Inventory Results

Existing urban land uses, future urban land use, construction sites, and eroding streambanks were the urban sources of pollutants evaluated during the preparation of the priority watershed plan. The inventory of the urban land uses was designed to quantify the acres and the development characteristics of each land use. Existing land use categories were delineated on 1" = 400' scale, aerial photographs were digitized, quantified, and mapped by the Southeastern Wisconsin Regional Planning Commission.

Annual pollutant loadings of sediment, phosphorus, and lead were calculated for existing and planned land uses by running SLAMM. Input parameters for SLAMM included the acres of each land use and the development characteristics, such as the percent connectedness. SLAMM was also used to evaluate the effectiveness of different BMPs on the existing and future urban areas.

Lincoln Creek receives an annual lead loading of about 8,000 pounds. Major land uses contributing to the elevated lead levels are: high density residential (33%), industrial (32%), multifamily residential (14%), and commercial (14%). Future development could increase lead loads by 21 percent. These same land uses also contribute relatively large amounts of other toxicants, such as PAHs and heavy metals.

Runoff from construction sites and streambank erosion annually contribute about 6,500 tons of sediment to the stream. Sediment loads are expected to decrease as the remaining planned areas are developed.

R0014072

Storm water flows have adverse effects on the creek. High flows cause flooding, bottom scour, and streambank erosion. The Milwaukee Metropolitan Sewage District is evaluating alternative measures for reducing flows in the creek.

Pollutant Reduction Goals

Pollutant reduction goals were based on the needs of the stream. A different approach was taken to establish the reduction goals for each type of problem.

Sediment and Phosphorus

An overall 50 percent reduction in the existing sediment loading is needed to improve the habitat in the creek. Implementation of the storm water pollution control program should reduce the sediment load from construction sites by about 75 percent.

A high reduction of phosphorus (50% to 70%) is needed to reduce the excessive aquatic plant growth in the Milwaukee River and reduce the threat to Lake Michigan.

Storm Water Pollutants

Lead is being used as an indicator pollutant for the other toxic pollutants. Although the State of Wisconsin does not currently use numeric effluent limits to regulate storm water, the pollutant reduction goals for lead were based on meeting the chronic toxicity standards in the Wisconsin Administrative Code. The average annual concentration of total lead in the Milwaukee River exceeds the chronic toxicity standard by 50 percent for surface waters. The proposed pollutant load reduction goal for lead in Lincoln Creek is 50 percent.

By combining the output of SLAMM with a Probabilistic Dilution Model for the creek, the frequency with which the chronic toxicity standard for a number of pollutants is exceeded in Lincoln Creek. The models will assist in determining the amount of reduction needed to significantly lower the probability of exceeding the chronic toxicity standards. The Probabilistic Dilution Model was developed by the EPA and is a good technique for estimating the amount of pollutant reduction needed.

Stream Flow

Specific goals will be established by the Milwaukee Sewage District; however, there are three basic hydrologic goals that must be considered.

1. Maintain baseflow in the creek as much as possible.

2. Reduce stream flows to prevent streambank erosion and bottom scour.

3. Maintain peak flow discharge for 2-year 24-hour storm at predevelopment conditions.

Bottom Sediments

Bottom sediments are heavily polluted. Although a specific reduction goal has not been determined for the bottom sediments, the watershed project has a goal of reducing the levels of pollutant in the bottom sediments.

Management Practices

BMPs are those practices identified in the Wisconsin Administrative Code and are referenced in the Milwaukee River South Watershed Plan to be the most cost-effective controls for storm water pollutants. SLAMM was used

to evaluate the effectiveness of wet detention basins, infiltration devices, street sweeping, and roof top disconnection for both existing and future urban areas. Pollution prevention measures were also suggested for controlling construction site erosion and streambank erosion.

Following is a list of BMPs proposed in the storm water management plan.

Best Management Practice	State Cost-Share Rate
Critical Area Stabilization	70%
Grade Stabilization Structure	70%
Shoreline and Streambank Stabilization	70%
Shoreline Buffers	70%
Wetland Restoration	70%
Structural Urban Practice	70%
Street Sweeping	50%

A high level of control is needed to achieve the pollutant reduction goal for lead. All of the critical land uses in established areas would have to be controlled with structural practices, such as wet detention basins or other structural practices.

About 90 one-acre wet detention basins will be needed to treat all the critical land uses in Lincoln Creak. Street sweeping could be used as an interim practice before all the structural practices are built. About 14,000 curb miles of streets would need accelerated sweeping schedules. Twelve one-acre ponds would be needed to treat all the land uses in the planned areas.

Using structural practices in the existing and planned areas would also achieve the pollutant reduction goal for sediment. However, the watershed plan also recommends the implementation of construction site erosion and streambank protection practices. These practices will provide greater than 50 percent reduction before the structural practices are completed.

The watershed plan assumes that an effective construction erosion program will be in place for the cities to obtain cost-share dollars. Erosion control practices standards and applicability criteria should be consistent with those set forth in the *Wisconsin Construction Site Best Management Practice Handbook* (DNR, 1989). Cities in the Lincoln Creek drainage area are required to effectively administer and enforce their existing ordinances.

Control of streambank erosion will require a combination of streambank protection practices. The Cities of Milwaukee and Glendale plan to control peak flows to help protect their streambanks. The Milwaukee Metropolitan Sewage District is preparing a comprehensive stream corridor management approach for Lincoln Creek. The approach will consider flow reduction, alternative approaches for stabilizing eroding streambanks, and rehabilitation of the concrete stream sections.

Construction on the stream corridor will have the most impact on the quality of Lincoln Creek in the near future. Monitoring the proposed project will document the effectiveness of improving the stream corridor. The changes should occur over the next 3 years, while other practices will take longer to bring about significant changes in the water quality of the creek. Urban education is also a practice recommended in the watershed plan.

R0014074

Institutional Roles and Responsibilities

Wisconsin Department of Natural Resources

The Wisconsin Department of Natural Resources (WDNR) will have both administrative and monitoring responsibilities for the Lincoln Creek Evaluation Monitoring Project. The administrative role is defined as part of the Department's role in the Wisconsin Water Pollution Abatement Program.

Administration

Administration of the project began by following a selection process. After the project was selected, WDNR worked with Wisconsin Department of Agriculture Trade and Consumer Protection, the cities, and counties to prepare a watershed plan. Implementation of the plan is based on the guidance in the plan.

The Department is working with the Cities of Milwaukee and Glendale to develop cost-share agreements for the practices recommended in the plan. Grant requests will be reviewed by the Department. Interpretation of the State statutes, administrative rules, and watershed plans is provided by the Department.

Financial Support

Financial support for implementation of watershed projects is provided by local assistance agreements and a nonpoint source grant agreement. The cost of implementing all rural and urban practices in the Milwaukee River South Watershed Project is between $89,000,000 and $159,000,000. The State share is about $18,000,000. Installation of the structural practices in existing and future areas in Lincoln Creek will cost between $36,000,000 and $74,000,000. The State share of this cost is about $5,000,000. Total cost of street sweeping each year would be about $350,000. Development of storm water management plans for Lincoln Creek cost about $1,000,000. Most of the cost for the implementation of the watershed plan is for the structural practices. State funds are available to cover the State's share of the cost.

Project Evaluation

Project evaluation will involve the collection, analysis, and reporting of information needed to track the progress of the project. The categories of evaluation include administrative accomplishments, pollutant reduction, and water quality improvements. The local units of government will report annually on the progress of core and segmented program activities. Information will also be provided on financial expenditures and time spent on project activities.

Technical Assistance

The WDNR will provide technical assistance to the local units of government on the design and application of BMPs.

Monitoring Responsibilities

Fish, habitat, and macroinvertebrate sampling will be the responsibility of the Department. Field work will be done by crews supervised by the Department's Bureau of Research.

Stakeholders

Local Units of Government

Each local unit of government will have a number of responsibilities for the core and segmented programs.

University of Wisconsin Extension

Area extension agents will provide support in developing and conducting a public information and education program.

Milwaukee Metropolitan Sewage District

Sewage districts have all the privileges and responsibilities of cities, villages, and counties when participating in the program.

Landowners and Land Operators

In some situations, private landowners will install practices on their property.

United States Geological Survey

All of the chemical and physical monitoring will be the responsibility of the U.S. Geological Survey (USGS). Peter Hughes will be the project manager for the USGS.

R0014076

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R0014078

CHAPTER 3

CHAPTER 3
GUIDANCE ON COMPLETING ADMINISTRATIVE REQUIREMENTS

INTRODUCTION

Chapters 1 and 2 summarized the municipal storm water management program regulatory requirements and guidance for municipal officials to rank storm water management activities for maximum cost effectiveness. This chapter discusses the administrative requirements of a municipal storm water management plan. These requirements include public information and participation campaigns, fiscal resources, and annual assessment reports.

Public information and public participation programs are essential to the implementation of an effective municipal storm water management plan. The key points to consider in developing this component of the plan include creating appropriate goals and objectives, targeting the proper audience, explaining and selling the program to the audience, and having the necessary equipment and staff for proper program implementation. The availability of fiscal resources is another essential component of municipal storm water management plans. Several funding options are available to municipalities: local funding mechanisms, matching fund programs, and grant programs. In addition, to implement an effective plan, an assessment of the plan must be developed annually and submitted to the permitting authority. This assessment allows the permitting authority and municipality to critique the effectiveness of the plan and to make any necessary changes.

PUBLIC INFORMATION CAMPAIGNS

Developing Goals and Objectives

The program's goals and objectives will form the framework for developing public information and participation efforts. Program goals are usually general and should include the essence of a program's purpose. They should also include some measure of the expected outcome. An example goal might be "to protect our watershed by linking and supporting citizens and organizations that are working locally for protection of wetlands and water quality."

R0014080

Objectives are more specific and should identify actions or activities to be taken at the program-operations level. They focus the broad vision of the goal to something that can be accomplished through organizational resources. An example of an objective is "to publish and distribute four 12 to 16-page wetland journals by June 1, 1994."

To accomplish these goals and objectives, everyone involved in the program must be given the opportunity to participate and contribute and agree on the ideas. To ensure cooperation, the benefits should be explained. Otherwise, goals and objectives will not be important to the staff and will not be considered seriously when implementing the program. Also, because people may interpret goals differently, it is essential to develop the goals and objectives jointly with the staff through a meeting or other forum that is appropriate in your organization and to make sure that everyone understands them.

Identifying the Target Audience

When developing a public education campaign, it is critical to identify the target audience and develop materials accordingly. Target audiences are groups that have common characteristics, such as age, culture, socioeconomic background, language, and the educational level of the community or watershed. Learning more about the target audience will assist the staff in developing an effective outreach program. To reach the target audience, you must know specifically who it comprises and what common traits they share. This involves breaking groups down into subgroups that exhibit similar characteristics or traits. For example, construction contractors who are likely to have projects within your municipality or residents who change their own oil can be targeted. Some likely target audiences include:

- Members of industrial categories (e.g., landfills)
- Developers
- Construction contractors
- Auto repair/gas station owners
- Environmental groups (e.g., Adopt-a-Stream, local chapters of Sierra Club, Audubon Society)
- Community groups (e.g., churches, Boy and Girl Scouts, Jaycees)
- Non-English speaking residents
- Outdoor recreation groups (fishermen, garden clubs)
- Homeowners
- Students.

R0014081

Identifying and learning about target audiences allows messages and programs to be developed in a way that will reach and influence these subgroups. The following contacts can provide more information about the target audiences in your community:

- Chamber of Commerce for information on the interests of local business people and what types of materials are most useful to them
- Other government agencies that interact with groups similar to those you will target (e.g., planning department for a list of construction contractors who have received building permits or an economic development department to learn about certain industries)
- Tax records or zoning records to find industrial and commercial facilities
- Wastewater treatment plants for a list of industry types, facility sizes, and potential pollutant sources
- Board of Education to identify ongoing school programs and methods for contributing to school programs and curricula
- Libraries to find local and State magazines and newsletters directed at specific audiences (e.g., environmental and outdoor recreation topics).

"Selling" the Storm Water Program

Educating the public about a new regulatory program and getting them involved with its implementation are among the most important factors for ensuring program success. Issues such as regulatory deadlines and implementation procedures all depend on educating both the regulated community and the public at large. A key element of the municipal storm water management plan is to help communities understand the importance of the storm water program and citizens' participation in improving water quality.

When creating public outreach materials, the storm water management program goals must be clearly communicated and the importance of accomplishing these goals explained. This is especially true in cases where municipalities intend to impose a utility fee for the storm water program. Municipalities may encounter opposition to a new fee if the benefits of the program are not understood. In such cases, it is important to obtain public and political support for the program through education.

One of the biggest political obstacles that municipalities face is that the impacts of polluted storm water runoff may not be obvious. For example, a water body that has been overloaded with sediment from an

R0014082

upstream construction activity may look fine to the casual observer when, in fact, the fish and plant life has been harmed significantly. Once an awareness of both the sources and impacts of water pollution is created, educational programs can be developed to motivate the public to effect positive changes in their daily activities, thereby reducing the addition of pollutants to receiving waters.

Information intended to educate the target audience should include solutions as well as explanations of the issues. Simply providing people with information may not make them change their attitudes and rarely makes them change their behavior. People need to know more about the solutions and action that they can take. Education efforts, therefore, should present the reasons why the program is important and focus on actions that citizens and businesses can take to prevent increases in pollution of storm water. Examples of successful outreach materials that provide information and solutions are included at the end of this chapter.

Developing Outreach Materials

Specific education activities can include disseminating information through flyers included in residential utility bills; interactive methods, such as workshops; open houses at industrial facilities; school curricula materials; or talks or slide shows for schools and community groups. Whichever activities you use, communication should strive to be interactive and allow for feedback to those implementing the plan. For example, written materials become interactive when a telephone number to receive further information is provided. Keeping track of the number of callers and the questions they have also provides a way to judge the effectiveness of the materials. Some examples of communication methods that can be used to publicize public involvement are given in the following list:

- TV public service announcement
- TV news story
- Radio public service announcement
- Radio news story
- Newspaper advertisement
- Newsletter
- Fact sheet
- Pamphlet
- Storm drain stencils (e.g., "Dump No Waste, Drains To Lake")
- "Freebies (i.e., bumper stickers, magnets)
- T-shirts, hats, etc.
- Workshops
- Community meetings
- Church meetings
- School meetings
- One-on-one personal contact
- "Event" days
- Opinion leaders (i.e., community leaders, parents, teachers)

R0014083

- Magazines
- Magazine advertisement
- Magazine article
- Billboard
- Fairs
- Libraries
- Books
- Transit cards (i.e., in buses).

Table 3-1 presents positive and negative characteristics of several outreach options.

Many outreach materials already exist that you may borrow ideas from or incorporate directly into your storm water management program. One particularly good source of public education materials is a guidance manual entitled, *Urban Runoff Management Information/Education Products*, developed by EPA Region 5, Water Division, and EPA Office of Wastewater Enforcement and Compliance, February, 1993. This document describes specific materials (booklets, books, bumper stickers, catalogs, citizen action guides, computer software, fact sheets, handbooks, newsletters, pamphlets, posters, slide shows, student activities, and videos) and how to obtain them. It is available from the EPA Office of Water Resources Center, (202) 260-7186.

Outreach materials should use clear, concrete language and, where possible, incorporate graphics. The goal is to design effective materials that people pay attention to, remember, and use. Effective materials should persuade people to behave in a more environmentally friendly manner and to influence others to do the same. The ideas discussed below should help you create interesting materials that will attract public attention, encourage community action, and ultimately make a positive impact on environmental conditions in your area.

When crafting outreach materials, remember to use concrete language that helps people to understand, visualize, and remember information. Here are some tips:

- Do not use jargon or technical, scientific language.
- Use anecdotes and examples. Tell a story to draw you reader in and to add more "human interest."
- Use analogies.
- Use descriptive adjectives and adverbs.

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TABLE 3-1. CHARACTERISTICS OF SELECTED MEDIA

Media Format	Channel	Pros	Cons
Newsletters	Mail, handout	Can reach a large audience	Printing/mailing is costly
		Can be more technical	Staff time
			Passive, not participatory
Videotape	Workshops	Can reach a large audience	Relatively expensive
	Mail	Visually pleasing	Must be done well
	Cable TV	More participatory	
		Can show behavior	
Public Service Announcements	TV	Free	Sometimes aired at night
	Radio	Can reach a large audience	Competition for air time
		Can target audience	Very passive
			Difficult to evaluate
Mass Media	TV	Can reach a large audience	Constrained by time, space
	Radio	Good for raising awareness	Must be "newsworthy"
	Newspapers	Usually considered credible	Cannot explain complex issues
			Bad for persuasion
Presentations	Workshops	Can be participatory	Reach smaller audience
	Conferences	Good for persuasion	Staff time
	Group meetings	Can show behavior	Can be too technical
		More personal	People may not attend
Exhibits	Libraries	Can reach a large audience	Staff time
	Malls	Visually pleasing	Must be durable
	Fairs		
Freebies (i.e., bumper stickers, buttons, magnets, hats, etc.)	Fairs	Increases awareness	Very short message
	"Event" days	Inexpensive	Weak on persuasion
	Easy to produce		

R0014085

- Use active verbs.
- Try to visualize what you are saying.
- Use graphics to illustrate and highlight what you are saying.
- Describe consequences of action (or no action) in terms of an individual, family, or business rather than using a broader term, such as "the public."

The format and layout of the materials will also influence the readers reaction to the information. Materials should be designed to help the reader find information quickly and easily. An audience that is confused or overwhelmed will be less likely to read and remember the message of the materials. Even though you may have many important points to make, try to avoid crowded pages with small type and little white space. Important information can be highlighted by using bullets, boxes, side-bars, or shading to highlight it. For example, side-bars with the following heads will capture the reader's attention: "Things You Can Do To Help" or "Where to Get More Information." An appealing layout and easy-to-read type will greatly increase the chances that your materials will be read. Special type fonts, bold, italics, or colors can be used for titles, headings, or, occasionally, extra emphasis. A medium-weight type that is large enough, usually 10 point and above, is more easily read. Selected examples of outreach materials that are easy to read are included at the end of this chapter.

Graphics can enhance the program materials by capturing attention and providing a simple visual picture of important information. A good rule of thumb is to keep graphics simple and portray images that the reader shall remember. For example, to influence people to dispose of hazardous waste properly, a person pouring oil down the storm sewer should not be used (even if the text is talking about the hazards of doing so). A picture of a person taking the waste to a proper collection site would be more effective. The following list provides further tips on using graphics effectively:

- Large illustrations are better than small ones.
- Photographs are more effective than sketches.
- If sketches are used, simple, clear, realistic ones are better than cartoons or more abstract drawings.
- A large photo at the beginning of an article draws the reader in.

- Bright colors are useful because they attract our attention.
- Pictures grouped together have greater interest than pictures scattered throughout an article. They can also the be used to "tell a story."
- Graphics are especially useful for showing "how to" type information.

Meeting Staffing and Equipment Needs

Consider the resources allocated to your storm water management program. What kind of budget do you have to spend on production and distribution? How much time do you have? How many staff people are available and what are their skills and expertise? Is it possible to get help from citizen volunteers for development and distribution of materials? Producing your communication materials may be a major cost of your program. Make sure that you have enough resources to produce sufficient quantities of your material and to distribute them in your community.

Consider the number of people that need to be reached as a function of the amount of available money. A "cost-per-person" can be calculated by dividing the total cost of production by the number of people being targeted. This will allow comparison of different communication strategies on a cost basis.

PUBLIC PARTICIPATION PROGRAMS

Public education and participation efforts often go hand-in-hand, but public participation may require additional coordination efforts and can present unique challenges to those implementing the storm water management program. The benefits of involving the public in the implementation of the storm water program are many:

- If the public is encouraged to participate in the decisionmaking process of the program, their support for the program will likely increase.
- Large numbers of community members can watch over more of a watershed or municipality than a handful of regulators.
- The public is often the primary source of reports of illicit connections and illegal dumping to storm drains.

R0014087

- Only the homeowners and residents can implement pollution prevention practices on their residential properties.
- Public volunteer efforts will save staff resources.

With proper training, citizens (e.g., community groups, local colleges, and high schools) can also be included in field screening and sampling portions of the storm water management plan. This can possibly reduce the labor required to perform a large-scale dry-weather screening program or at least locate more discharges than could be done by staff alone. In addition, dischargers would be constantly reminded that the public is watching and has access to the system, thereby encouraging compliance with the municipality's management plan. To take full advantage of the public participation watchfulness in dry-weather screening programs, municipalities can develop reporting criteria and procedures for the public to follow. The information needs to be clearly stated, public participation should be voluntary, and the city should not be liable if someone is injured in attempting to collect information. The reporting procedures can be similar to crime-watch or fraud-reporting programs and can even include a hotline for the public to report illegal dumping.

Coordination and Integration

Many water quality programs already exist at the local, State, and Federal levels. It is essential, therefore, that storm water management efforts be coordinated with these existing programs so that you are not repeating efforts. By coordinating with other agencies, non-profit groups, industry associations, chambers of commerce, and other citizen groups, you will not only save resources but will also build a coalition of supporters for the program. It may even be possible for your agency to take the lead in identifying all relevant programs and orchestrating them into an effective, comprehensive program with a focus on water quality improvement.

Resources and existing programs do not need to be strictly environmental in focus. For example, in Prince George's County, Maryland, the Police Community Relations Program will incorporate water pollution control information into their outreach program. In this way, the enforcement of water quality regulations will be enhanced through integration between police and water quality specialists.

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Program Components

Public participation efforts contribute to the success of the storm water management program by educating other citizens and promoting responsibility for, and interest in, the preservation of water quality. This, in turn, will help generate public and political support for the storm water program. The municipality staff may save certain resources, but will have the added responsibility of communicating with other groups and programs, coordinating and training volunteers, and organizing public events. The following efforts, among others, have contributed to the success of various public participation programs:

- Partnerships with civic organizations, such as with the Boy Scouts and Girl Scouts to stencil storm drains
- Neighborhood representatives to educate their neighbors about the effects of household chemicals, such as fertilizers, herbicides, and cleaners, and alternatives homeowners can use and proper disposal methods
- Citizen watch and reporting programs
- Citizen advisory groups to help create and establish local ordinances
- Household hazardous waste collection days
- Stream and lake cleanup campaigns.

CASE STUDIES

The following pages present case studies of selected municipalities and their public information and public participation programs.

R0014089

The overall goal of Santa Clara County's public outreach effort is to educate its target audiences about the significance of storm water pollution. The objectives of the program are to elicit public support through volunteer efforts, to encourage changes in everyday chemical usage and disposal habits, and to generate political support for the storm water management program in general. The target audiences include households, small businesses, large industries, educational institutions, private and public waste management programs and facilities, environmental groups, community/neighborhood groups, and local governmental offices. Specific education campaigns address:

- Proper disposal of pollutants that would otherwise enter storm drains and channels
- Control of leaks and spills from automobiles, trucks, and storage tanks
- The role of atmospheric emissions in generating nonpoint source pollution
- The need to promote better site runoff and sediment control.

Many of the objectives of the Santa Clara County public information and participation program will be achieved through a combination of activities that are designed to address various interest groups. A number of activities and coordination efforts have already been conducted, including the development of a public information participation plan, the establishment of a public information subcommittee, the development of program logo and stationery, and the development and distribution of a four-color general awareness brochure. Santa Clara County has also developed a storm drain stencil with instructions, a slide show, and poster and convened focus groups to coordinate a nonpoint source educational effort with existing educational programs. Specific action items include:

- Distribution of a storm drain stencil and how-to pamphlet and slide show for use with volunteer groups and general audiences
- Coordination with the Santa Clara County Household Hazardous Waste Program to develop and distribute 1) two pollutant-specific brochures to commercial and industrial audiences and 2) information guidebook for use by the jurisdictions
- Distribution a "how-to manual" explaining storm water management requirements and pollution prevention opportunities at industrial facilities
- Development of educational curriculum to teach students about the impacts of urban runoff and ways to prevent pollution
- Development of media support and advertising to promote public awareness of municipal storm water pollution and for the Santa Clara County storm water management program.

R0014090

The city of Seattle has implemented an education and outreach plan designed for each watershed to inform and educate the general public, businesses, and students about the fate of pollutants discharged to the storm drain system and what individuals can do to reduce pollution. The following paragraphs briefly describe some of the major components of the education program.

Schools Education Program

Seattle's extensive school education program includes field trips to an aquarium and a trout farm, videos and films, guest speakers, teachers guides, aquarium displays, and training and equipment for raising salmon in classrooms and releasing the fish into local receiving waters. Development of the program was enhanced by obtaining input from both students and teachers about what kinds of materials would be most interesting and educational.

Consumer Education

The city of Seattle has recruited more than three dozen businesses in the Pipers Creek watershed to display information about caring for the watershed and the proper use and disposal of household, yard, and automotive products. Information is presented in a series of brochures that are displayed in a colorful holder depicting a typical house and its connections to the water through the storm drain and sanitary sewer systems. Each business or service that is hosting a display is given a plaque that they in turn can display to the public.

Clean Water Business Partners

Businesses are mailed invitations to become clean water business partners. To qualify, businesses must earn a certain number of points based on their commitment to clean water. Points are earned by following sound management practices to help protect clean water, hosting information displays, and promoting community activities related to water quality. Each qualified business is presented with a plaque suitable for display certifying that they are a Clean Water Business Partner and honoring their commitment to the environment. The city will bring attention to these businesses through other educational promotions.

Storm Drain Stenciling

Volunteer school and community groups have been recruited to paint a pollution prevention message on a number of Seattle's 30,000 storm drain inlets. The message reads "Dump No Waste - Drains to Stream" and other variations depending on where the storm drain discharges. The program has been expanded through incorporation into the school education program and will likely expand further into a new "Adopt-A-Street" program. To date, more than 5,000 storm drain inlets have been stenciled in Seattle.

Motor Oil Recycling

Motor Oil Recycling is a joint project of the Seattle Drainage and Wastewater Utility (DWU) and the Seattle Solid Waste Utility. Waste oil collection tanks have been placed at 12 auto supply stores located throughout Seattle. The program is publicized by the auto store (Shucks) and by the two utilities. Spin-off programs have been initiated by other auto supply establishments in response to this program.

Waterfront Awareness Campaign

Seattle's downtown waterfront is a major tourist and recreation destination. Litter is a major problem along the waterfront, especially within the water itself. An association of waterfront businesses has initiated a cleanup campaign aimed at improving the appearance of the waterfront. The DWU has joined this partnership and has expanded the message to include the impact of litter and pollution on water quality. DWU recruited youth from the recreation centers around Seattle to paint trash receptacles colorfully with clean water and anti-pollution

messages. Signs have been designed by Seattle Aquarium artists and placed along the waterfront reminding people about the effect of their actions on aquatic habitat. Posters similar to the signs will be displayed in waterfront businesses.

Bill Inserts and Citywide Direct Mailings

Seattle utilities include education and public awareness information in their bimonthly billings, which are sent to 188,000 customers. DWU's bill is shared with the Seattle Water Department and the Seattle Solid Waste Utility. The information is distributed on a variety of water quality subjects, including household hazardous waste, protection of Elliott Bay and the Duwamish River, and the school education program. A brochure has been distributed to every customer describing the storm water protection program and the role of the drainage and wastewater utility.

Television Public Service Announcements

Seattle has also developed four television public service announcements (PSAs) for broadcast on local television as part of the education video project in the schools program. The PSAs address the importance of watersheds, the difference between storm drains and sanitary sewers, nonpoint pollution, and pet waste.

R0014092

Grand Traverse County, Michigan, developed a storm water control ordinance in response to the increase in development the county was experiencing. The primary reason for creating a new ordinance, rather than relying on the old system of Drain Commissioner review of drainage plans, was to establish clear, written guidelines for developers to follow for storm water management.

In writing the ordinance, the Grand Traverse County Drain Commissioner formed the Storm Water Management Advisory Committee. The committee comprised of area engineers, concerned citizens, and officials from the township, county, and state. The committee was split into two subcommittees: a technical committee and a policy committee. The technical committee wrote the technical guidelines for the ordinance and then submitted them to the policy committee for approval. The policy committee made all the final decisions on the ordinance and were assisted by a county-funded environmental planner.

After the ordinance was approved by the committee, the Drain Commissioner took the ordinance to each Township Planning Commission and Town Board for comments and approval. The county then held public hearings, particularly to communicate with some community members who thought the ordinance was unnecessary. The public hearings allowed the county to hear these skeptic's concerns and, in turn, to educate them about the potential impacts to the lakes and streams from soil erosion and additional storm water runoff. The county is convinced that the majority of people now understand the need for this ordinance. After the public hearings, the County Board of Commissioners approved the ordinance and it went into effect January 1992.

The ordinance went into effect with no major problems and has become acceptable practice throughout the community. Many developers are glad that there are finally written guidelines, which make project planning easier. Neighboring counties have been interested in adopting similar ordinances in their communities.

Grand Traverse County also established a program to educate landowners about pollution control on their property and the availability of conservation easements and tax-deductible land gifts through the Grand Traverse Regional Land Conservancy. A citizen committee and the Conservancy assist landowners in permanently protecting the wetlands, streamside greenbelts, and ground water upland recharge areas on their property. The county plans to contact every land owner within the critical areas of the watershed to discuss the various land protection programs offered by the Conservancy. The Conservancy has put together a Mitchell Creek Watershed Landowner's Handbook which covers creek protection issues, watershed care, land protection regulations, and a Mitchell Creek Watershed Map. There will also be a series of workshops to give property owners the chance to learn best management techniques "hands-on."

The county has also targeted areas with streams running through the property, including an elementary school and two golf courses. The county has worked with the Michigan State University Extension Service to assist the landowners in creating buffer zones around the stream and to reduce the amount of fertilizers and pesticides used. At the elementary school, students will participate in planting a buffer zone along the edge of the creek. Where possible, financial assistance is also provided either through public or private grants to cover the cost of planting additional vegetation. These programs are intended to protect the quality of the streams but they also provide education about storm water runoff and watershed protection.

The goal of the Prince George's County program is to educate the public about water quality, focusing on steps that people can take to improve water quality. The program will identify specific tasks for public participation in the management of water quality. Tailored to the specific community demographics and types of land use, the program may include an array of educational programs dealing with the following topics: lawn care (proper fertilizer and pesticide application), car care (car washing tips proper disposal of oil and antifreeze), recycling, composting of yard wastes, reporting of pollutant spills, landscaping to improve wildlife habitat and water quality, swimming pool care, septic system overflows, use/storage/disposal of household hazardous wastes and toxic material, and animal waste control.

The county has also proposed a number of public outreach programs to involve citizens and industries in watching over their local water resources. Along with public education programs, public outreach programs will be important in storm water pollution prevention efforts. To the extent possible, community groups will be identified to conduct and organize a number of volunteer activities, including tree planting, stream cleanups, road cleanups, biological monitoring, and environmental watch programs to report and stop illegal dumping activities. Environmental activists in communities, citizen groups and Citizen Advisory Committees, industrial coalitions, and schools will all be targeted for various programs, such as:

- Adopt-A-Stream and Adopt-A-Road projects
- Water Quality Hotline
- Water pollution contests and projects at area schools
- Recreational opportunities
- Recycling
- Co-op for organic fertilizers
- Wildlife sanctuary delineations
- Wildlife corridors
- Tree planting
- Cleanups
- Award programs
- Household hazardous waste collection.

In addition, communities and public meetings will be held to encourage reporting of illegal dumping into storm drains. The public will also be instructed to watch for industries or other entities that may be contributing unpermitted, non-storm water discharges to the storm sewer. A Water Quality Hotline number is planned that will enable the public to talk to local officials about violations and other water quality problems. This information may then be used in conjunction with local and State investigation and enforcement programs to control illicit discharges to the county's waterways.

Prince George's County has also planned a Community Liaison Service to assist in implementing the storm water management program. The program stresses non-enforcement methods to solve water pollution problems by empowerment and cooperation. County officials will coordinate with various organizations, such as business groups, community associations, environmental groups, Citizen Advisory Groups, schools, to enlist their help in implementing the storm water management program. This coordination will entail notification of programs (stream surveys, watershed surveys, complaints), training of all people interested in any program, and recruitment of volunteers for baseline water quality sampling.

R0014094

You Can Make A Difference

Cleaning up after your pet can be as simple as taking a plastic bag or pooper scooper along on your next walk. What should you do with the waste you pick up? No solution is perfect, but here are the choices:

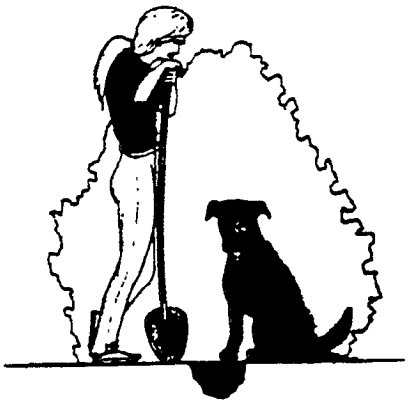
❶ Flush it down the toilet . . .



The water from your toilet goes to a septic system or sewage treatment plant that removes most pollutants before the water reaches a lake or stream.

To prevent plumbing problems, don't try to flush debris such as rocks, sticks, or cat litter. Cat feces may be scooped out and flushed down the toilet, but used litter should be put in a securely closed bag in the trash.

❷ Bury it in the yard . . .



Dig a hole or trench that is:

- About 5 inches deep;
- Away from vegetable gardens;
- Away from any lake, stream, ditch, or well.

Microorganisms in the top layer of soil will break down the waste and release nutrients to fertilize nearby plants.

Be cautious. Keep pet waste away from vegetable gardens and water supplies to prevent disease. Don't add pet waste to your compost pile. The pile won't get hot enough to kill disease organisms in pet waste.

❸ Put it in the trash . . .



This may be easy, but it is not the best solution. Waste taken to a landfill or incinerator can still cause pollution problems.

Check local ordinances. Putting pet waste in the trash is against the law in some communities.

Another option is to install an underground pet waste digester that works like a small septic tank. Before buying one from a pet store, check local laws that may restrict their use, design or location.

A Few Words of Caution

Around Your Home—If you leave pet waste to decay in your yard, be sure it does not become a problem. To prevent water pollution, clean up areas near wells, sewer inlets, ditches, and waterways. Always remove waste from areas where children play. They are the most frequent victims of diseases from pet waste. Of course, the best protection for children and adults is washing hands with soap and water.

In Your Community—Many communities have "pooper scooper" laws that govern pet waste cleanup. Some of these laws specifically require anyone who takes an animal off their property to carry a bag, shovel, or pooper scooper. Any waste left by the animal must be cleaned up immediately. Call your city or village clerk to find out more about local pet waste laws.

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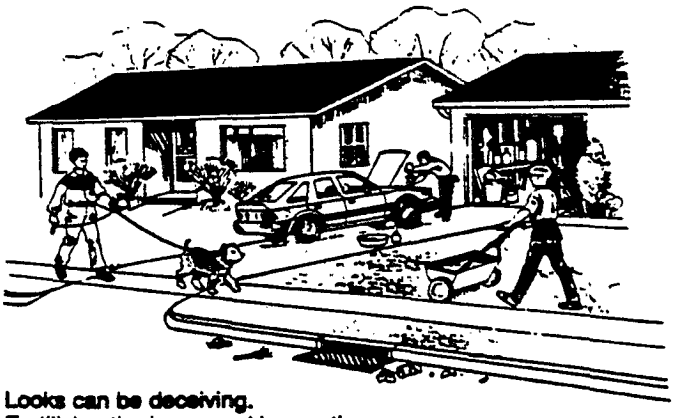
Practical Tips for Home and Yard

A SERIES OF WATER QUALITY FACT SHEETS FOR RESIDENTIAL AREAS

It's an unfortunate fact of urban life—many of our streams and lakes have been polluted. It may be a surprise, however, to learn that water pollution often starts right where you live.

In the community. Urban water pollution begins when development alters natural processes. Removing vegetation and replacing it with streets, rooftops and driveways greatly decreases the amount of water soaking into the soil. As a consequence, the amount of water running off to streams and lakes increases dramatically.

How does the water get from street to stream? Nearly every city street has storm sewer inlets, which open into a network of underground pipes. Leaves, litter, pet wastes, and other materials dumped or washed into storm sewer inlets *do not* go to a sewage treatment plant but flow *directly* to streams and lakes. Also, most storm sewer systems are designed to remove water from developed areas quickly during a storm. This allows pollutants to reach streams and lakes at a "rapid transit" pace.

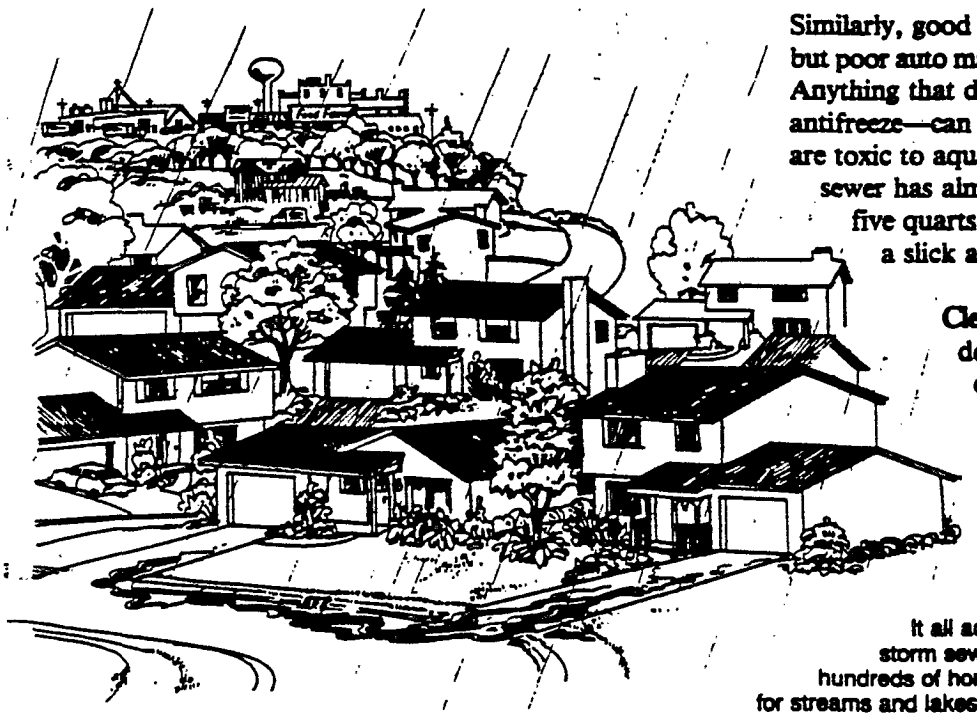


Looks can be deceiving. Fertilizing the lawn, working on the car, walking the dog and other home activities might seem far removed from water quality. But with gutters and storm sewers, it's as if we all live on a streambank.

Around the home. Our actions around home can either help or harm water quality. For example, rain can wash improperly applied lawn fertilizer and pesticides into lakes and streams. On the other hand, careful landscaping and sound lawn care practices can reduce the need for chemicals and protect water quality.

Similarly, good auto maintenance pays in the long run, but poor auto maintenance can seriously harm our waters. Anything that drips from a motor vehicle—oil, gas, antifreeze—can wash into storm sewers. These materials are toxic to aquatic life. Dumping them into a storm sewer has almost unthinkable consequences. Just five quarts of oil in a stream or lake can create a slick as large as two football fields.

Clearly, there is a need to rethink what we're doing at home if urban waters are to be clean and usable. Fortunately, by following the tips inside, we can all contribute to cleaner water while making our homes and communities more attractive and liveable.



It all adds up. Pollutants washed into storm sewers from dozens of streets and hundreds of homes can become major problems for streams and lakes in a community.

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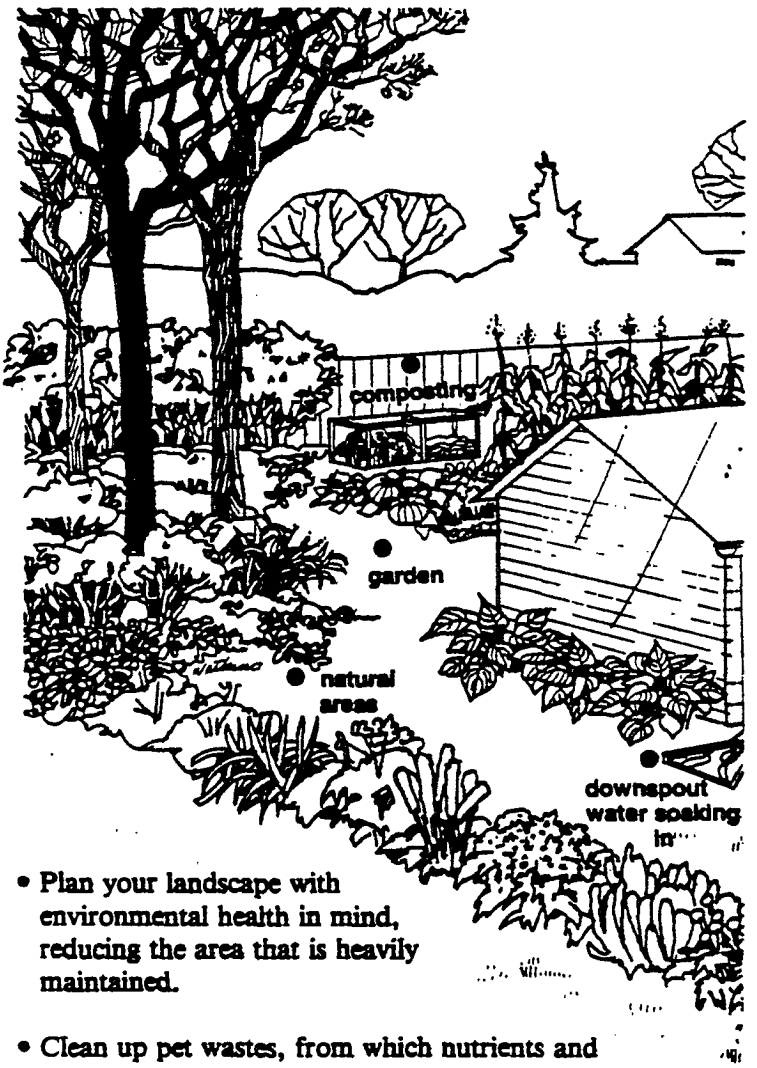
SIMPLE TIPS FOR CLEANER WATER

It really doesn't matter whether you live in the city or the country . . . whether your home is large or small . . . whether you have a lot of time and money to invest in your yard or just a little. There is something you can do to improve water quality. The following suggestions are ways that you can make a contribution to clean water and a healthy environment.

Around your home

- Mow often enough to leave grass clippings on the lawn. Alternatively, use clippings as a mulch or compost them along with leaves that might otherwise "fertilize" local waters.
- Keep fallen leaves out of the streetside gutter or ditch, using them around the yard as practical. Properly place the remainder near the curb (not in the street) just before municipal collection.
- Plant an extra tree for multiple environmental benefits, especially where it becomes part of a planting bed or "naturalized" landscape area that recycles leaves, twigs, and other yard "wastes."
- Seed bare soil and cover it with a mulch as soon as possible to minimize erosion. Disturb no more ground than necessary for a project, while preserving existing vegetation.
- Direct roof downspouts away from foundations and driveways to planting beds or lawns where water can safely soak into the ground. Consider using a rain barrel if practical.
- Use lawn and garden chemicals carefully and sparingly. Pesticides, including weed killers, should be considered a last resort—other controls come first.
- Limit the use of toxic or hazardous products in general. Keep them away from storm sewers, lakes, and streams.
- Collect oil and other automotive products preferably for recycling, or tightly seal and wrap them for proper disposal.
- Wash cars on the lawn, where soapy water can't quickly run toward the nearest storm sewer, picking up other pollutants as it goes.
- Keep cars tuned up and in good operating condition. Check especially for drips and repair leaks immediately to keep nuisance oils off pavement. Better yet, walk, bike or take the bus.
- For waterfront property, grow a "buffer strip" of dense, natural vegetation along the water's edge to filter pollutants and stabilize the shoreline.
- If using a septic tank system, maintain it properly through regular inspections and licensed pumping every two to three years.
- Monitor fuel use from any underground gas and oil tanks to make sure they are not leaking.



- Plan your landscape with environmental health in mind, reducing the area that is heavily maintained.
- Clean up pet wastes, from which nutrients and bacteria could be washed toward lakes and streams.
- Conservatively use salt in winter. Use sand or chip the ice off pavement when possible.

R0014097

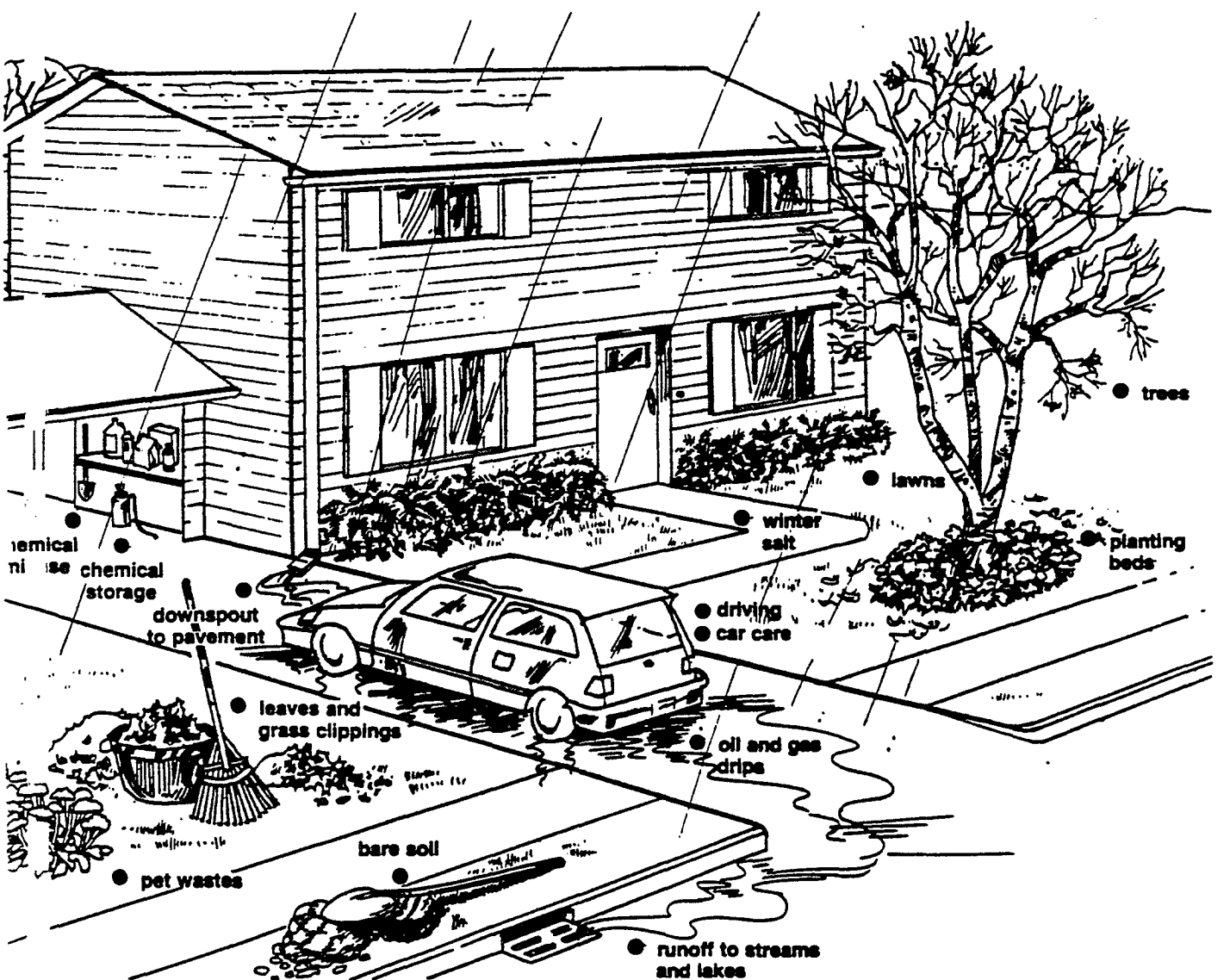
In your community

- Support and follow ordinances that limit soil erosion from construction sites.
- Encourage stormwater management practices that reduce runoff pollution by temporarily holding water in ponds or letting it soak into the ground.
- Encourage the safe but conservative use of salt on roads and limit application to critical areas.
- Tell public officials about your interest in cleaning up local waters and about their value to recreation and the economy.
- Support the preservation of wetlands as natural filters that protect water quality, prevent flooding, and provide vital open space.
- Promote "environmental or parkway corridors" adjacent to streams and waterways for water quality, wildlife, and multiple-use benefits alike.
- Participate in groups, projects, and events that promote conservation, waterfront recreation, or shoreline clean-ups.

Home Hot Spots for Water Quality

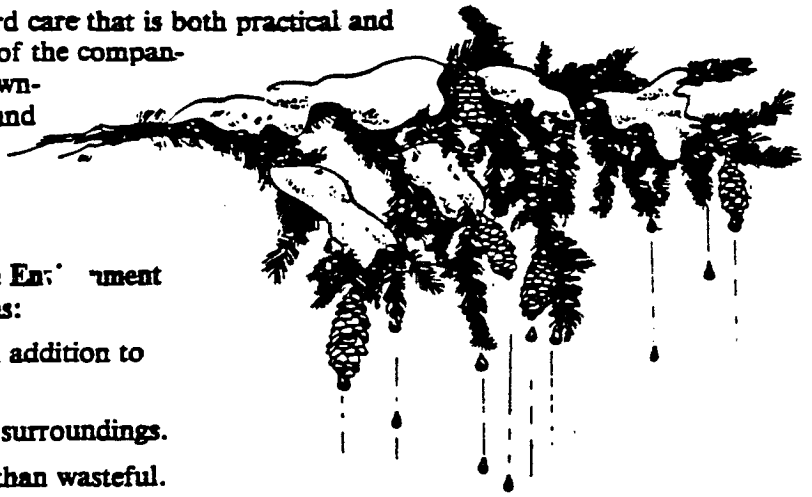
Around every yard are spots where your activities affect water quality. The illustration shows a few of them. Take a look around your own home with an eye toward water quality.

● Good for water quality ● Bad for water quality
● Could be good or bad, depending on your actions



R0014098

PRINCIPLES OF ENVIRONMENTALLY SOUND YARD CARE



This publication describes an approach to yard care that is both practical and environmentally sound. As a shorter version of the companion piece, *Rethinking Yard Care,* it offers down-to-earth tips for protecting water quality around your home and in your community. Look inside for information on home "hot spots" for water quality.

As stressed throughout the **Yard Care and the Environment** series, environmentally sound yard care means:

- Thinking of environmental consequences in addition to conveniences.
- Planning for greater harmony with natural surroundings.
- Being conservative and resourceful, rather than wasteful.
- Believing that small changes collectively make a big difference.
- Capitalizing on the time and cost-savings that rethinking yard care can bring.

Fact sheets in the **Yard Care and the Environment** series are designed to illustrate principles of environmentally sound yard care. They provide specific information about pesticides, fertilizers, landscaping, watering and related topics. These and other publications can be obtained from your local UW-Extension office, usually located in the county courthouse or another public building. Help is also available there regarding soil testing, pest identification, plant selection and other important items related to yard care and water quality.

A publication of the University of Wisconsin–Extension, in cooperation with the Wisconsin Department of Natural Resources under funding from the Wisconsin Nonpoint Source Water Pollution Abatement Program, Gary K. Korb, Water Quality Education Coordinator, Southeast Area UWEX. Editorial and design assistance from Bruce Webendorfer, Environmental Resources Center, UWEX. Illustrations by Carol Watkins.

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GWQ007 Practical Tips for Home and Yard

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359-3165

U.S. Agricultural Stabilization and Conservation Service
219 East Main Street
Lexington, SC 29072
359-3205

S.C. Forestry Commission
219 East Main Street
Lexington, SC 29072
359-2415

OTHER OFFICES

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2600 Bull Street
Columbia, SC 29201
734-5228

S.C. Land Resources Conservation Commission
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Columbia, SC 29205
734-9100

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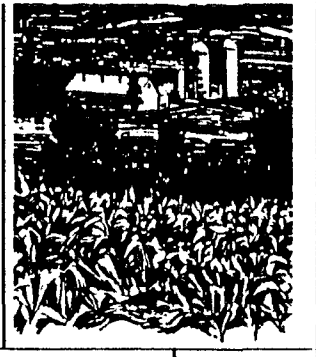
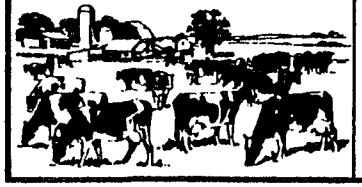
R0014100

Clean Water:

A Clear Choice for Bush River and Camping Creek





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276-0000

S.C. Forestry Commission
P.O. Box 129
Newberry, SC 29108
276-3823

(List continued on back panel)

10 Ways You Can Help Keep Your Lake Clean.

1. ***Get Involved.*** Each of us pollutes ground and surface water. Each of us can help save it. Our contributions may seem small, but they join with those of others on the lake. Here are nine more ways you can help keep the lake clean.

2. ***Save Water.*** Saving water will help water quality by reducing the volume of water going through septic tanks. A dripping faucet wastes 20 gallons of water a day and a leaking toilet wastes 200 gallons. Use water sparingly while brushing your teeth, washing dishes, or shaving. Install a water conservation shower head and take short showers instead of baths. A bath uses 30-50 gallons of water, a short shower only 10.



3. ***Soil Test for Fertilizer Application.*** Many farmers apply the same fertilizer at the same rate every year. Excessive amounts of nitrogen, phosphorus, or potassium that are not used by the crop leach through the soil and contaminate groundwater. Soil testing allows farmers to determine the exact needs of their fields. This insures optimum yields, a clean groundwater supply, and helps farmers save money by using less fertilizer.

4. ***Control Soil Erosion.*** Utilize conservation practices such as conservation tillage and strip cropping to reduce soil erosion. Nutrients and pesticides bond with soil particles. When these particles are eroded into streams and rivers the chemicals are carried with them. Use filter strips near surface water areas and drainage ditches to help prevent water contamination.

5. ***Practice Sensible Pest and Weed Control.*** Apply pesticides and herbicides at the labelled rate. Excessive amounts will leach through the soil and can cause damage to crops and beneficial insects. Make sure the pesticide is labelled for the specific weed or insect and the crop to be treated. Do not apply in windy conditions, when rain is forecast, or to other areas as a "precaution."

6. ***Dispose of Pesticide Containers Properly.*** All pesticide containers have a residue of the chemical stored in them. Triple rinsing the containers will remove over 99% of the residue. Use this rinsate in your applicator and be sure to puncture all old containers to prevent re-use. Take the rinsed containers to an approved landfill for disposal. NEVER pour rinsate on the ground!

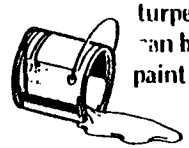


7. ***Protect Your Wellhead Area.*** Many farmers mix chemicals at or near a wellhead. Any spills near a well can easily contaminate the well water by flowing down against the well casing to the water. Always mix chemicals at least 100 feet from the well. In hilly areas make sure the mixing site is below the wellhead. A concrete pad with low curbs to catch any spills is an excellent mixing site.

8. ***Manage and Utilize Animal Wastes Properly.*** Concentrated animal wastes can chemically and biologically impair water supplies. Maintain lagoons and manure storage areas properly. Apply animal wastes to land to build up soil organics and lower commercial fertilizer costs. Incorporate applied wastes into the soil as soon as possible to obtain the greatest nutrient benefit. Do not apply wastes to stream banks or eroding areas.

9. ***Use Equipment Service Products Wisely.*** Petroleum products, antifreeze, and battery acid contaminate water supplies just as easily as pesticides and wastes. Capture all used motor oil for disposal or re-use in lubricating chains or blades. Dispose of motor oil and antifreeze at recycling centers. Do not use gasoline as a parts cleaner or weed killer. Never pour oil or gasoline on the ground!

10. ***Dispose of Household Products Carefully.*** Many products under your kitchen sink or in the garbage can harm the water quality. Never pour paints, preservatives, brush cleaners, and solvents down a drain. Sewers or septic tanks do not treat these materials, and they can enter the groundwater untreated. Buy the product with the least amount of toxic material. Used turpentine and brush cleaners can be filtered and reused. Stuff paint cans and other chemical containers with newspapers before discarding.



The Lake Bowen HUA Project is a group effort of local, state, and federal agencies. The USDA Soil Conservation Service (SCS) is assigned the overall leadership responsibility and also provides technical assistance to landowners. Financial cost sharing funds are provided by the USDA, Agricultural Stabilization and Conservation Service (ASCS), and information and education assistance are coordinated by Clemson University Cooperative Extension Service.

R0014101



Clean Water Begins at Home!

Some household products should never be washed down the drain—they can harm people, animals and the environment.

★ Never [illegible] paint, thinner, pesticides or poisons down the drain. Ask your [illegible] how to dispose of these hazardous [illegible].

★ Use [illegible] cleaner, a plunger or a mechanical snake to unclog drains.

★ Take your motor oil to a service station that collects petroleum products for recycling.

★ Help organize a cleanup day to collect and dispose of hazardous house and garden products.

★ Know what happens to your wastewater after it goes "away." Visit your local wastewater treatment plant and learn what substances the plant can handle.

R0014102

Household alternatives for source control of heavy metals.

Often it is impossible to tell whether a product contains metals or not. Product ingredient lists are incomplete for one reason or another. Gradually this will change as the public demands "green" or environmentally sensitive products and more complete labelling information. In the meantime, research into the contents of household products is continuing, locally and nationally.

Testing conducted by the Washington Toxics Coalition of Seattle and other organizations has shown that certain products contain lower levels of metals than others. The information in this brochure is only a partial listing of products and alternatives, and will be updated and expanded from time to time.

And choices don't have to be all or nothing.

Say for example that you have a favorite detergent that contains heavy metals. Try a substitute every second or fourth washload. You'll still be reducing the amount of metals by 25 to 50%—and eventually you may choose to make the substitution completely.

Garden:



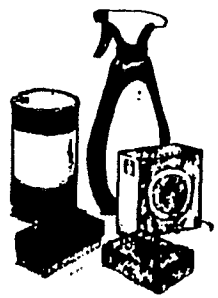
Product	Alternative
Root Killer	Crystals that are flushed down the toilet to control the growth of roots in sewer lines may contain copper. Mechanical removal may be an alternative.
Pesticides	May contain copper. Try attracting birds or introducing lady bugs or praying mantis to your garden. For small infestations, wipe leaves or use a high-pressure water sprayer and plain soap.
Weed control	Pull by hand or cover area with mulch, fabric, or plastic.
Fertilizers	Start a backyard compost bin, or use organic soil additives such as peat moss.

Laundry:



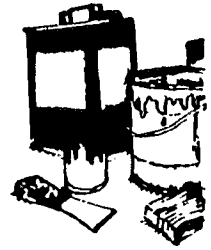
Product	Alternative
Detergents	In general, phosphate-free liquid laundry detergents contain lower levels of metals than do powdered varieties. Cheer liquid, Life Tree, Shaklee Liquid L, and White King Soap contain the lowest metals levels of products tested.
Bleach	Non-chlorine liquid bleaches are lowest in metals. Avoid bleaches containing phosphates. Try less bleach per load, with baking soda added, or presoak heavily-soiled items for 30 minutes in warm water with a half-cup washing soda.
Fabric softeners	Sheets have lower metals levels than liquids. Or add one cup vinegar or a quarter cup baking soda during final rinse.
Dishwashing Detergents	No difference between powder and liquid. An alternative is sodium hexametaphosphate, in same quantity as detergent. Hand-washing detergents have less metals than machine detergents, but do not use them as an alternative in the machines.

Household Cleaners:



Product	Alternative
Scouring Powder	Dissolve baking soda in water; or sprinkle on surface to be cleaned or on a sponge. Shaklee at Ease liquid and Soft Scrub have lowest metals levels of products tested.
General Purpose	Liquids are generally lower in metals.

Paints & Preservatives:

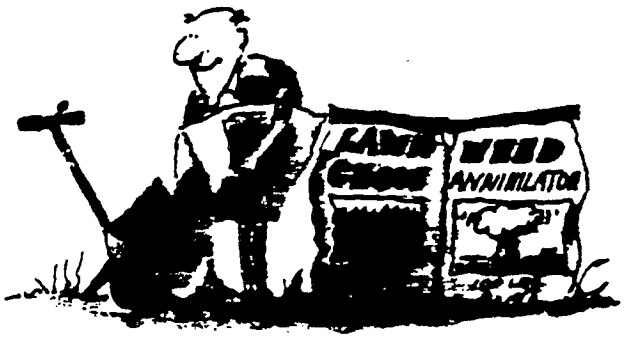


Product	Alternative
Paints	Avoid oil-based paints. Buy latex or water-based types. Estimate quantity carefully.
Paint removers	To remove paint from hands, massage with margarine or a few drops of baby oil. Wipe dry and then wash with soap. To strip paint, use a hook scraper, an abrasive block or sandpaper. Clean brushes right after use. Never use gasoline. Soften hard paint brushes in hot vinegar and wash with soap and water.
Preservatives	Avoid products with copper, arsenic, creosote. Use decay-resistant wood products such as redwood and cedar.
Stains	Use finishes derived from natural sources, such as shellac, tung oil, and linseed oil.

Automotive:



Product	Alternative
Used motor oil	May contain metals; never pour on land or down a sewer drain. San Jose and other cities have curbside recycling pick-up; or check with service stations/autocenters. Also, try to buy recycled oil—even for high performance autos.
Fluids	Spent antifreeze and brake fluid should be stored properly until they can be disposed of at a hazardous waste collection event.



Cultivate Clean Water!

Fertilizer runoff, eroded sediments, septic wastes and pesticide residues are leading causes of water pollution.

- ★ Have your soil tested; use the right fertilizer at the right time, and don't use more than is needed.
- ★ Use pesticides only when other methods have failed—follow the manufacturer's instructions for use, storage and disposal. Buy only as much as you can use this season.
- ★ Help prevent erosion by planting slopes and resodding bare spots.
- ★ Keep your septic system running properly; keep the tank and leachfield areas clear.
- ★ Don't dispose of trash, lawn clippings, leaves or brush in drainage ditches or on flood control lands.

R0014104

FISCAL RESOURCES

The part 2 municipal permit application requires municipal permittees to demonstrate sufficient financial resources to meet the costs of implementing conditions of the permit. This section provides guidance on some sources of revenue available to permittees.

Selection of one or more revenue sources to fund a storm water management program depends on three factors: (1) type of organization that is operating the storm water management program, (2) amount of money that may be raised by various revenue options, and (3) political feasibility of the options.

The first consideration when choosing revenue options is to identify options that are legally authorized. This will depend on the type of local government organization used to implement the storm water program. Frequently, storm water programs are set up as storm water utilities and use a variety of revenue options. A storm water utility is an independent government entity established to design, construct, maintain, and operate a drainage system to control storm and surface water runoff. Utilities handle decisions concerning financing, personnel, and administration. These decisions are not delegated to another governmental department.

Once the legally authorized revenue options have been identified, the second consideration is the amount of money that may be raised and the activities that may be funded by each option. Each revenue source should be examined to determine if the funding is equitable to the consumers. It is critical that the revenue options chosen are able to finance all aspects of the program.

Third, the revenue options must be politically feasible. A successful capital improvement plan will select the revenue option, or package of options, that raises the required funding and is most politically feasible.

Revenue may be generated from the sectors of society that will benefit most from the replacement and expansion of the storm water infrastructure. Local governments may levy impact fees on developments for expansion and on redevelopments for upgrading the existing system. Impact fees should not be used for the replacement of facilities servicing current users. Likewise, current users should not be responsible for funding the expansion of an existing system. The revenue options chosen should be equitable in meeting the needs for replacement, upgrading, and expansion of the storm water system. Figure 3-1

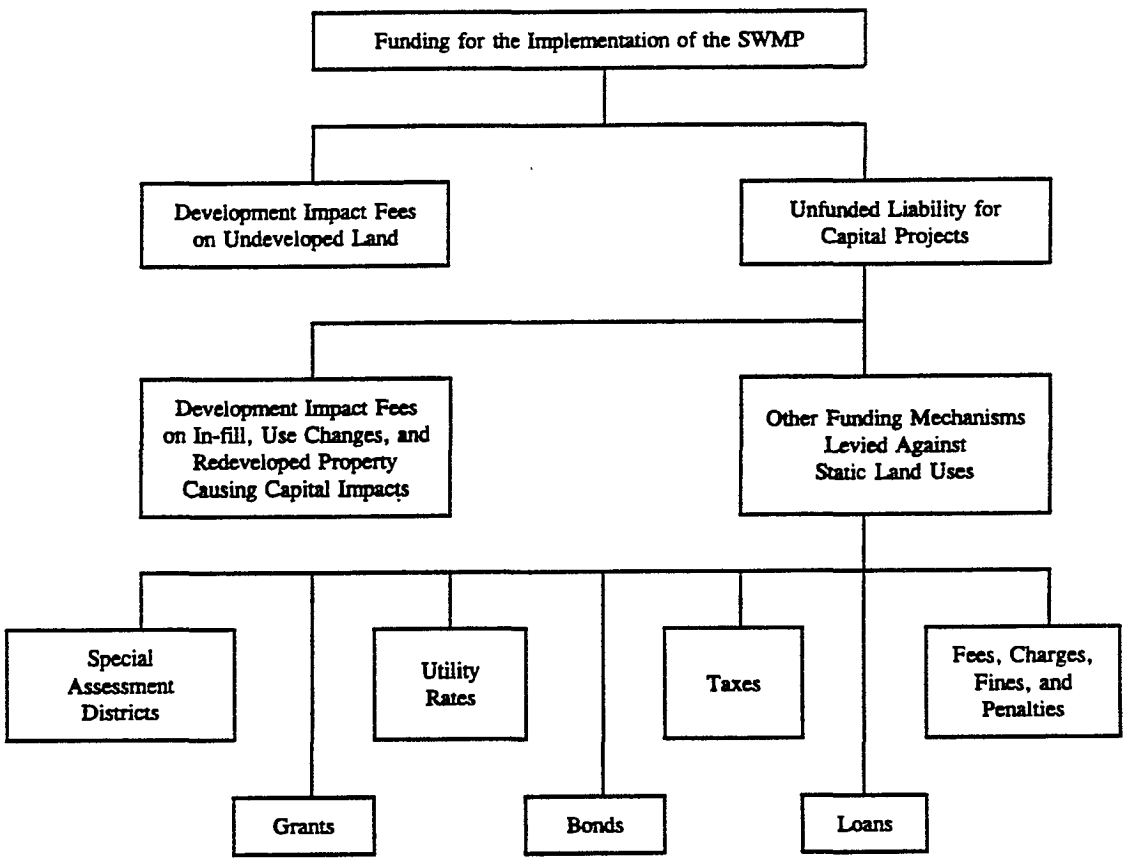


FIGURE 3-1. STORM WATER MANAGEMENT PLAN—FISCAL RESOURCES*

*This schematic is adapted from a figure in an article written by Douglas W. Ayres and Scott Thorpe titled, "Financing Capital Improvements," that was published in the *American Water Works Journal*, August 1991.

illustrates the capital and financing process. The figure shows the process by which capital projects are financed in relation to the benefits derived from the projects.

The following discussion provides an overview of the revenue options identified in Figure 3-1. In choosing a series of options to finance a storm water program, the first step is to determine whether funding is needed for replacing, upgrading, or expanding the system. If funds are needed to finance growth and expansion onto previously undeveloped land, then the authority should assess development impact fees. Development impact fees are assessed against private developers in compensation for the new capacity requirements their projects impose on public facilities.

Development Impact Fees on Undeveloped Land

A significant part of the SWMP is dictated by private development of previously undeveloped property. Additional homes and businesses require service that can only be supported by the construction of new infrastructure (including storm water BMPs). Local governments can levy development impact fees to defray the proportionate share of the infrastructure costs caused by and of benefit to the development. The capital improvement plan should contain sufficient detail to validate such fees.

Unfunded Liability for Capital Projects

Development impact fees will help finance the growth of storm water infrastructure in new developments; however, the upgrading and replacement of the system as it ages still needs to be financed. Local governments need a mechanism to finance the unfunded liabilities, other than continually drawing upon the historical funding sources. One way to help upgrade the storm water infrastructure is by including development impact fees on in-fill,[1] use changes, and property redevelopment. The funds collected can be used to help offset the cost of upgrading an existing system.

[1]In-fill is the cumulative development of single lots scattered throughout the community or the redevelopment of property that results in higher densities or increased demand on public facilities. In terms of storm water management, it includes residential to commercial use changes and an increase in the amount of impervious surface area.

R0014107

Development Impact Fees on Developed Land

Levying development impact fees on properties being redeveloped, in-fill developed, or under changed use must be determined to assure current ratepayers that they are not subsidizing development. When levying development impact fees, there should be a distinct division between replacement and expansion of the system. The component of a project apportioned to replacement should be quantified. The component required for system enhancement to service new customers should be attributed to development impact fees. If the division is not made, current customers may pay for both replacing and upgrading the storm water infrastructure.

Funding of Nondevelopment-Related Project Liabilities

Portions of projects that cannot be legally or accurately charged to development should be financed by revenues paid by existing users of the capital projects. These projects may include the replacement of existing facilities or portion of an upgrade or an expanded plant that cannot be properly be apportioned to development. For example, new customers should not be expected to pay for replacing a down stream storm sewer line that has deteriorated as a result of age. Methods appropriate for use in financing storm water capital expenditures include fees, charges, fines, and penalties; taxes; utility rates; special assessment districts; debt financing (i.e., bonds and loans); and grants.

Fees, Charges, Fines, and Penalties

Municipal storm sewer operators have discovered that greater revenues may be secured with fewer complaints by separating special services and charges from general services and billing full recovery costs separately for these special operations. In addition, fines and penalties may be used to modify behavior.

Fees

Permit fees may be used to fund the portion of a storm water program that regulates activities of construction and development. Construction permits generate revenue, and they can be used to standardize the construction of new facilities and promote the use of BMPs to limit construction site runoff.

R0014108

Charges

Special services are those requested and received by a few ratepayers. Utility services for which special fees should be charged include initiation of service, restoration of discontinued service, detection and repair of household leaks, line location, and review of construction plans.

Fines and Penalties

Fines and penalties are an important part of any effective enforcement program. These revenue sources are better suited to modifying behavior than raising revenue. As enforcement improves and the number of violations decrease, revenue from fines and penalties will decline. This is a reflection of an effective program. In some cases, especially in the early years of the program, revenue from fines and penalties are sizeable and may help to finance enforcement and related efforts.

Taxes

Local governments may levy a variety of taxes to fund their programs. The sales tax, property tax, business and occupation tax are the principal sources of revenue for most local governments. While all these tax sources have the potential for financing storm water management programs, in reality, few dollars are available for such programs for two primary reasons: (1) many local governments have utilized all available taxing authority provided by the State and (2) it is difficult to obtain political support to raise taxes in jurisdictions that have not exercised all of their legally authorized taxing power.

Many local governments have used all of their taxing authority and still have difficulty financing their basic programs. In these cases, it is unlikely that local governments will be able to make tax dollars available to fund storm water management programs. In jurisdictions where voters have a strong preference for minimizing local taxes, raising taxes is politically difficult. Thus, while taxing authority may be available, raising taxes to fund storm water management programs may not be a viable alternative.

If taxes are involved, then a tax analysis of the community's ability-to-pay should be performed. In such cases, the jurisdiction that has the power to levy taxes must have a clear understanding of its current and future tax sources. This will help quantify the need in terms of operational, subsidy, fixed-asset

replacement, or capital project purposes. With such information, specific tax sources may be identified to finance capital projects, relate benefits to payments, and indicate ability-to-pay.

Utility Rates

Municipalities may choose to form a storm water utility that is funded based upon values of fees charged to users of the storm sewer system. A storm water utility's rate structure should finance the portions of the capital improvement plan that are not the responsibility of new or in-fill development. The portions of utility rates that will fund capital improvements are determined through detailed rate studies. Such studies are conducted to assess the proper payment level for operations and maintenance, fixed asset replacement, and system capital needs that cannot be attributed to development.

Rates are an appropriate mechanism for raising revenue for programs where there is a defined population being serviced. There are two types of rates: (1) unit charges and (2) service charges.

Unit Charges

Unit charges, the traditional types of rates, are calculated monthly and based on the quantity of a product consumed. For example, water and electricity rates are unit rates based on consumption. Utilities have traditionally levied rates in this form. Because it is difficult to measure the amount of storm water discharged by each user, however, storm water management programs do not lend themselves to levying rates based on unit charges. Increasingly, local governments turn to service charges to finance such programs.

Service Charges

Service charges are attractive when users cannot be charged according to their level of use, and services are difficult to price on a unit basis. Most service charges are structured to minimize administrative costs and to ensure that payments approximate the distribution of benefits received. As such, they are viewed as an equitable way to pay for services. Revenue from service charges is predictable and may be substantial.

The storm water service charge is determined through three commonly used methods, each based on the disruption of the natural drainage system. The first is an approximation of the percent impervious surface. Percent impervious surface is a measure of the property that does not allow water to penetrate

the ground. This includes roofs, parking lots, and sidewalks. A second method is a flat rate based on the number of residents in a community. The third method assesses a service charge through a combination of percent impervious surface, type of business (SIC classification), and size of the property. Each business type is assigned a runoff factor that reflects the potential discharge of pollutants from the property and a development factor that reflects the percent impervious surface. The product of these two factors is then multiplied by the size of the property in 500 square foot increments. Once the rate is calculated, a fixed fee is added to cover administration costs. A municipality may use a combination of these methods or develop an entirely different method that better suits the characteristics of the community served.

An analysis of the service charge should be conducted annually to update needs, assure continued internal equity, and update cash flows and reserve projections. Computer models may be developed to provide annual rate updates. This type of operating system deflates potential political and financial problems by small annual rate increases instead of less frequent and more dramatic rate increases.

Special Assessment Districts

For services that cannot be categorized within a utility or fee schedules, a city, county, or utility district with the legal authority may create a special assessment district. Special assessments are levied for infrastructure installation or operations and maintenance. Normally, bonds are issued to finance capital construction that is backed by special assessments levied on district members.

Debt Financing

Financing of capital projects through public utility debt has three major advantages: (1) once the money is borrowed or a bond issued, a fixed interest rate and repayment schedule are established, and the debt is repaid over the years with dollars that are cumulatively deflating in value; (2) individuals who require and will use the facilities being built with the borrowed funds will pay for the facilities as they use them throughout debt repayment; and (3) debt financing provides large sums of money up-front to finance the capital expenditures.

Bond issues and loans are the two primary methods to acquire capital through debt financing. It is important to note that because borrowed funds must be repaid, the ultimate source for repayment of bonds

and loans is either taxes or rate revenue. Bonds are not suited to fund ongoing routine expenses, such as the operation of a storm water management program.

Bonds

The two types of bonds commonly used to finance capital acquisitions are general obligation and revenue bonds. General obligation bonds are backed by the full faith, credit, and taxing power of the local government issuing the bond. While a particular revenue source may be earmarked for their repayment, guarantee for repayment of the bonds is provided by the entire stream of tax revenues paid to the local government. For this reason, general obligation bonds may be considered stronger guarantees of repayment than revenue bonds.

Revenue bonds are backed by revenue from a dedicated source as a rate revenue. Because revenue bonds have far fewer statutory constraints, they have replaced general obligation bonds as the primary form of municipal financing. In theory, because this form of debt has its own guarantee (the project revenues, if any), it should not affect a locality's credit rating. In practice, however, revenue debt represents an indirect obligation of the issuing government. Because the lender has only the project revenues to depend on for repayment, interest rates are generally higher for revenue bonds than general obligation bonds.

In most cases, established utilities issuing bonds will issue revenue bonds. New utilities may not have enough history to issue revenue bonds. In these cases, general obligation bonds are issued or, alternatively, double-barreled bonds may be issued. These bonds are backed by both a dedicated revenue source and the full faith and credit of the local government.

Many small communities are unable to enter the national bond market because of poor credit ratings, little financial expertise, and relatively small capital needs. When access to the national bond market is available, small communities usually pay very high interest rates. Some States have created bond banks that enable small communities to issue bonds through the bank. This provides the small communities access to the municipal bond market at lower interest rates and with lower issuance costs.

Loans

A common loan program available within most States is the State Revolving Fund (SRF) for water pollution control planning. SRFs are intended to create a perpetual source of low cost financing. The

funds invested in the capitalization of SRFs assist communities in meeting their needs by providing one-time loans or grants. Below market interest rates are the single most important advantage to some communities. This reduced capital cost decreased the level of user fees required to repay the project debt. The CWA requires recipients of SRF assistance to provide a dedicated source of revenue to cover loan payments. However, SRF assistance to storm water management programs is limited. To address this concern, EPA has developed a case study guidebook that presents examples of how expanded use activities can be funded under the SRF program. For more information on expanded uses, refer to EPA, Office of Water, *Funding of Expanded Use Activities by State Revolving Fund Programs: Examples and Program Recommendations*, August 1990, (EPA 43/09-90-006).

Most States have issued SRF loans at interest rates of 2 to 5½ percent below market rates. With the current interest rate being relatively low, the difference between State SRF loans and the market rate may be minimal and, therefore, not as attractive to communities. Similar to the construction grants, some States may require communities to provide a "match" prior to granting the loan. However, economically distressed communities have indicated that they would be unable to pay back a loan even at a zero percent interest rate and must rely on grants for funding.

Grants and Matching Programs

In addition to all the financial methods mentioned previously, States provide grants to communities for their wastewater quality needs. Grants can be in many forms, with or without community matches or use restrictions. Some States, for example, may provide grants to communities to be used as the prerequisite SRF match. Grants are neither a constant or consistent revenue source and should not be seen as an integral part of financing the daily operations of the storm water program. Grants are more likely to be issued for large one-time capital expenditures to assist in reducing the financial burden on the local community.

Table 3-2 lists selected Federal grant programs that can assist in the financing of storm water management needs. The list does not include grant programs available at the State level. The *Catalog of Federal Domestic* contains a comprehensive list of Federal assistance programs.

TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS

Program Name	Economic Development—Grants for Public Works and Development Facilities
1992 Catalog of Federal Domestic Assistance Number	11.300
Administering Office or Agency	Economic Development Administration, U.S. Department of Commerce
Legislative Authority	Public Works and Economic Development Act of 1965, as amended
Objectives	To promote long-term economic development and assist in the construction of public works and development facilities needed to initiate and encourage the creation or retention of permanent jobs in the private sector in areas experiencing severe economic distress.
Types of Assistance	The basic grant rate may be up to 50 percent of the project cost. Severely depressed areas may receive supplementary grants to bring the Federal contribution up to 80 percent of the project cost; designated Native American Reservations may be eligible for up to 100-percent assistance. Additionally, redevelopment areas located within designated Economic Development Districts may, subject to the 80-percent maximum Federal grant limit, be eligible for a 10-percent bonus on grants for public works projects. On average, EDA grants cover 50 percent of project costs.
Uses and Use Restrictions	Grants can be used for public facilities, such as water and sewer systems, and infrastructure improvements. Qualified projects must fulfill a pressing need for the area and must (1) tend to improve the opportunities for the successful establishment or expansion of industrial or commercial plants or facilities, (2) assist in the creation of additional long-term employment opportunities, or (3) benefit the long-term unemployed and members of low-income families. In addition, proposed projects must be consistent with the currently approved Overall Economic Development Program for the area and for the Economic Development District, if any, in which it will be located and must have adequate local share of funds with evidence of firm commitment and availability.
Eligible Applicants	States, cities, counties, and other political subdivisions and private or public nonprofit organizations or associations representing a redevelopment area or a designated Economic Development Center are eligible to receive grants.
Information Contacts	Director, Public Works Division, Economic Development Administration, Room H7236, Herbert C. Hoover Building, Department of Commerce, Washington, DC 20230.

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TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS (Continued)

Program Name	Economic Development—Support for Planning Organizations
1992 Catalog of Federal Domestic Assistance Number	11.302
Administering Office or Agency	Economic Development Administration, U.S. Department of Commerce
Legislative Authority	Public Works and Economic Development Act of 1965, as amended
Objectives	To assist in providing administrative aid to multi-county districts and redevelopment areas economic development planning and implementation capability and thereby promote effective utilization of resources in the creation of full-time permanent jobs for the unemployed and underemployed in high distress redevelopment areas.
Types of Assistance	A minimum of 25 percent must be obtained from nonfederal sources, except for grants to Native American Tribes. This may be in the form of cash and in-kind contributions. The Secretary is authorized to fund up to 100 percent planning support grants to Native American Tribes.
Uses and Use Restrictions	Grants are used to staff salaries and other planning and administrative expenses of the economic development organization.
Eligible Applicants	(1) Public bodies and other nonprofit organizations representing groups of State-delineated adjoining counties, which include at least one area designated as a redevelopment area by the Secretary of Commerce and one or more centers of growth not over 250,000 population, (2) Native American Tribes, and (3) counties designated as redevelopment areas or nonprofit organizations representing redevelopment areas or nonprofit organizations.
Information Contacts	Director, Planning Division, Economic Development Administration, Room H7023, Herbert C. Hoover Building, Department of Commerce, Washington, DC 20230.

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TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS (Continued)

Program Name	Economic Development—Public Works Impact Projects
1992 Catalog of Federal Domestic Assistance Number	11.304
Administering Office or Agency	Economic Development Administration, U.S. Department of Commerce
Legislative Authority	Public Works and Economic Development Act of 1965, as amended
Objectives	To promote long-term economic development and assist in providing immediate useful work (i.e., construction jobs) to unemployed and underemployed in designated project areas.
Types of Assistance	The basic grant rate for Public Works Impact Program areas is 50 percent, except for Native American areas, where the rate can be 100 percent. Severely distressed areas may receive supplementary grant assistance to bring the Federal contribution up to 80 percent. Local matching share may be waived if appropriate entity can demonstrate that it has exhausted its effective taxing and/or borrowing capacity. On average, EDA grants more than 50 percent of project costs.
Uses and Use Restrictions	Renovation or construction of public works and development facilities to provide immediate jobs to the unemployed and underemployed in project areas.
Eligible Applicants	Eligibility is based on designation of the county or city as a redevelopment area according to the criteria under Section 401(a)(6) of the Public Works and Economic Development Act of 1965 (Public Law 89-136).
Information Contacts	Director, Public Works Division, Economic Development Administration, Room H7236, Herbert C. Hoover Building, Department of Commerce, Washington, DC 20230.

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TABLE 3-2. SELECTED FEDERAL GRANT PROGRAMS (Continued)

Program Name	Water Quality Management Planning 205(j)
1992 Catalog of Federal Domestic Assistance Number	66.454
Administering Office or Agency	Office of Water, U.S. Environmental Protection Agency
Legislative Authority	Clean Water Act, Section 205(j), as amended
Objectives	To assist States (including territories and the District of Columbia), Regional Public Comprehensive Planning Organizations, and Interstate Organizations in carrying out water quality management planning.
Types of Assistance	Formula Grants. Each fiscal year, the Administrator shall reserve under Section 205(j)(1) an amount not to exceed 1 percent of the amount allotted and available for obligation or $100,000, whichever is greater, for the purposes of making grants to the States to carry out water quality management planning. Forty percent of the State's annual award must be allocated to Regional Public Comprehensive Planning Organizations and Interstate Organizations, unless EPA approves a lesser amount.
Uses and Use Restrictions	Section 205(j)(1) and Section 604(b) funds are awarded under Section 205(j)(2), to the State water quality management agencies to carry out water quality management planning. States are required to allocate 40 percent of the State's annual award to Regional Public Comprehensive Planning Organizations and Interstate Organizations. EPA may approve a State's request to pass through less than 40 percent if, after consultation with its Regional Public Comprehensive Planning Organizations and Interstate Organizations, the Governor determines that pass through of at least 40 percent will not (1) result in significant participation by Regional Public Comprehensive Planning Organizations and Interstate Organizations unless in water quality management and (2) significantly assist in development and implementation of the State's water quality management plan.
Eligible Applicants	State water quality management agencies.
Information Contacts	Contact the appropriate EPA Regional Office.

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ANNUAL REPORTS: ASSESSING THE EFFECTIVENESS OF THE STORM WATER PROGRAM

Purpose of Annual Reports

On the annual anniversary of permit issuance, the municipality is required to submit an annual report discussing the progress made toward achieving the specified storm water management program goals. As stated in Section 122.42(c) of the regulation:

> 40 CFR Part 122.42(c)(1)-(7)
>
> ***The report shall include -***
>
> (1) Status of implementing components of storm water management program that are established as permit conditions;
>
> (2) Proposed changes to storm water management programs that are established as a permit condition. Such changes shall be consistent with §122.26(d)(2)(iii) of this part; and
>
> (3) Revisions, if necessary, to the assessment of controls and the fiscal analysis reported in the permit application under §122.26(d)(2)(iv) and (d)(2)(v) of this part;
>
> (4) Summary of data that is accumulated throughout the reporting year;
>
> (5) Annual expenditures and budget for the year following each annual report;
>
> (6) A summary describing the number and nature of enforcement actions, inspections and public education programs;
>
> (7) Identification of water quality improvements or degradation

In developing their Part 2 municipal permit applications, applicants should have considered their strategy for preparing annual reports. While each municipality will take a different approach, in general, strategies will include identification of measures to track the long-term progress of their storm water management program goals, discussion of the role of monitoring data in assessing program effectiveness, and discussion of how the municipality plans to provide for future adjustment to this reporting strategy.

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The annual report will be used by the municipality to provide an assessment of the program performance, and guidance in establishing longer term assessment strategies.

The annual report will be used by the permitting authority to monitor program compliance, and determine if the program is achieving the goal of improved storm water quality.

Benefits for Municipality

Completing annual reports is an invaluable exercise for municipalities because it allows them to gather all relevant information from the past year's storm water management activities and to assess the effectiveness of the program to date. If program goals are being met (or are in the process of being met), then the municipality can feel confident that its storm water management program has been designed and implemented in a relatively effective manner. If program goals are not being met, however, the municipality can reassess current program measures and make alterations if necessary. This annual evaluation should help permittees gauge tangible and intangible measures of progress (e.g, pollutant loadings or public awareness).

Benefits for State

Many municipalities are still in the early stages of developing storm water management programs suitable for controlling pollutants in discharges under an NPDES permit; others have relatively sophisticated programs in place. By reviewing the annual report, the State can determine whether various municipalities are developing their programs in a timely manner and can use information gathered in these reports to assess aquatic conditions on the State level.

While the annual report may be used by the States to evaluate municipal compliance with permit conditions, it also may indicate to the permitting authority where permit conditions need to be modified to address specific problems. Access to monitoring data identifying water quality improvements or degradation is important to the State for several reasons. First, it can be used to evaluate the success or failure of a management program in reducing pollutants. Second, it provides the State with information to use in a watershed data base. Third, the State can use the data to meet the informational requirements of various Federal programs. Data drawn from the annual reports will be especially useful for programs

such as the Coastal Nonpoint Source Pollution Control Program (CZARA), the Safe Drinking Water Act Program, the Clean Lakes Program (CWA 314), and among others, which are identified in Section 1.3 of this document.

Required Elements

The annual report contains several requirements aimed at evaluating the accomplishments of the past year. This information can be used to evaluate the relative effectiveness of the storm water management program and to determine which elements should be continued or dropped from the plan. In some cases, the review will indicate that new methods or measures should be tried. The next several sections appear in the same order as in the permit; however, evaluating them in a slightly different order may be more productive.

Status of Implementing Components of Storm Water Management Program

This section addresses the relative degree to which storm water management program elements have been completed. Numerous approaches can be taken to accomplish this. You may want to begin by providing an overview of the program approach and history. Then, using your permit requirements as a guide, look at each component and decide whether it can be evaluated directly (e.g., pollutant removal) or indirectly (e.g., the success of a public outreach program). To complete this section, you can refer to various documents, including ordinances proposed or enacted, documentation for design or completion of structural controls, inspection reports, site assessments, and progress reports on cleanups. For components that can be directly measured, an effective way to present the information is in a matrix format, as shown in Figure 3-2.

Figure 3-2 shows activity goals versus activities accomplished. If the component you are addressing is not directly measurable, a narrative description can be given to convey its status. For example, you might describe the effectiveness of a public education program by discussing the number of meetings held to generate community awareness, the results of a post-meeting survey, any followup inquiries or letters from the meetings, or by discussing the increase in the number of citizens reporting violations.

Once you have addressed the circumstances of each program component, the status of the SWMP as a whole should be summarized.

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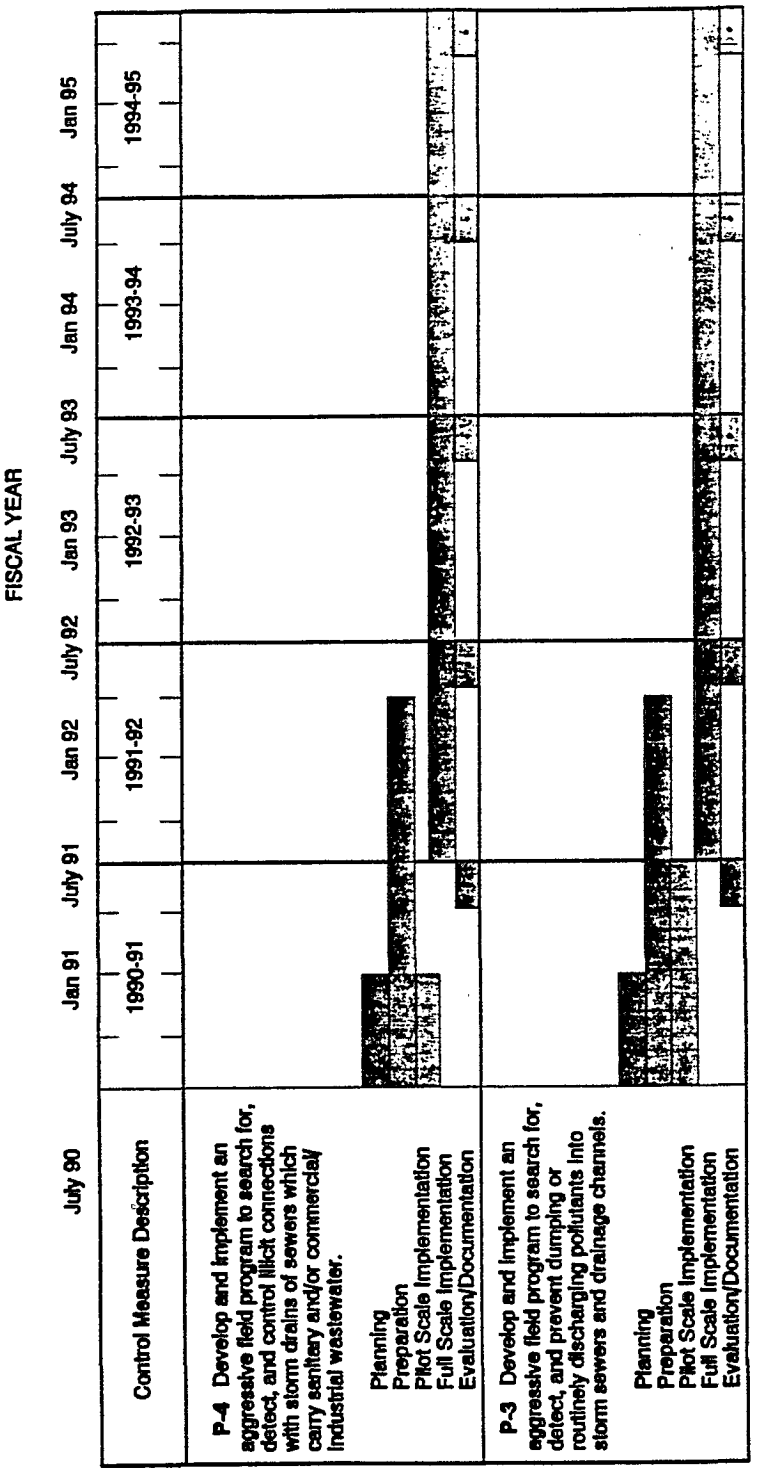

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FIGURE 3-2. IMPLEMENTATION SCHEDULE FOR PROGRAM ELEMENT IV—ILLICIT CONNECTION ELIMINATION AND ILLEGAL DUMPING ELIMINATION

Proposed Changes to SWMP Established in Permit Conditions

After reviewing the effectiveness of your program components over the last year, you can determine which components require adjustments in order to meet long-term goals of water quality improvement. Among the reasons for proposing a change are:

- The existing component is not cost-effective
- The existing component has not performed as anticipated
- Physical circumstances have changed (e.g., the addition of an outfall or consolidation of existing ones)
- New technologies are available that produce better results.

When municipalities make programmatic changes, the background information used to formulate original decisions should be consulted. For example, you should be aware of the initial strategy used to develop the component, such as cost or time constraints. Consider how the initial strategy may have influenced component performance (e.g., lack of funding may have curtailed an activity before the end of the period). The next step is to explain the reason for requesting the change. A detailed description of the proposed component in terms of its impact on budget, schedule, and previously stated program goals should also be provided. For example, Santa Clara Valley's annual report included sections that described successes and shortfalls and future changes as a result of these two areas. All changes must be consistent with regulatory requirements in Section 122.26(d)(2)(iii). Requests for significant revisions to the storm water management program may require municipalities to partially resubmit their storm water permit application, as noted in Section 122.26(d)(2)(iv) and (d)(2)(v).

Revisions to the "Assessment of Controls/Fiscal Analysis" Sections of SWMP

Assessment of Controls

As part of the Storm Water Management Program, municipalities are required to provide an annual "assessment of controls," as well as a "fiscal analysis." This section should be completed only after you have reviewed and summarized the data gathered throughout the year. The municipality will compare the collected data and documented achievements of the program to the estimated data (e.g., reductions in pollutant loading and other site-specific measurements included in Parts 1 and 2 of the permit). Program components will not always meet the anticipated return value, and others may exceed

expectations. The effectiveness of controls should be modified based on the actual values from data gathered throughout the past year.

A number of control measures cannot be evaluated in terms of direct measures, such as pollutants removed, but instead must be evaluated in terms of indirect measures. Indirect measures can often be very effective when direct measures are not appropriate or when they do not tell the whole story. For example, public education campaigns generally cannot be assessed in terms of pollutant reduction. An increase in the number of citizens participating in a cleanup program, however, would be a good indirect indicator of program effectiveness. Similarly, an increase in the rate of volunteerism within the community could indicate the relative success of a particular program. Another indirect measure might be an increase in the volume of recycling materials collected. An indirect measure of success in lowering pollutant loads would be a lowering in the number of beach closings or fishing restrictions. Be aware of the possibility of these indirect indicators as you review your records.

Table 3-3 contains control activities and possible ways to indirectly measure their effectiveness. Some of these activities may be appropriate for your situation.

TABLE 3-3. SWMP COMPONENTS AND SELECTED MEASURES

SWMP Component	Indirect Measure
Classes/art or writing contests for school aged children	Attendance records, entries received
Public hearings/discussions/seminars	Attendance records
Community cleanup programs or adopt-a-highway campaigns	Number of volunteers or truckloads of trash collected
Public education/outreach programs (e.g., print, video, audio)	Number of handouts distributed, media spots, or citizen response (e.g., phone calls or letters)
Violations reported by citizens	Number and type of violation
Public awareness	Letters, reported violations, court records indicating citizen suits against specific facilities, or a rise in recycling program participation
Household hazardous waste/used oil collection program	Number of gallons of hazardous waste or used oil collected
Industry outreach programs	Increase in the number of permit applications or articles in industry/local publications

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Fiscal Analysis

The fiscal analysis section will also be updated based on actual figures for the year past. The information to be updated will include the existing budget, estimated operation costs necessary for the storm water management program during the term of the permit, capital available to meet these costs, and the list of available sources of funding and legal restrictions on these sources. Information for this section and the section on assessment of controls can be presented in a number of ways, including graphs, pie charts, and matrices. When the projected and actual figures differ, the permittee should also include a narrative explanation. For example, if the monitoring program exceeded its budget in a particular area, the permittee may indicate in the narrative that this was caused by the addition of several outfalls that were not included in the original list.

Summary of Data Gathered Throughout the Year

This section of your annual report is used to present an overview of the data gathered during the past year and is an important step in evaluating the effectiveness of your program to date (e.g., data may indicate that efforts to reduce a particular pollutant have been successful). This section should address, at a minimum, the results of the storm water monitoring program and the seasonal pollutant load estimates for each major outfall identified in the application.

Your municipality was required to include, in the Part 2 permit application, a proposed monitoring program for data collection from the separate storm sewer system. The permit issued to your municipality should specify the required monitoring for the permit term. The amount, type, and schedule for monitoring data collection will vary, depending on the proposed plan and on the permitting authorities need to characterize the discharge from the separate storm sewer system. The annual report should summarize the monitoring activities for the previous year indicating, at a minimum, the number of outfalls or screening points sampled, the number of times each outfall was sampled, and the location of the outfalls sampled. The annual report should also summarize the data collected in the monitoring program. The monitoring data should be organized by watershed. For example, the results of all monitoring performed on discharges to Smith Creek should be listed together in the same table. The report should include the following information for each outfall sampled:

- The date the sample was collected
- The duration and depth (in inches) of the storm event that generated the discharge

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- The form of precipitation (rainfall or snow melt)
- The type of sample collected (grab, flow weighted composite, or time weighted composite)
- The results of the analysis performed on the samples (e.g., the concentrations of the pollutants).

Monitoring data are best presented in a table or matrix format. Monitoring data can also be given in line graphs, bar charts, pie charts, or other easily understood formats.

Municipalities are also required to submit in their Part 2 applications a schedule for providing estimates of the seasonal pollutant loads and event mean concentration of any parameter detected in any sample collected for the Part 2 application requirements. The proposed schedule will be reviewed by the permitting authority and should be included in the permit conditions. The annual report should present the estimates of pollutant loads and event mean concentrations in the years specified in the permit schedule. The following information should be provided:

- Location of the major outfall
- Estimates for four seasonal pollutant loads for each parameter
- Brief description of method used to estimate the pollutant load
- Estimate of the event mean concentration of each parameter for a representative event
- Brief description of the method used to estimate the event mean concentration.

The estimates of pollutant loads and event mean concentrations should be presented in tabular format by watershed. The description of the calculation methods should indicate the extent to which the monitoring data were used. You may also include a written evaluation addressing the results.

For instance, Santa Clara Valley has a 5-year monitoring plan. This plan contains 10 monitoring sites, including 5 new sites—an industrial site, two transportation corridors, and two outfalls at a detention basin. The objectives of the plan are to:

- Gather data to determine long-term water quality trends
- Assess impacts of toxicity in storm water runoff and determine the pollutants causing the toxicity

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- Evaluate the appropriateness of the WQOs in protection aquatic life
- Determine the treatment effectiveness of an existing detention basin under different hydrologic conditions
- Assess the role of stream sediments as pollutant sinks or sources
- Describe the management implications of the findings.

Annual Expenditures and Budget for the Upcoming Year

This section addresses the coming year's proposed budget and the previous year's expenditures. An analysis of last year's budget and actual expenditures is used to determine if targeted amounts in the new budget will be adequate. Note which of your program elements will be continued, which will be dropped, and whether any new ones are to be added. Compare this list of proposed program changes to your available budget to ensure adequate funding. Once you have listed the projected cost for each item, note the source of funding and its approval status. Tracking approval status of funding for planned activities is important because the program may not be able to achieve its goals or permit compliance without funding approval. For example, the Santa Clara Valley Water District (SCVWD) is the managing agency for the municipality's budget. A management committee is appointed to decide on budget matters. The committee is chaired by the SCVWD Manager of Operations and Water Quality and includes representatives from each of the 15 co-permittee municipalities. The nonpoint source division's program manager is responsible for the administration and management of the budget program.

Summary Describing the Number and Nature of Enforcement Actions, Inspections, and Public Education Programs

This section should describe each enforcement action, educational program, or inspection conducted during the past year. This may include actions initiated by citizens, private industry, or the municipality. Refer to legal notices, court records, and newspaper articles for this information. Permittees should note the number and type of each action and, where appropriate, the number of participants or the number of materials distributed (as in the case of educational programs). When addressing enforcement actions, it may be useful to indicate the types of outcome (e.g., the names of offenders published in the local newspapers, the number of fines levied and the amounts, or the number of closures or stop work orders issued). The total number of inspections, the types of facilities inspected, and the number of violations cited due to these should also be indicated. It may be helpful to note the number of in-house training programs held for inspectors and the number of attendees. Public education programs may be assessed

by noting the number of meetings or classes, subject matter, attendance figures, the number and type of media spots, printed materials distributed, etc. In evaluating program success, it may also be helpful to use some indirect measures, such as a decrease in illegal storm drain dumping, which may be attributable to storm drain stenciling. The key to Santa Clara Valley's enforcement program, for example, is the ordinance regulating industrial or other polluting activities within the municipality. The ordinance to be developed by Santa Clara Valley will include language addressing the following activities: controlling non-storm water discharges to storm drains, watercourse protection, regulation of outdoor material storage, control of improper grease disposal, and storm water management requirements for new development and redevelopment. For more specific information on how the ordinance will affect these areas, various subcommittees will develop guidance manuals on storm water controls.

Identification of Water Quality Improvements and Degradation

An important measure of the program effectiveness is the extent to which water quality has improved during the past year. In particular, municipalities should examine the water quality of the receiving waters to which the system discharges. This section should include such changes in receiving water quality and cite the reasons for them.

Municipalities were required to provide information on receiving waters and watersheds in Part 1 of the permit application. This information included a discussion of water bodies cited in State reports required by CWA Sections 305(b), 304(1), and 314(a); the State Nonpoint Source Report; and other reports identifying sensitive watersheds. To complete this section, you will need to review information gathered for these State and Federal programs during the past year and data from the required monitoring program. The municipality may have also gathered receiving water data as part of its strategy for continuing program assessment. In addition, information may be available from other Federal programs, as noted in Chapter 1. Be aware that numerical data are not the only way to determine water quality. One criterion you may use when judging water quality is how well the body of water meets its designated uses (e.g., recreational or industrial uses).

Once water quality improvement has been noted, the next step is to determine the cause for these changes. For instance, if the annual monitoring data indicate that discharge water quality and receiving water quality have improved proportionally, it may be attributable to the successful implementing of the SWMP. If monitoring data indicate an improvement in discharge quality yet receiving water quality has

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degraded over the past year, you must try to find the reasons (e.g., unforeseen weather conditions, such as flooding or drought, or sources upstream). Available computer water quality modeling programs may be helpful in completing this section.

Sample Annual Reports

An excerpt from an annual report on the Santa Clara County program is given after the summary.

SUMMARY

This chapter discussed the procedures on implementing the specific administrative requirements, which include public participation and public information programs, fiscal analysis, and annual reports. Each of these components is essential to the successful implementation of a municipal storm water management plan. Public participation and public information programs solicit public support by informing individuals of the importance of good storm water management and its effect on water quality. By conducting a thorough fiscal analysis program, a municipality examines all of the available sources of funding and selects the funding option(s) according to its specific needs. The annual report assesses the effectiveness of the management plan and allows the municipality to revise the plan based on the results of the assessment. The next chapter provides procedures for implementing an effective illicit connections detection program as a key element in the municipal storm water management plan and provides examples of programs from different municipalities.

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SANTA CLARA COUNTY STORM WATER MANAGEMENT PLAN

Public Information/Participation Program

Provision 4b of Santa Clara County's NPDES permit requires the individual co-permittees to implement educational control measures to inform the public of and encourage participation in nonpoint source pollution control activities. Educational control measures are being implemented through a Public Information and Participation (PI/P) program.

Overview and Objectives

The main objective of the PI/P element is to implement educational control measures that provide information to the public and increase understanding of and participation in controlling nonpoint source pollution. The overall goals for FY 91-92 were to generate awareness of the program by defining the problem, inform individuals on ways to participate in solutions to the problem, and provide the means for participation. Specific industries were targeted for development of Best Management Practices (BMP) manuals, brochures, and posters. To aid in the development, publication, storage, and distribution of educational materials, the program established a PI/P Subcommittee in FY 90-91 to have primary responsibility for the implementation of this PI/P element.

Program Activities Completed and In Progress

The subcommittee produced nine types of educational material during FY 91-92. This included development and distribution of an Automotive Industry BMP manual and poster, a construction BMP poster, a "Recycle Your Used Motor Oil" poster, brochures describing how to decrease the use of toxic chemicals in the home, guidebooks, and stencils. The storm drain stencils developed in FY 90-91 were made available to co-permittees and volunteer groups to use during FY 91-92, and the remaining brochures developed in FY 90-91 were distributed to the co-permittees as needed. The co-permittees distribute them to the public through presentations, events, direct mailing, and billing inserts. In addition, the subcommittee distributes the materials to the public through presentations and events and to schools, teacher organizations, and specific businesses.

FY 92-93 Program Activities

The subcommittee will continue to be primarily responsible for implementation of this PI/P element, and to act as the central development and distribution point for all materials. The subcommittee will also be evaluating the effectiveness of the PI/P element activities of the past 2 fiscal years and developing recommendations for increasing the outreach effort. Activities planned for FY 92-93 include development of a program newsletter for nontechnical audiences with periodic distribution and development of a brochure for homeowners to use when dealing with contractors who offer potentially hazardous services (e.g., carpet cleaning, pest control). Other activities planned for FY 92-93 are creation and implementation of a distribution plan for program educational materials, translation of one brochure into Spanish, reprinting of existing materials to keep distribution points supplied, provision of funds to support other programs and for the purchase of educational materials produced by other programs in the Nation, development of a strategy for a recognition program for industry compliance efforts, and funding of the San Francisco Bay National Wildlife Refuge's Alviso Environmental Education Center.

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Co-Permittee Activities Completed and in Progress

The activities conducted by the subcommittee and the co-permittees for the PI/P element are summarized below. The detailed reports submitted by the subcommittee and the co-permittees are presented in the "Public Information/Participation" Program Element Report.

Infrastructure

The funding, staffing, and organizational/institutional infrastructures established by the co-permittees are summarized in Table 3-4. Of the 15 co-permittees, 6 relied wholly or partially on their general fund for funding of PI/P element activities in FY 91-92, and 10 acquired funding through related program funds, fees, or utilities. Funding for the program element was sufficient for 14 co-permittees in FY 91-92, and 1 reported that the budget was constrained. Staffing for the PI/P element was sufficient in FY 91-92 for nine co-permittees and insufficient, overextended, or limited for six co-permittees. A total of five of the six co-permittees reporting insufficient or limited staff proposed changes to resolve the problem; one indicated no changes would be made due to a hiring freeze. The 4 co-permittees who reported organizational limitations to implementation of the PI/P element identified the problems as establishment of effective communication among departments and difficulties in analysis of activities; 11 co-permittees reported that there were no organizational limitations.

Public Information and Participation Activities

The activities conducted by the co-permittees to meet the objectives of the PI/P element included storm drain stenciling; publication of articles in newspapers, community reports and newsletters, preparation of advertisements for radio and TV; direct mailing of brochures, and distribution of billing inserts (Table 3-5). Brochures and posters were distributed at presentations and special events and were made available at community centers and public office buildings. Some co-permittees provide telephone and mail service to distribute materials on request. In FY 91-92, more than 21,000 storm drains were stenciled, 76 articles and advertisements were published, 238 presentations and events were presented or attended, and more than 77,000 brochures and posters and over 82,00 billing inserts were distributed. The city of San Jose took the lead in producing bookmarks for the co-permittees to distribute to libraries for summer reading programs. Copies of San Jose's co-permittee PI/P activities are attached.

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TABLE 3-4. PI/P PROGRAM ELEMENT INFRASTRUCTURE

Co-Permittee	Funding		Staffing		Organizational Limitations
	Source	Amount	Current	Proposed	
Campbell	General Fund	Sufficient	Overextended	Recruit volunteers	None
Cupertino	Environmental Bill	Sufficient	Sufficient	No changes	None
Los Altos	Sewer Enterprise Fund	Sufficient	Sufficient	No changes	None
Los Altos Hills	General Fund	Constrained	Limited	Hire 1 staff	None
Los Gatos	General Fund	Sufficient	Insufficient	Contract with WVSD	Reorganization of departments
Milpitas	Capital Improvement Program	Sufficient	Sufficient	No changes	None
Monte Sereno	General Fund	Sufficient	Limited	Recruit volunteers for stenciling	None
Mountain View	Wastewater Enterprise Fund	Sufficient	Limited	No changes due to hiring freeze	Coordination between divisions
Palo Alto	Storm Drain Utility	Sufficient	Sufficient	No changes	None
San Jose	Storm Drain User Fee	Sufficient	Sufficient	No changes	None
Santa Clara	Capital Improvement Program	Sufficient	Limited	Hire labor as needed	None
Santa Clara Co.	Existing Programs	Sufficient	Sufficient	No changes	Activity analysis difficult
SCVWD	Water Utility/Flood Control	Sufficient	Sufficient	No changes	Coordination due to physical separation of departments
Saratoga	City Budget	Sufficient	Sufficient	No changes	None
Sunnyvale	General Fund	Sufficient	Sufficient	No changes	None

Source: Santa Clara Valley Part II Municipal Permit Application

TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
CAMPBELL				
Storm drain stencils	200	200	600	Goal met
Newsletter articles	2	2	2	Goal met
Special events	No goals established	2	No goals established	Not applicable
Brochures/poster distribution	1,115	1,120	1,210	Goals met
CUPERTINO				
Storm drain stencil	All catch basins	Complete	Target businesses	Goal met
TV programs	2	2	1	Goals met
Articles in newsletters, newspapers, billings	5	7	2	Goals met
Adopt-a-creek program	Implement program	No	Implement program in 1992	Required additional research
Brochure/posters distribution	No goals established	As needed	Ongoing	Not applicable
Special programs/events	4	4	3	Goals met
LOS ALTOS				
Storm drain stencils	Ongoing (900 total)	200	Ongoing	Not reported
CATV announcements	10	6	12	Display period too long
Advertisements in newsletters, newspapers, billings	12	17	16	Goals met
New programs	1	1	1	Goals met
Brochures/poster distribution	No goals established	4,313	Ongoing	No goals established
Telephone service	500	32	Ongoing	No goals established
LOS ALTOS HILLS				
Storm drain stencils	Access activity	0	Implement alternatives	Aesthetics
Brochure mailing	8,000	8,000	800	Goal met
Brochure distribution	8,000	8,000	Ongoing	Goal met
Advertisement in newspaper	1	1	1	Goal met

Source: Santa Clara Valley Part II Municipal Permit Application

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TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY (Continued)

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
LOS GATOS				
Storm drain stencils	Not reported	Not reported	Not reported	Activity under consideration
News releases	6	Not reported	1+ article	Not reported
Brochure distribution	Not reported	90	0	Not reported
Brochure mailing	Not reported	Not reported	Not reported	Not reported
Brochure availability	Not reported	Not reported	Not reported	Not reported
MILPITAS				
Storm drain stencils	1,500	2,700	3,047	Goal met
Mailings	12,000	0	12,000	Scheduled for 11/92
CATV advertisement	3	3	3	Goal met
Brochure/poster distribution	No goal established	Ongoing	No goal established	Not applicable
Events/presentations	No goal established	0	3	Not applicable
MONTE SERENO				
Storm drain stencils	100%	0	100%	Volunteer program unsuccessful
Presentations	25%	0	25%	Not reported
Video presentation CATV	100%	0	100%	Program did not develop video
Article in newsletter	100%	100%	100%	Goal met
MOUNTAIN VIEW				
Storm drain stencils	1,555	1,127	600	Slowed to involve volunteer community group
Advertisements in newsletters, newspapers	7	5	6	Short reporting period
Brochure distribution	300	2,600	1,000	Goals met

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TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY (Continued)

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
PALO ALTO				
Storm drain stencils	100	750	2,000	Goal met
Brochures/poster distribution	4,400	4,600	6,240	Goals met
Billing inserts	27,000	54,000	54,000	Goals met
Community report	1	0	1	Report space restriction
Advertisements in newspaper, TV	3	2	5	Insufficient staff time to coordinate
Presentations/events	4	6	13	One event canceled due to budget cuts
SAN JOSE				
Storm drain stencils	19,345	15,537	3,808	Not reported
Phone/mail service	1,000	1,200	1,000	Goals met
Brochures/poster distribution	8,100	11,880	6,000	Goals met
Advertisements in radio, TV, newspaper, newsletters, transit	22	22	As needed	Goals met
Special events	14	14	As needed	Goal met
SANTA CLARA				
Storm drain stencils	100% industrial areas 100% other	70% industrial 20% other	30% industrial 80% other	No reported
Advertisements in TV, newspapers, newsletters	5	7	6	Goals met
Phone service	50	50	50% as needed	Goals met
Presentations/events	7	7	As available	Goals met
Brochures/poser distribution	No goal established	As needed	Ongoing	Not applicable

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TABLE 3-5. PI/P PROGRAM ELEMENT ACTIVITY SUMMARY (Continued)

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
SANTA CLARA COUNTY				
Storm drain stencils	Conducted pilot program	50%	100%	Goal met
Presentations/events	No goals established	5	As needed	Not applicable
Brochures/poster distribution	As needed	4,975+	Ongoing	Not applicable
Advertisements in newspapers, newsletters	As needed	4	As needed	Not applicable
HHW pilot program	Complete pilot program	8,800 door hangers	Expand program	Goal met
Mailings	No goals established	Not applicable	Develop industry mailing list	Not applicable
SCVWD				
Storm drain stencils	All at district headquarters	All inlets	No goal established	Goal met
Advertisement in newsletters	No goals established	3	4	Not applicable
Presentations/events	No goals established	187	As needed	Not applicable
Calendar distribution	No goals established	1,000	1,000	Not applicable
SARATOGA				
Storm drain stencils	25	240	240	Goal met
Brochures/poster distribution	28,000	30,000	Ongoing	Goals met
Presentation/display/events	No goals established	4	As needed	Not applicable
Advertisements in TV, newspapers	3	3	3	Goals met
SUNNYVALE				
Storm drain stencils	1,000	1,129	1,000	Goal met
Brochures/poster distribution	No goal established	5,865	1,700	Not applicable
Presentations/events	12	9	6	Events rescheduled
Mailings/billing inserts	38,400	38,400	38,400	Goals met
Newsletters, quarterly reports	No goals established	1 report	1 report/as needed	Not applicable

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TABLE 3-5. PUBLIC AGENCY CONTROL MEASURES ACTIVITY SUMMARY—PART A

Co-Permittee/Activity	Goals FY 91/92	Accomplished	Goals FY 92/93	Reasons Goals Not Met
CITY OF CAMPBELL				
Street sweeping	5 events/259 miles per month	5 events/261 miles per month	13 events/326 miles per month	Goals met
Catch basin cleaning	As needed	Not reported	284	Not applicable
Conveyance cleaning	As needed	Not reported	12.5 miles	Not applicable
CITY OF CUPERTINO				
Street sweeping	6 events/628 miles per month	6 events/628 miles per month	8 events/628 miles per month	Goals met
Catch basin cleaning	1,420	2,840	2,840	Goals met
Conveyance cleaning	As needed	30 incidents	As needed	Not applicable
CITY OF LOS ALTOS				
Street sweeping	5 events/291 miles per month	7 events/332.5 miles per month	7 events/332.5 miles per month	Goals met
Catch basin cleaning	900	900	900	Goals met
Conveyance cleaning	As needed	None	As needed	Not applicable
TOWN OF LOS ALTOS HILLS				
Street sweeping	As needed	Not reported	No goals established	Not applicable
Catch basin cleaning	250	250	250	Goals met
Conveyance cleaning	5 miles	5 miles	5 miles	Goals met
TOWN OF LOS GATOS				
Street sweeping	23 days/700 miles per month	23 days/700 miles per month	23 days/700 miles per month	Goals met
Catch basin cleaning	500	325	600	Limited staff
Conveyance cleaning	20	20	20	Goals met
CITY OF MILPITAS				
Street sweeping	20 events/390 miles per month	18 events/390 miles per month	16 events/390 miles per month	Goals met
Catch basin cleaning	3000	2172	3000	Limited staff
Conveyance cleaning	85 miles	1.25 miles	4.5 miles	Limited staff

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CHAPTER 4

CHAPTER 4

PROCEDURES FOR IMPLEMENTING A PROGRAM TO IDENTIFY AND REMOVE ILLICIT AND/OR INAPPROPRIATE DISCHARGES FROM STORM SEWER SYSTEMS

INTRODUCTION

The previous chapters presented information on municipal storm water management program regulatory requirements, guidance for municipal officials to rank storm water management activities for maximum cost effectiveness, and detailed procedures on how to implement specific administrative requirements. This chapter describes the procedures for identifying illicit discharges and implementing illicit discharge programs. Specifically, it discusses the components of an effective illicit discharge detection program, EPA's method for identifying illicit discharges, and examples of illicit discharge programs that have been or will be implemented in different municipalities.

Current interest in illicit or inappropriate connections to storm drainage systems is an outgrowth of investigations into the larger problem of determining the role of urban storm water runoff as a contributor to receiving water quality problems. Water discharge from storm water drainage systems often includes waters from many non-storm water sources. A 1987 study in Sacramento, California, found that almost half the water discharged from the storm water drainage system was not directly attributable to runoff. Illicit and/or inappropriate entries to the storm drainage system are likely sources of this discharge and can account for a significant amount of the pollutants discharged from storm drainage systems.

Common sources of non-storm water entries include sanitary wastewater, automobile maintenance and operation waste products, laundry washwater, household toxic substances, accident and spill waste streams, runoff from excess irrigation, and industrial sources of cooling waters, rinse water, and other process wastewater. Although these sources can enter the storm drainage system various ways, they generally result from either direct connections (e.g., wastewater piping either mistakenly or deliberately connected to the storm drains) or indirect connections (e.g., infiltration into the storm drain system or spills collected by drain inlets). Sources can be further divided into those discharging continuously and those discharging intermittently. Table 4-1, presented in *Investigation of Inappropriate Pollutant Entries Into Storm Drainage Systems*, gives a simple overview of typical pollutant sources and their most likely characteristics. The table lists the potential sources for inappropriate pollutant entries into the storm sewer system from residential, commercial, and industrial areas.

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TABLE 4-1. POTENTIAL INAPPROPRIATE ENTRIES INTO STORM DRAINAGE SYSTEMS

Potential Source	Storm Drain Entry		Flow Characteristics		Contamination Category		
	Direct	Indirect	Continuous	Intermittent	Pathogenic/ Toxic	Nuisance	Clear
Residential Areas							
Sanitary wastewater	X	x	X	x	X	x	
Septic tank effluent		X	X	x	X	x	
Household chemicals	x	X		X	X		
Laundry wastewater	X			X		X	
Excess landscaping watering		X		X	x	x	X
Leaking potable water pipes		X	X				X
Commercial Areas							
Gasoline filling station	X	x		X	X		
Vehicle maintenance/repair	X	x		X	X		
Laundry wastewater	X		X	x	x	X	
Construction site de-watering		X	X	x		X	
Sanitary wastewater	X	x	X		X		
Industrial Areas							
Leaking tanks and pipes	x	X	X	x	X		
Miscellaneous process waters	X	x	X	x	X	x	x

Note: X: most likely condition
x: may occur
blank: not very likely

REQUIRED COMPONENTS OF AN ILLICIT AND/OR INAPPROPRIATE DISCHARGE DETECTION AND REMOVAL PROGRAM

The regulations under 40 CFR 122.27 require that the Storm Water Management Plans include "a description of a program . . . to detect and remove . . . illicit discharge and improper disposal into the storm sewer." The regulations further require the following components be included in the program:

- Prohibition of illicit and/or inappropriate discharges
- Field screening of outfalls within the drainage area

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- Investigation of potential illicit and/or inappropriate discharges
- Spill response and prevention
- Public awareness and reporting program
- Control of infiltration of seepage from sanitary sewers to municipal separate storm sewer systems (MS4s).

Prohibition of Illicit and/or Inappropriate Discharges

Applicants must develop and implement an effective program to prohibit illicit and/or inappropriate discharges from entering MS4s. This is accomplished through the implementation of inspection procedures, local ordinances, and other legal authorities. In addition to adopting prohibition procedures, a schedule of the implementation process should be developed, and sufficient staff and resources should be allocated. The prohibition of illicit and/or inappropriate discharges should be linked to legal authority to ensure proper enforcement.

Field Screening

Applicants must propose procedures for a continued outfall field screening program. They can use the procedures from their Part 1 applications or use alternative methods. The field screening procedures in the Part 2 application should identify target areas to be examined for continued field screening and the reasons for selecting these areas. Also, any additional major outfalls recently identified should be included in the Part 2 field screening process. Of particular concern are areas of older development, areas with automobile-related industries, and areas with high concentrations of industrial facilities, among others.

This section should provide a detailed summary of the departmental responsibility for field activities, frequency of inspections, inspection procedures, inspection equipment, and documentation procedures for field activities.

Investigation of Potential Illicit and/or Inappropriate Discharges

Applicants should propose criteria to identify the parts of the MS4 that need investigation. Procedures for investigating likely locations for illicit and/or inappropriate connections include an MS4 inspection,

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use of remote control cameras, onsite facility inspections and dye-testing, and additional monitoring to pinpoint pollutant sources. To adequately address these procedures, a checklist should be developed to ensure a comprehensive evaluation of the problem. The checklist should emphasize the use of the easiest, least expensive, and most effective methods for detecting illicit and/or inappropriate discharges. EPA suggests that a map be developed to supplement the investigation by identifying the illicit and/or inappropriate discharge locations.

Spill Response and Prevention

The purpose of spill response programs is to reduce the risk of spills to the public. These programs usually require coordination among fire, police, health, and public works departments. The municipal departments responsible for implementing the program should be identified and should address topics such as employee training, reporting procedures, spill containment, storage and disposal activities, documentation, and followup procedures. For each of these elements, particular attention should be given to good housekeeping and materials management practices. Procedures can be implemented through modification of the land use planning process and ordinance enforcement or through coordination with existing spill prevention or spill containment programs.

Public Awareness and Reporting Program

Applicants should promote, publicize, and facilitate public reporting of illicit and/or inappropriate discharges or water quality impacts associated with discharges from MS4s. The public awareness program should stress that the public is the beneficiary of this program. Typical public awareness and reporting programs may include developing a hotline number, educating school students, using inserts in utility bills, and media announcements. Effectively implementing these programs should lead to a reduction in the residential discharges noted in Table 4-1.

Proper Management of Used Oil and Toxic Materials

This program component should facilitate the proper disposal of used oil and toxic materials from households, industrial, and commercial users by establishing municipal collection sites or identifying private collection sites. This program should also include any outreach plans for handlers of used oil, as well as the general public.

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Control of Infiltration of Seepage

This program component should describe procedures that would control infiltration of seepage from sanitary sewers to MS4s. Some controls to consider for limiting seepage include inspection programs, preventive maintenance surveys, and ongoing infiltration and inflow programs for locating seepage sites. Seepage from malfunctioning septic systems should also be controlled.

EPA'S SUGGESTED METHOD FOR DETECTING ILLICIT AND/OR INAPPROPRIATE CONNECTIONS

EPA's suggested method for detecting illicit and/or inappropriate discharge connections, developed by the Office of Research and Development, is described in *Investigation of Inappropriate Pollutant Entries into Storm Drainage Systems* (user's guide), which is available from the Center for Environmental Research Information, (513) 569-7562. This method focuses on data collection and quantitative analysis to implement a proper illicit and/or inappropriate discharge connection program.

The user's guide may be used as part of a comprehensive storm water management plan that addresses all sources of storm water pollution. Correcting only the most obvious pollutant entries is unlikely to significantly improve the quality of storm water discharges or receiving waters.

A municipality planning to investigate inappropriate entries to its storm drainage system needs to base this on local conditions. This user's guide describes the issues and provides examples to facilitate the design of a local investigation.

All the applicable procedures described in the user's guide may be used to successfully identify pollutant sources. For example, attempting to reduce costs by only examining a certain class of outfalls or using inappropriate testing procedures will significantly reduce the utility of the testing program and result in inaccurate data. Cursory data analyses are also likely to result in inaccurate conclusions.

The methodology (appropriately modified) can also be applied to other types of sewerage systems, such as combined and separate sanitary sewerage, to locate inappropriate entries (e.g., untreated or toxic industrial wastewater/wastes and infiltration/inflow) into sanitary systems.

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Figure 4-1 presents a simplified flow chart for the detailed methodology contained in the user's guide.

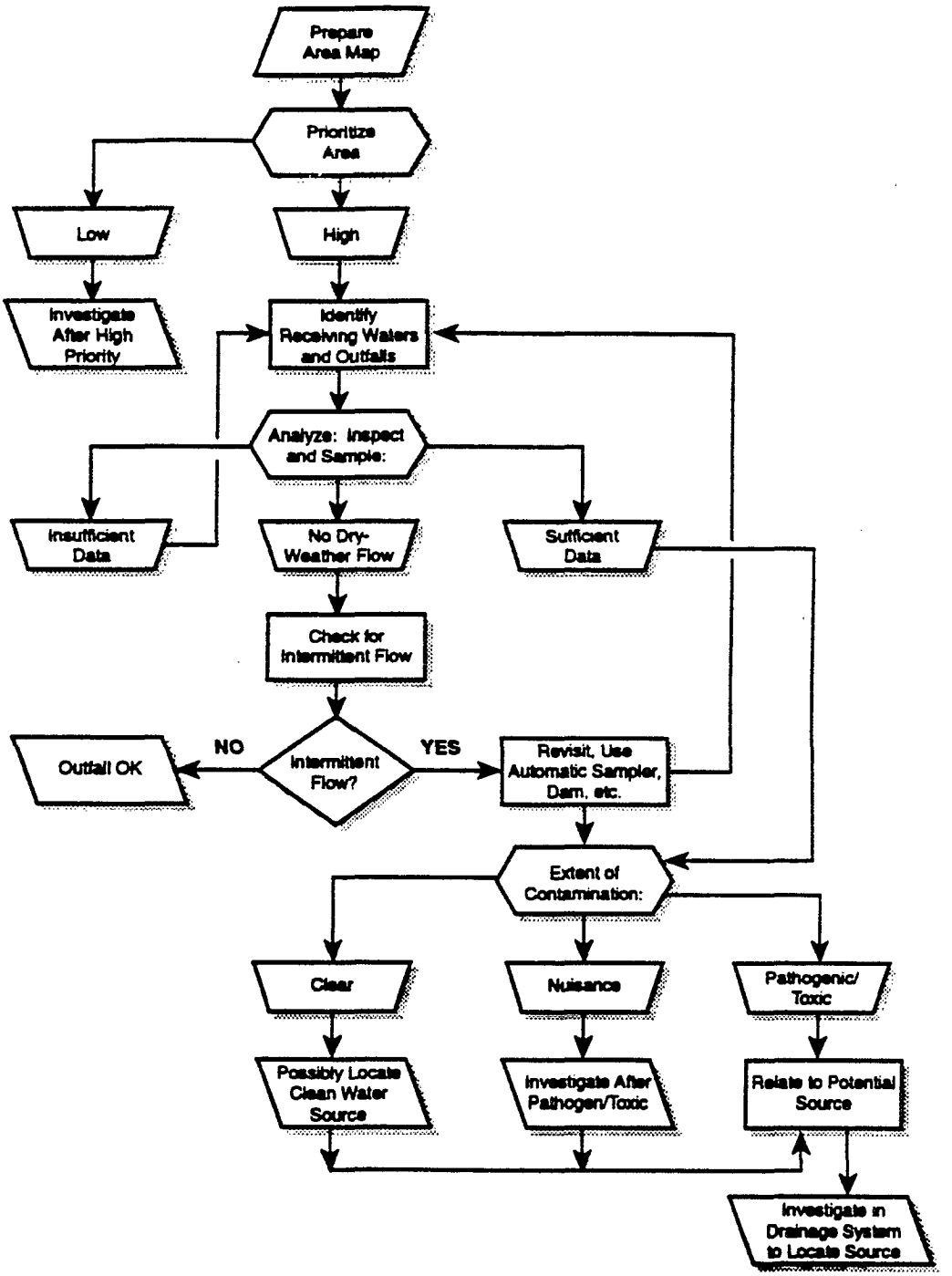

FIGURE 4-1. SIMPLIFIED FLOW CHART SHOWING THE DETAILED METHODOLOGY CONTAINED IN THE USER'S GUIDE

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The initial phase of the investigative protocol includes initial mapping and surveys. These activities require minimal effort and result in little chance of missing a seriously contaminated outfall. More detailed watershed surveys are then performed to locate and correct the sources of the contamination in the identified problem areas. After corrective action has been taken, repeated outfall field surveys are required to ensure that the outfalls remain uncontaminated. Receiving water monitoring should also be conducted to analyze water quality improvements. If expected improvements are not noted, then additional contaminant sources are likely present, and additional outfall and watershed surveys are needed.

The user's guide is designed to provide information and guidance to agencies planning or implementing an investigation of illicit and/or inappropriate entries to a storm water or wastewater drainage system. This is achieved by:

- Providing a methodology to identify and describe potential sources of non-storm water pollutant entries into the storm drainage system
- Describing an investigative procedure that will allow a user first to determine whether significant non-storm water entries are present in a storm drain and then to identify the potential type of industrial, residential, or commercial sources responsible, as an aid to determining the ultimate location of the source.

Procedure

The user's guide describes the following investigation steps:

- Drainage area mapping
- Tracer identification
- Field survey and data collection
- Analyses of data collected
- Categorization of outfalls
- Investigation and remediation
- Pollution prevention program.

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Mapping

The mapping exercise is carried out as both a desktop operation by using existing information and with field visits to collect further data and to confirm existing information. The maps should provide complete descriptions of the drainage areas, including outfall locations, watershed boundaries for each outfall, critical land use areas (mostly commercial and industrial areas), permitted discharges to the storm drainage system, city limits, major streets, and streams. The user's guide discusses critical land use areas and lists major industries and their potential to be non-storm water entry sources.

The drainage areas are ranked in the order of their potential to cause problems. This allows priorities to be set for field investigation of the outfalls. Note that all outfalls will eventually require investigations, and the mapping stage is important because the entire investigation is based on it.

Geographical information systems (GIS) are computer-based tools that can be used to store, display, and analyze geographical information; GIS can be used by municipalities when mapping their storm sewer systems for the purpose of documenting illicit and/or inappropriate connections. The GIS system also serves as a data base to store information about the illicit and/or inappropriate connections, such as field screening and enforcement activities. If GIS is not being used or is not available to a municipality, then zoning maps, marked with important features (e.g., identification of potential discharge points) can also be used to target potential discharges for identification and further action, as necessary.

Tracer Identification

To detect and identify non-storm water entries, dry-weather outfall discharges are analyzed for selected tracers (e.g., ammonia, surfactant), which are found in the potential contaminating sources. Ideally, the selected tracers should be unique for each potential non-storm water contaminating source and should exhibit the following properties:

- Significant difference in concentrations between possible pollutant sources
- Small variations in concentrations within each likely pollutant source category
- A conservative behavior (i.e., no significant concentration change due to physical, chemical, or biological processes)
- Ease of measurement with adequate detection limits, good sensitivity, and repeatability.

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The user's guide suggests tracers for common pollutant sources (e.g., sanitary wastewater, septic tank effluent, laundry wastewater, and vehicle washwater, as well as potable water and "natural waters"). A non-storm water entry investigation may need to select additional tracers specific to potential pollutant sources, especially industries, in the study area (e.g., major ions, specific heavy metals). For each selected tracer, the concentration means and standard deviations in all the potential source flows in the drainage area are needed (use of data from other drainage area investigations is not recommended).

Local data collected on tracers will be essential to identify the contamination sources in the outfall discharge. It is important that the tracer data be accurate. Guidance is provided in the user's guide on representative sampling and on the number of samples required for valid data.

Field Survey and Data Collection

Field investigations are used to locate and record all outfalls, including outfalls not previously identified from the mapping exercise. During field investigations, outfalls are physically inspected and samples are taken of any dry-weather flow for analyses. The field survey should, at a minimum, include:

- Accurately locating outfalls and assigning ID numbers
- Photographing outfalls
- Estimating outfall discharge flow rate (or identifying likely intermittent discharge)
- Physically inspecting and recording outfall characteristics, including discharge odor, color, turbidity, floatable matter (e.g., solids, oil sheen), temperature, deposits, stains, vegetation affected by pollutants, and damage to outfall structure
- Collecting dry-weather discharge samples for tracer analyses of specific conductivity (can be field measured with temperature), fluorides, hardness, ammonia, potassium, surfactants, fluorescence, and pH, as well as other samples, depending on industrial activities.

Intermittent flows will be more difficult to confirm and sample. Additional field visits, use of automatic samplers, and flow damming techniques may prove successful for obtaining samples of intermittent flows.

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Clean water discharged through storm water outfalls can originate from natural springs feeding urban creeks that have been converted to storm drains, infiltrating ground water, infiltrating domestic water from watering leaks, etc.

Outfalls can be classified by comparing the collected dry-weather outfall discharge data with potential sources flow data. At the very least, outfalls with major pollutant sources should be identified for immediate remediation.

Investigation and Remediation

Drainage area investigations to locate the source(s) of non-storm water entries can take a number of forms:

- In-depth watershed evaluation (e.g., evaluate whether sources are likely to be an individual industry or an areawide problem, such as general failure of sanitary wastewater sewers)
- Drainage system upstream surveys (e.g., tracer analyses, visual inspections, smoke and dye tests, and TV surveys to trace the individual sources of the pollutant)
- Industrial and commercial site studies (e.g., identify materials/chemicals used and/or produced and whether the sites discharge to a storm drainage system).

Pollution Prevention Program

The goal of eliminating all non-storm water entries will probably not be achieved completely; however, any action that prevents future entries should be promoted. Typical actions include educating the public (industrial, commercial, residential, and governmental) and developing zoning and ordinances.

Discussion

In addition to these steps, the user's guide provides background information in the form of discussions, tables, and checklists to assist the user in identifying contaminated outfall discharges and potential sources and in using the tracer data to estimate the proportion of each contaminating source flow in the outfall flow.

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SUMMARY

This chapter discussed the components of an effective illicit and/or inappropriate discharge detection program. The presence of illicit and/or inappropriate connections within a storm sewer system can adversely affect water quality. By implementing an effective illicit and/or inappropriate discharge detection program, a municipality can identify the source(s) of illicit and/or inappropriate discharges and take the action necessary to eliminate the discharges. Before the development of an adequate illicit and/or inappropriate discharge detection program, however, municipalities must identify the available fiscal resources, assess the public's knowledge of water quality issues, and develop an SWMP that will successfully complement the illicit and/or inappropriate discharge program. This chapter presented the components of an effective program, EPA's method of detecting illicit and/or inappropriate discharges, and detailed examples of programs from various municipalities. The components of an effective program include a mechanism for prohibiting illicit and/or inappropriate discharges, field screening, investigation of potential illicit and/or inappropriate discharges, spill response and prevention procedures, public awareness and reporting program, used oil/toxic materials management and disposal procedures, and methods to control infiltration from sanitary sewers to storm sewers. Within these components, the use of GIS for mapping illicit and/or inappropriate connections and for maintaining a data base of information on illicit and/or inappropriate discharges throughout the municipality is essential. EPA's method for detecting illicit and/or inappropriate connections is discussed within the user's guide. This method relies on the quantitative analysis of dry weather flows to identify the pollutants within illicit and/or inappropriate discharges. This information is then used to locate the potential source(s) of the discharges.

CASE STUDIES

The following case studies provide information on the various ways illicit and/or inappropriate discharge programs can be developed and implemented. These municipalities have incorporated the components of an effective program in ways that are most effective to their specific needs.

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In 1985, the Fort Worth Public Health Department (Health Department) developed and implemented a unique program for detecting illicit and/or inappropriate discharge connections to its MS4s. The program, known as the Drainage Water Pollution Control Program, focuses on empowering people to take action against illicit and/or inappropriate dischargers and places less emphasis on excessive data collection. As a result, Fort Worth's program is cost efficient and ensures corrective compliance. The four components of Fort Worth's program are:

- Problem detection
- Source investigation
- Correction of problems
- Prevention of problems.

Problem Detection

The Health Department identified three means of detecting surface water contamination: (1) a drainage water quality assessment and monitoring program, (2) a biotoxicity testing method, and (3) a program for determining the concentrations of six metals in drainage sediments.

Assessment and Monitoring

The drainage water quality assessment and monitoring program examines the types of discharges entering a receiving water body (Trinity River). To properly assess the affect these discharges have on the water body, the Health Department thinks it is essential to monitor the discharges over an extended period of time. The monitoring technique used, however, is not one of quantitative analysis but relies mostly on visual observation of the outfalls or drainage ways. From its observations, the Health Department concluded that the presence or absence of persistent features (e.g., vegetation, animal life) at an outfall are directly related to water quality. Even though persistent features are a direct indication of water quality, one has to know which features are associated with good water quality and vice versa. One indication of a healthy waterway is the presence of a variety of plant and animal life; unhealthy waterways have little or no plant and animal life.

The assessment and monitoring phase of this program is based on detecting subtle changes in the waterways from frequent observations and by the use of modified versions of conventional chemical tests. The Health Department's methodology does not readily utilize consulting firms or laboratories to determine if a problem exists; however, if exact determinations are required, then the services of the aforementioned are solicited.

The Health Department chose 24 drainage outfalls and one control site for monthly water quality monitoring to assess the presence or absence of the undesirable features in the outfalls. Undesirable features include filamentous sewage bacteria, mosquito larvae, fish kills, water color, water odor, water clarity, water pH, oil sheen, floatable solids, and positive water tests to Nessler reagent. The information gathered from the monthly monitoring is recorded on data sheets. The data are compiled from all of the sites and displayed on a table with a 45-month profile. The occurrence and persistence of undesirable features indicate the impact that outfall drainage has on the Trinity River and the effectiveness of correction and prevention measures within the program.

Biotoxicity Testing

The 24 drainage outfalls are then subjected to biotoxicity testing. The purpose of the testing is to determine the presence of toxins in the waterway, the hazard level created by the toxins, and the source of the toxins. The object of the test is not to define the properties of toxic substances. Instead of a laboratory biotoxicity test, the Health Department conducts in-situ toxicity tests. Native aquatic species are used to assess the environmental affects of the toxins on the waterway habitat. The use of native species is key because they are accustomed to the environmental characteristics of the ecological region. To test these species, the Health Department used homemade

minnow buckets, which are floating, ventilated, transparent combiners used to hold test organisms. The test is also used to examine surface water contamination.

Metal Testing

In addition to biotoxicity, the 24 sampling sites are analyzed for 6 metals. Water and sediment samples are collected for the following metals: cadmium, chromium, copper, lead, nickel, and zinc. To establish a basis for comparison, three nonpolluted background sampling sites were chosen to reflect the natural occurrence of these six metals within the waterway. The samples are analyzed according to the protocol within Standard Methods for the Examination of Water and Wastewater.

Source Investigation

After the detection of a drainage source of pollution, an investigation follows to determine whether the source of the problem is known or unknown. If the source is known, then the responsible party is connected, and action is taken to stop the discharge as soon as possible. The notification is done by a pollution control officer or other designated official. Unknown sources are traced back from the detection point to the source. The Health Department has a specially trained Storm Tunnel Investigation Team to trace illicit and/or inappropriate discharges through the sewer system to the source. The Health Department uses the following tools for source investigation: Storm Tunnel Investigation Team; a safety equipment Step Van; biotoxicity testing devices; fluorescent dyes and smoke generators for obscure tunnels and leaks; water evaluation equipment; Federal, State, and local regulations; and drainage maps.

All investigative activities are documented with photographs, reports, and samples. Required sampling is done according to Standard Methods and is handled through the chain of custody procedures specified by the legal authority. Other important information recorded during the investigation include time and date of the violation and investigation, location of the violation, location of the responsible party, name and telephone number of the responsible party and witnesses, description and results of any tests conducted during the investigation, and the name(s) of the investigator(s). All of this information is recorded on a Discharge Report Form.

Correction of Problems

The Health Department's approach is to correct the problem at the source, instead of the typical "end-of-the-pipe" treatment. Correcting problems at the source is essential because the drainage way below the outfall improves and the responsibility is placed on the pollution generator and not the municipality. Fort Worth notifies the responsible party, explains the violation(s) and the need to make corrections, issues time-dated notices on when to make corrections, and checks the violator's progress. If the pollution generator refuses to make corrections, then legal enforcement agencies (e.g., EPA) are notified.

Prevention of Problems

In addition, the Health Department uses a strategy of "concentric containment." Concentric confinement includes the recognition, containment, and resolution of existing illicit and/or inappropriate connections to prevent their spread to other areas of the city. To achieve this, the Health Department conducts weekly "roving patrols" of various city sectors and critiques the development plans of new industries and businesses. Public education programs (e.g., videotapes, workshops) are also available to community groups, schools, and other regulatory organizations.

To receive more information about Fort Worth's program, contact Gene Rattan at (817) 871-5463.

R0014151

In Charlotte, North Carolina, controlling illicit and/or inappropriate discharges is an important issue. In conjunction with Mecklenburg County, Charlotte is in the process of developing an extensive program for detecting and removing sources of illicit and/or inappropriate discharges. A discussion of the components of Charlotte's illicit and/or inappropriate connections program follows.

Ordinances

Presently, Charlotte does not have an ordinance prohibiting illicit and/or inappropriate discharges into storm sewers or surface waters. However, the city is proposing an ordinance that will prohibit plumbed-in connection, intermittent discharges, and the dumping of trash and wastes (hazardous and nonhazardous) into surface waters. Other aspects of the ordinance will define non-storm water discharges and address the enforcement process, penalties for violation, and due process for appeals of violations. The development effort will be coordinated with Mecklenburg County's ordinance and will occur during the first year of the permit. The cost is estimated to be about $11,300.

Field Screen

Charlotte's proposed field screening program will result in a one-time visual field screen of every outfall in the city. The program will specifically address improving the efficiency of field screening methodology; a one-time visual screen of all outfalls; field screening of problem area outfalls; continuation, support, and expansion of Mecklenburg County's Stream Walk program; and maintenance of a GIS storm water data base.

Field Screening Methodology

To improve the efficiency of the field screening methodology, Charlotte takes a two-phased approach. Phase one will utilize the observation protocol used in the Part 1 application process. Observations will be made for the presence of dry weather flow, color, turbidity, and oil sheen. Phase two will identify sources of the illicit and/or inappropriate discharges and ensure compliance with the illicit and/or inappropriate discharge ordinance. The cost of this program is $10,000.

One-Time Visual Field Screen

Charlotte is in the process of developing a storm water utility, which includes a preventive maintenance program for the storm sewer system infrastructure. The storm drainage system is currently being inventoried. As part of this inventory, the city has initiated a 2-year, one-time visual field screen for dry weather flow of all outfalls. The cost of the program is $8,000 per year.

Problem Area Outfalls

As part of field screening the problem areas, Charlotte and Mecklenburg County investigated known water quality problems throughout the municipality. The city was broken down into polygons, which represented neighborhoods, land uses, and stream segments. These polygons were then prioritized on the types and magnitudes of the problems. To address the problems identified in the investigation, the city will be divided into zones and each zone will be assigned a zone team. This will be implemented in the second year of the permit and costs $130,000.

Mecklenburg County Stream Walk Program

The Mecklenburg County Department of Environmental Protection (MCDEP) sponsors a Stream Walk program. The participants in the program are volunteers from the county, Charlotte, and other surrounding counties. The volunteers are split into teams and assigned a resource person from the MCDEP staff. They walk streams that are affected by point and nonpoint source pollution and are responsible for investigating and determining the pollutant

source(s). The weaknesses of the program, to be addressed by Charlotte and MCDEP, are available personnel, volunteer motivation, volunteer training, and public education. The program will cost approximately $36,000.

GIS Data Base Maintenance Program

A GIS data base will be used to track all field screening activities. The results of initial and followup field screening will be entered into the data base and used to identify the problem areas. The program is currently in use and the estimated cost is high.

Followup Investigation

The program tries to identify and remove all sources of illicit and/or inappropriate discharges by enhancing MCDEP's current program. The only two possible improvements to the program are to add more staff and to computerize it. Charlotte will be:

- Developing followup program procedures
- Developing and implementing a training program
- Implementing the followup procedures
- Maintaining a GIS data base.

Followup Procedures Development

The followup procedures will respond to the problems identified by the visual field screenings, MCDEP's Stream Walk, MCDEP's monitoring programs, problem area investigations, and citizen complaints. The areas to be addressed will be prioritized based on the urgency and magnitude of the problem. Teams will be assigned to the problem areas and are responsible for the determination and elimination of pollutant sources. To accomplish this task, the teams have to review existing data on the area, perform field reconnaissance, locate and identify problem sources, perform source identification methods (e.g., video, smoke, and dye testing), distribute violation notices, perform other enforcement actions, and notify higher authorities when appropriate. The program will be implemented during the first year and will cost $22,200.

Training Program

The training program for the followup investigations team will be developed with the training programs for industrial and related facilities. Charlotte will also coordinate the development of this training with supervisors of MCDEP's Stream Walk and Charlotte Mecklenburg Utility Department (CMUD). The training will address the reconnaissance followup methods (e.g., observation techniques, chemical screening), detailed followup methods (e.g., closed circuit television, dye and smoke testing), and enforcement methods. Training should begin in the middle of the first year and is estimated to cost $23,100 over the 5-year period.

Followup Procedures Implementation

During field investigations, the followup teams will identify sources of illicit and/or inappropriate connections using the prioritization system and the followup procedures. This will begin in the second half of the first year and will cost $50,000 annually.

GIS Data Base Maintenance

All of the information, including information on violations, received during the followup investigations will be entered into a GIS data base. This data base will be used to track repeat offenders and to produce annual reports to be presented to the State. The data base will cost approximately $14,000 per year.

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Spill Response Program

The objective of the spill response program is to prevent and respond to spills. The existing program is well developed; therefore, Charlotte will only enhance the public education and awareness aspect of the program. In Charlotte, the Fire Department is responsible for the spill response program and maintains a Hazardous Materials (HAZMAT) team. The city will review the types of spills and their causes in order to minimize the risk to storm systems and surface waters. The public education and awareness component will educate people on the illicit and/or inappropriate connections ordinance and encourage public reporting of spills. This program, which has an estimated cost of $30,000, will begin immediately.

Public Reporting Program

The objective of this program is to increase and improve public reporting of spills and improper disposal. The program will focus on public education and information to inform the public of the importance of reporting spills and illicit and/or inappropriate discharges. This program will be coordinated with other public education programs and will include information on:

- Charlotte's overall storm water management program
- The importance of the illicit and/or inappropriate connections component
- Charlotte's illicit and/or inappropriate connections ordinance
- Proper disposal and recycling programs
- The purpose of stenciling catch basins.

In addition, the program will:

- Publicize Charlotte's storm water hotline
- Encourage the public to readily report signs of illicit and/or inappropriate discharges
- Urge the public to participate in MCDEP's Stream Walk.

Information will be disseminated through public speaking, distribution of written materials at civic functions, participation of neighborhood groups and associations, and local media announcements. This program will begin immediately with an estimated cost of more than $70,000.

Used Oil/Household Hazardous Waste Program

The objective of this program is to properly dispose of and manage used oil and household hazardous waste. Charlotte will address this problem with public education and changes to existing programs. The program will include used oil recycling, permanent household hazardous waste program, and a review of the current small quantity generators.

Used Oil Recycling Program

The used oil program is currently based on extensive public education. The components to revise/expand this program include:

- Review of the public and private facilities that accept used oil and a determination of additional facility locations

- Review of the existing Mecklenburg County program to determine the feasibility of expanding the program to include recycling other automotive parts

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- Review of the possibility of providing curb-side pick-up of nonhazardous materials

- Inventory of used oil recycling facilities and implementation of a regular inspection program to prevent storm water pollution.

Household Hazardous Waste Program

The used oil public education program will provide information to the public and private sectors and will be coordinated with the household hazardous waste program. It will include education on:

- Illicit and/or inappropriate connections ordinance
- Negative impacts of dumping used oil into storm sewers
- Stenciling of catch basins
- Misconception that dumping in sanitary sewer is an alternative to the storm sewer
- Education of operators of recycling facilities the proper handling procedures of materials
- Economic incentives for private companies to encourage participation in used oil program.

The development of this program will begin immediately but will not be implemented until the third year. The estimated cost is $30,000 per year.

Charlotte, in conjunction with Mecklenburg County, will develop a permanent household hazardous waste turn-in program. The proposed methods of disposing of the wastes will include:

- Modular Structures (Bare Bones): This is a continuous service program in which the public would bring their household hazardous wastes to a permanent site for temporary storage to be removed later by a licensed contractor. There is a minimum allocation for storage space.

- Modular Structures: This is the same program as above but it allows for more storage space.

- Fixed Structure: A continuous service program that will operate similarly to the modular structure except that it would be in a fixed place and allow for maximum storage.

- Independent Fixed Structure: This is the same as the fixed structure but would be located at a site different than the fixed location.

- Mobile Unit: This is a continuous service program in which the public would bring their household hazardous waste to a mobile unit that would move from one place to another.

Mecklenburg County currently has an educational plan which utilizes videos and brochures. This plan will be expanded by the use of utility bill inserts and media announcements. The planning of the household hazardous waste program is in progress and will be implemented in the second year. The costs for the city and county are estimated to be high.

Review of Small Quantity Generators

The purpose of the small quantity generators review is to determine what is required of the participants and how they impact storm water runoff. The data base of small quantity generators will be reviewed with HAZMAT and MCDEP to decide if any spill-related problems or contaminated site runoff have occurred in the past. As a result of this review, these facilities may included in Charlotte's inspection program for industrial facilities. The review program will begin immediately with an estimated cost of $15,000.

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Infiltration and Seepage Program

Sanitary Sewer Program

The object of this program is to reduce and eliminate sanitary sewer seepage into the storm sewer system. This program should also increase city/county coordination in dealing with problems related to infiltration and seepage from sanitary sewers and septic systems to storm sewers and surface waters. Charlotte currently has city codes in place that require new and replacement sanitary and onsite waste disposal systems to be built to lessen or eliminate leakage and infiltration of floodwaters into the system and discharge from the system into floodwaters. There is also a code that allows the city to fix inoperative sanitary sewer lines on private property and requires payment from the property owner.

MCDEP responds to sanitary flow issues on a complaint basis. CMUD has a cross connection program for the sanitary sewer that requires periodic inspection for leakage and overflows. The Mecklenburg County Health Department issues septic tank permits for the inspection of new and failed septic systems within Charlotte. The Health Department also requires remediation of failed septic systems, which are usually reported by citizen complaint, an MCDEP stream walker, or government inspector.

CMUD is currently developing a dynamic sanitary system model, along with a monitoring program for sanitary system flows and rainfall. Charlotte's role in the development of this program includes:

- Coordinating the preparation of ordinances to enforce the programs
- Ascertaining whether storm water detention facilities should continue to be built over sanitary sewer lines
- Ensuring that illicit and/or inappropriate disconnections from the storm sewer will not increase connections to sanitary sewer
- Implementing a source control program that will limit the dumping of materials into the sanitary sewer that are not treatable
- Developing public education and awareness programs.

The review and coordination of the infiltration and cross connection program with CMUD will begin immediately with an estimated cost of $15,000.

Septic Tank Program

Charlotte, in conjunction with the Mecklenburg County Health Department, will review and revise the current septic tank program. The weaknesses they will address include:

- Notification/inspection procedure
- Lack of contractor supervision
- Abandoned septic tanks not required to be sealed
- Allowable construction of septic tanks in sensitive areas.

The septic tank program will also include a public education component and a data base of septic tank failures. The review and revisions will begin immediately with an estimated cost of $15,000.

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The city of Seattle realizes the negative impacts of illicit and/or inappropriate discharges and currently operates a program that detects and eliminates such discharges. Public education and awareness is an important component of this program, but emphasis is also placed on enforcement.

Ordinances

Seattle's key ordinance to prevent illicit and/or inappropriate discharges is the Storm Water, Grading and Drainage Code. Other ordinances, with pollution prevention components, include the Side Sewer Ordinance, the Street Use Ordinance, and the Solid Waste Ordinance. The Storm Water, Grading and Drainage Code prohibits certain discharges into the storm drainage system, requires existing dischargers and land users to implement pollution prevention practices to minimize the pollutants entering storm water discharges, requires the city to review plans for drainage control and grading activity, regulates sediment and erosion controls for construction sites, designates responsibility for maintenance of drainage control facilities and erosion practices, and establishes enforcement procedures. The Storm Water, Grading and Drainage Control Code is enforced by the Department of Construction and Land Use (DCLU), the Department of Engineering - Street Use Section, and the Department of Engineering - Drainage and Wastewater Utility (DWU).

Metro's Key Manhole Monitoring Program

The Municipality of Metropolitan Seattle (Metro) uses a manhole monitoring program to ascertain whether or not illicit and/or inappropriate connections are present and, if so, to identify the sources. After the sources are identified, companies are brought into compliance with Metro's discharge limits and pretreatment standards. This program also requires inspections of facilities that violate the permit requirements.

Field Screening

Seattle DWU's field screening program consists of responding to citizen complaints, responding to city employees or other agency calls, and implementing source control programs and long-term monitoring of surface waters. Seattle will rely on its ordinances, the erosion control program, citizen response, and field personnel to control future illicit and/or inappropriate connections problems.

Followup Investigation Program

The objectives of Seattle's Source Control Program are to eliminate cross connections, reduce spill-related risks, promote better waste disposal, promote good housekeeping practices, provide educational materials on water quality, and require routine maintenance of storm water control facilities where new storm drains will be constructed to reduce combined sewer overflows. This program is implemented on a watershed basis and responds to the unique characteristics of that watershed. The Source Control Program is first implemented in watersheds identified by the Department of Ecology as having surface waters of concern. These are areas of concern because they are used for recreation or as a fisheries resource. The Source Control Program contains the following steps:

- Data Gathering: All the water and sediment quality data from the storm drainage system and all the basin information (e.g., size, topography, industry type) are compiled. Drainage maps and side sewer cards identify outfalls and sewer lines.

- Initial Investigation: Drainage basins are field checked. The side sewer cards are examined, industrial sites are inspected, historical information from the owner is obtained, dye testing is performed to prove connections, and a television inspection is done when necessary. Seattle's storm drain lines and catch basin maintenance schedule is evaluated and when necessary revised to improve water quality.

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- Business Inspection and Education Program: Businesses with a high potential to pollute storm water discharges are visited by Source Control Water Quality Investigators. During the visit, the operator will receive a copy of the written inspection procedures. If necessary, followup visits are conducted to guarantee compliance. The operators are encouraged to implement new BMPs or improve old ones to ensure compliance. The facilities are also given information on current programs, including enforcement information. Repeat offenders are referred to the appropriate agency for enforcement action.

- Education and Outreach: Educational materials describing the negative impacts illicit and/or inappropriate discharges have on the storm sewers and surface waters are distributed within watersheds to the public and to industrial facilities. An incentive program is provided for businesses to encourage participation.

The Source Control Program approach by watershed allows for onsite visits and for pipes to be checked for illicit and/or inappropriate connections and has been very effective. Seattle also works with Metro's Industrial Waste Staff because of their authority to enforce pretreatment limits on discharges from industries.

Spill Prevention Program

As required by the Source Control Program, site inspections are performed at industries identified as significant polluters. The inspectors ensure that each facility has a spill prevention plan, including the materials to respond to a spill. The Seattle Municipal Code requires all industrial facilities to develop and implement spill prevention plans.

Seattle Fire Department - Hazardous Materials Unit

Within Seattle, the Fire Department is the main responder to spills within the city, as well as those to surface waters. The Fire Department enforces sections of the Uniform Building Code that address buildings used for storing, handling, or using hazardous wastes. Each industry that uses or stores certain amounts of hazardous wastes is required to obtain a permit from the Fire Department. Facilities are inspected when they apply for the permit and are inspected each year after permit issuance.

Seattle Police Department - Harbor Patrol Unit

The Seattle Harbor Patrol is responsible for the enforcement of oil spill regulations within the Seattle Harbor Code. The patrol investigates complaints received from a 24-hour hotline and reports from the Department of Ecology and the U.S. Coast Guard. If a pollution problem exists, the source is traced and enforcement actions taken.

Trouble Call Network

Metro runs a Trouble Call Network for public use for handling potential water quality problems, including spills. Seattle works with Metro on this project.

Public Reporting Program

DWU published literature with telephone numbers for citizen use when reporting water quality problems or for requesting information on disposal of hazardous materials.

DWU recognizes the importance of public education in relation to protecting water quality and has taken an approach that combines the following three components: public involvement, in-school education, and general public outreach.

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Public Involvement

Citizen involvement was important in developing Seattle's storm water program, and DWU involves citizens at various levels of the decisionmaking process. The public involvement programs include the following:

- Comprehensive Drainage Plan Citizens Advisory Committee: Citizens were key in developing the DWU. The DWU is charged with developing a Comprehensive Drainage Plan to determine which areas would benefit the most from the new fees. A Citizens Advisory Committee (CAC) was created to represent the community interests. The Comprehensive Drainage Plan is the foundation of Seattle's water quality projects and will be updated in 5 years with public involvement.

- Drainage and Wastewater Utility Citizens Advisory Committee: The CAC is now the advisory committee for the ongoing activity of the DWU. The Drainage and Wastewater Utility Citizens Advisory Committee (DWUCAC) has expanded its membership to include minority communities and industrial interests that are concerned about water quality and utility services.

- Capital Project Development: When plans for new capital facilities are developed, DWU involves the public. The public interest usually focuses on the impacts of construction but may expand to include water quality and environmental improvement.

- Watershed Planning: The Puget Sound Water Quality Authority and the Department of Ecology administer a program that addresses planning for the control of nonpoint source pollution within watersheds. The watershed plans are developed by a Watershed Management Committee (WMC), which comprises members from community and business organizations and government agencies that are interested in the watershed.

Schools Education Program

These educational programs emphasize respect for water resources and encourage responsible behavior. DWU's schools program builds on existing environmental education and has reached 80 Seattle schools. The following list describes several of these programs:

- Salmon in the Classroom: DWU has provided the training and equipment for teachers in schools to raise salmon from egg to fry and then release the fry into local receiving waters. The salmon are raised in aquariums that simulate spawning stream conditions. DWU trains the teachers participating in the project and provides a manual for additional training and lesson planning. DWU also sponsors two field trips: one to obtain the eggs and the other to release the fry.

- Water Quality Field Trip: DWU sponsors a field trip every year for fourth or fifth grade students to the Seattle Aquarium to learn about aquatic species, their habitat, and the impacts of human activity on their habitat. DWU also sponsors a fishing field trip to a trout farm. Students receive a tour and learn about the impacts of nonpoint source pollution.

- Middle School Water Quality Education Video Program: "Water You Doing?" is a 35-minute educational video produced by DWU with a grant from the Department of Ecology. The video's audience is middle school students and includes a teacher's manual and field trip guide. Five video segments address five different water quality issues. The manual describes lesson planning, is a resource guide, and contains a field trip directory. DWU has given workshops on how to use the video and has distributed it to every public middle school in Seattle.

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- Speakers Bureau: DWU employees who work on water quality issues, community volunteers, and others are part of DWU's speakers bureau. The speakers give classroom presentations on water quality education activities sponsored by the DWU.

- Puget Sound on Wheels: DWU is sponsoring the development of a mobile educational display by the Seattle Aquarium. The display will include a truck outfitted with a walk-through exhibit describing the Puget Sound water resource, habitat, and pollution issues. The exhibit will be shown at schools and community fairs.

- Education Coordination: Other educational efforts sponsored by DWU include a teachers advisory committee that evaluates the water quality classroom and field trip activities to help DWU enhance its programs; DWU participation on Seattle's Environmental Education Committee and promotion of its programs, as well as work with other organizations; and membership in the Washington Environmental Education Committee sponsored by the State Superintendent for Public Instruction.

General Public Education Program

Many residents have an out-of-sight, out-of-mind attitude about their behaviors concerning water quality. General public education should change the negative everyday activities people perform on a regular basis. The following DWU programs encourage appropriate behavior and community initiative to protect water quality:

- Source Control Education: With a grant from the Department of Ecology, DWU has implemented a program to control nonpoint source pollution at the source. DWU accomplishes this through a three-pronged approach: Consumer Education, Clean Water Business Partners, and Targeted Education Campaigns.

- Watershed Education: DWU currently sponsors two watershed action plans in Seattle. The WMC responsible for developing the plans concluded that the people living and working within the watersheds must be educated on water quality in order to prevent further degradation of the watersheds.

- Storm Drain Stenciling: DWU uses volunteer school and community groups to paint a message on Seattle's storm drain inlets. With this program, DWU hopes to rid Seattle of the out-of-sight, out-of-mind attitude.

- Motor Oil Recycling: DWU and the Seattle Solid Waste Utility coordinate a used oil recycling program. Waste oil collection tanks are located at the 12 locations of an auto supply store in Seattle. The supply store, along with the utilities, publicizes the program.

- Waterfront Awareness Company: DWU and an association of waterfront businesses have initiated a cleanup campaign for the waterfront. DWU has also added a pollution prevention message to the effort and has recruited children to paint pollution prevention messages on trash cans.

- Seattle Aquarium Intertidal Exhibit: DWU has contributed to a new aquarium exhibit displaying an intertidal ecosystem and explaining the potential negative impacts of human activity on the ecosystem.

- Bill Inserts and Citywide Direct Mailings: DWU includes education and public awareness materials in its bimonthly billings. Customers are also mailed brochures about water quality protection and storm water management.

- Outreach to Non-English Speaking Communities: DWU is developing water quality messages in different languages for publication in community newspapers.

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- Television Public Service Announcements: DWU has developed four public service announcements for broadcast on local television. The announcements address the importance of watersheds, the difference between sanitary and storm sewers, nonpoint source pollution, and pet waste.

- Seattle Public Libraries: DWU is currently working to distribute copies of the educational videos to all branches of the public library. The video has also been made available for broadcast on the public access cable station. DWU will develop educational displays for all of the libraries.

Local Hazardous Waste Management Plan for Seattle-King County

Seattle is part of the local hazardous waste management plan and is currently developing and implementing programs for small businesses. The components of the program are to provide free onsite consultations to small businesses; organize seminars, workshops, and classes for business persons; create brochures, booklets, and other materials; create a resource library on hazardous waste issues; provide response to complaint calls and agency referrals; conduct onsite surveys of business practices; and research new treatment methods. Participating agencies include the Seattle-King County Health Department, King County, Seattle, Metro, and 29 suburban cities.

Solid Waste Utility Household Hazardous Waste Program

The Seattle Solid Waste Utility operates one permanent household hazardous waste collection site and sponsors a used motor oil collection system. The household hazardous waste component also provides educational materials to the public on alternative products, collection services, and the proper use and disposal of products.

Metro's Small Quantity Generator Program

This program provides small businesses with information and assistance on the proper use and disposal of hazardous wastes and on ways to minimize the pollutants entering storm drains and surface waters. The Waste Information Network was developed through this program and consists of private businesses, public agencies, and other groups that try to resolve waste management concerns.

Seattle-King County Department of Public Health Environmental Services Program

The health department operates a telephone information line that provides information on waste reduction and the proper storage and disposal of household hazardous wastes. The health department also operates a materials exchange, known as "Industrial Materials Exchange" (IMEX). IMEX oversees the transfer of hazardous materials from the generator to a party that can use them.

Infiltration Control Program

If infiltration from the sanitary sewer to the storm sewer occurs, the city's maintenance crew will conduct a television or walk-through inspection to locate the leak and make the necessary repairs. Storm drain maintenance activities include upgrading surface drainage facilities (e.g., inlets, catch basins, junction boxes, ditches) and removing debris from detention facilities. Sewer maintenance includes inspection, routine cleaning, and system repairs.

R0014161

Virginia Beach presently facilitates or participates in existing programs that address illicit and/or inappropriate discharges and other forms of pollution. The illicit and/or inappropriate discharge program described below will supplement the current programs for detecting and eliminating sources of illicit and/or inappropriate discharges.

Ordinances

The city of Virginia Beach has developed the Storm Sewer Discharge Ordinance, which authorizes the city to regulate non-storm water discharges to storm sewers and surface waters. This ordinance will supplement other codes currently in effect, specifically the building code, which requires sanitary and storm sewers of a building to be kept separate. The Department of Public Works will be responsible for implementing and enforcing the ordinance. The Storm Sewer Discharge Ordinance also grants inspection and monitoring authority, as necessary, for administration and enforcement to the Department of Public Works. An existing program conducted by Public Works through the Department of Permits and Inspections inspects construction sites for illicit and/or inappropriate discharges. Other city agencies that perform inspections are to report violations to the Department of Public Works.

Ongoing Field Screening Program

The purpose of this program is to test field screening points throughout the term of the permit for dry weather flows and other indications of possible illicit and/or inappropriate discharges. The program will screen points identified in the city's Part 1 application and screen new points.

Part 1 Sites

Out of the 112 field screening points with dry weather flow identified in Part 1, 30 sites were chosen for continued dry weather monitoring. The sampling results are compiled and added to the existing GIS data base. If dry weather flow continues at these sites, the possible source(s) will be investigated.

New Sites

New field screening sites will be chosen from areas with high concentrations of commercial, industrial, and older residential areas and from major highways and roads that have automotive and commercial service areas. The final selection of the new screening points will be determined by field inspection. The chosen outfalls are examined for dry weather flow. If flow is present, then a sample is taken. Twenty-five new field screening points will be evaluated during each year of the permit. The sampling data for each site will be compiled and entered into the GIS data base. If dry weather flow continues at these sites, the possible source(s) will be investigated.

Investigation of the Storm Sewer System

To locate the sources of illicit and/or inappropriate discharges, sections of the storm sewer will have to be investigated. Investigations will be conducted based on analysis of the data received from field screening activities and any other information the city receives concerning illicit and/or inappropriate connections. This program will emphasize public reporting to aid investigations. Investigations will occur at the problem areas and will involve mapping and evaluation, field surveys, and source identification.

Mapping and Evaluation

Each area to be investigated will be highlighted on the storm sewer map, and the drainage area will be defined. The types of land uses will also be evaluated to determine the types of residential, commercial, and industrial areas that may be potential polluters. Other areas that will receive special attention include sanitary, septic tanks, and vehicle maintenance activity sources.

R0014162

Field Surveys

The city will utilize the strategy of "halving-intervals" to locate the area of the source. This method will be applied to the main trunk of the sewer system and branch lines as necessary. Investigations will occur halfway between the field screening points and the upper most headwater locations. These investigations will use the same criteria as the field screening, except only one site visit will be conducted. The Department of Public Works will perform the field surveys.

Source Identification

After the area and the probable activity have been identified, field visits will be conducted to identify the source(s). Five actions are taken to eliminate a source once it is identified: sending a letter with a questionnaire; site visit and interview; dye tests or smoke tests, if needed; noncompliance notification; and followup inspections.

- Letter with Questionnaire: The Department of Public Works will send a letter to the owner/operator of the suspected source to advise the owner/operator of the problem and to request that the owner/operator complete the attached questionnaire. The completed questionnaire should describe the industrial activities and indicate the possible sources of non-storm water discharges.

- Site Visit and Interview: After the questionnaire is received, a staff person from the Department of Public Works will conduct a site visit and interview to further pinpoint the source.

- Dye Tests and Smoke Tests: If the questionnaire, site visit, and interview do not support the field screening data, then it is necessary to perform fluorometric dye tests of plumbing fixtures and floor drains. If several sources are suspected, a smoke test may be needed to limit the number of possible sources and to allow for a more detailed analysis. These tests will be performed by the Department of Public Works.

- Notification of Noncompliance: Once the suspected source is confirmed, the owner/operator will be issued a notification of noncompliance with the Storm Sewer Discharge Ordinance and will be subject to the penalties in the ordinance.

- Followup Inspection: The Public Works staff will conduct followup inspections to ensure that corrective action was taken and the illicit and/or inappropriate discharge has been eliminated. If the negligent violation continues, the Virginia Water Control Board (VWCB) and/or the news media will be notified.

Spills Program

The spills program in Virginia Beach has two components: hazardous material spill response and inspection of sites for proper compliance with State and Federal regulations for gas, oil, and hazardous chemicals.

Spill Response Program

The city will continue to implement its Hazardous Materials Emergency Response Plan through the Virginia Beach Fire Department. The plan is structured to comply with SARA Title III, Emergency Planning and Community Right-to-Know legislation. The response plan details the proper procedures to be followed in the event of a hazardous materials spill, which could affect persons, property, or the environment. The plan also describes the roles and responsibilities of local government and private agencies when responding to hazardous materials emergencies.

The Fire Department is responsible for the command and control of activities during a spill event. The Fire Department provides initial containment, fire suppression, rescue operations, and evacuation procedures. However,

cleanup is the responsibility of the spiller, or owner/operator of the facility, with monitoring from the Fire Department. When necessary, the Fire Department contacts local, State, and Federal government offices. The Department of Public Works will be notified if any spills enter or have the potential to enter the storm sewer or surface waters. Public Works will then assist the Fire Department with material and equipment to prevent the spill from entering the storm sewer and/or to remove an existing spill from within the storm sewer.

Inspection Program

The VWCB is responsible for regulating waste materials for wastewater and petroleum products, and the Virginia Department of Waste Management regulates solid and hazardous wastes. Under the Hazardous Waste Management Regulations, the Virginia Department of Waste Management requires facilities that generate more than 1,000 kilograms per month of hazardous waste to develop a contingency plan and emergency procedures. The Federal Government requires a spill prevention and containment countermeasures (SPCC) plan for facilities that have the potential to discharge oil in reportable quantities to surface waters. VWCB requires facilities covered under an SPCC to develop an oil discharge contingency plan for bulk storage of 25,000 gallons or more.

- The city has an inspection program that delineates the proper methods for the storage and handling of hazardous wastes to prevent spills from entering the storm sewer or surface waters. The Fire Marshal's office inspects all commercial properties for compliance. Inspection frequency is based on the nature of the perceived hazard. New buildings and construction sites are inspected by the Permits and Inspections Division of the Department of Public Works to ensure compliance with State and Federal regulations for gas, oil, and hazardous chemicals.

Reporting of Illicit and/or Inappropriate Discharges and Water Quality Impacts

Virginia Beach has implemented various programs to address water quality issues. Public education programs in relation to storm water are coordinated through the Public Information Office at Public Works. The city's local cable television channel has shown videos on water quality, litter control, sediment and erosion control, and storm water management. The city has also distributed literature in the form of leaflets and brochures on similar topics. On a regional level, storm water public information programs are developed through the Hampton Roads Municipal Communicators (HRMC). HMRC's membership includes the cities/counties of Virginia Beach, Norfolk, Hampton, Chesapeake, James City, Newport News, Portsmouth, Suffolk, and York. Upcoming projects include stenciling storm drains and developing public service announcements for media broadcast.

Awareness and Reporting

The current programs increase public awareness of water quality issues and of potential impacts of illicit and/or inappropriate discharges. The city would like the public to increase reporting of illicit and/or inappropriate discharges. The Department of Planning within the Division of Environmental Management, along with other departments, takes reports of odor, color, turbidity, and the presence of trash in storm sewers and waterways. The following information programs will continue to increase public awareness and encourage the public to report signs of illicit and/or inappropriate discharges. These information programs include a brochure, Cityline message, and a slide show:

- Brochure: The brochure will address "what to look for" and "who to report to." The public will receive discharges. The brochure will present the options of a hotline and a mailing address for reporting. The Public Information Office will develop and distribute the brochure with funding from Public Works. The brochure will be mailed with the water/sewer bill every 2 years and be distributed to schools and community groups.

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- Cityline Message: Virginia Beach has a public information service line called Cityline. A taped message concerning illicit and/or inappropriate discharges will be developed for Cityline and will include information similar to that in the brochure.

- Slide Show: A slide show with accompanying text will be developed by the Public Information Office. The target audience will be children and community groups. The slide show will be presented once a year at elementary, middle, and high schools. A copy of the slide show will also be given to the Virginia Marine Science Museum.

Proper Management and Disposal of Used Oil and Toxic Materials

The City currently participates in programs that facilitate the proper disposal of used oil and toxic materials. The Southeastern Public Service Authority (SPSA) has various recycling programs, including curbside collection and drop-off centers. SPSA produces and distributes brochures explaining the recycling program and listing the locations of the drop-off centers. Household hazardous wastes are accepted at the regional landfill and at seven transfer stations free of charge to private citizens. The State of Virginia operates a used oil recycling program through the Department of Mines, Minerals and Energy. This program recruits service stations to accept and properly dispose of used oil. A toll free number that gives the names and locations of the service stations is available to the public.

New Programs

The following new programs will be developed:

- Brochure: The Public Information Office will develop and distribute a brochure to promote and explain all programs within the city that handle the proper management activities of used oil and toxic materials. The brochure will list the telephone numbers of the various agencies with such programs. The brochure will be available at slide show presentations and mailed every 2 years with the water/sewer bill separate from the illicit and/or inappropriate discharges brochure.

- Cityline Message: A hyped message will be developed by the Public Information Office that will state the major programs and information sources that deal with the management and disposal of used oil and toxic materials.

- Slide Show: A slide show will be developed on the proper management and disposal of used oil and toxic materials. The slide show will be made available to schools, community groups, and the Virginia Marine Science Museum.

Controls to Limit Infiltration from Sanitary Sewers and Septic Systems

Sanitary Sewers

Problems with infiltration of seepage from sanitary sewers to storms sewers in Virginia Beach are rare because the storm sewer is located under the curb and the sanitary sewer is in the middle of the road. The Sewer and Water Standard Specifications and Details of the Department of Public Utilities requires consideration of design, pipe depth, and alignment to avoid conflict between the two sewer systems and to facilitate maintenance. When a leak or spill does occur from the sanitary sewer to the storm sewer, the sewage is contained in the storm sewer and pumped to the sanitary sewer or tanker trucks to prevent discharge to surface waters. If the sewage cannot be collected, Public Utilities will disinfect the site and obtain a special discharge permit from VWCB. Sanitary overflows are reported to VWCB's Tidewater Regional Office within 24 hours. A written report is also required within 5 days. Public Utilities reports any overflows to Public Works.

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The Department of Public Utilities has an inspection program for locating defects within the sanitary sewer system. Television inspections for infiltration problems are performed on 80,000 feet of sewer lines per year.

Septic Systems

Subdivision regulations require every subdivision to have an adequate sanitary sewerage system cohesive with the type of development proposed. If public sewerage is not an option, then private septic tanks must be built. These individual sewerage systems must be permitted by the Virginia Beach Health District in cooperation with the Virginia State Health Department.

If the public health director determines that the area chosen for the septic system has poorly drained soils, then a land management plan must be developed by the property owner and approved by the director. The plan must contain the location of the septic tanks and a proposed drainage plan. The owner is also responsible for the construction, repair, maintenance, and operation of the system.

If septic tanks are located in the Chesapeake Bay Preservation Area, the Chesapeake Bay Preservation Area Ordinance requires the property owner to provide a reserve sewage disposal drainfield site with a capacity at least equal to the primary sewage disposal drainfield site. The same is true for septic systems located in the Southern Watersheds, as stipulated in the Southern Watersheds Management Ordinance.

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Fundamentals of Urban Runoff Management:

Technical and Institutional Issues

By
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and
Eric H. Livingston and H. Earl Shaver
Watershed Management Institute

Produced by
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Produced under the direction of Lura T. Svestka, edited by Roberta F. Shulman, and designed and typeset by Jessica A. Johnson.

Dedication

This manual is dedicated to the memory of an individual who, for many years, carried the banner of resource protection through scientific study and analysis. D. Earl Jones, who passed away in 1991, was a leader in water resources research and a friend. We need more such individuals if our efforts to protect and maintain water quality are to be successful.

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Introduction

This manual departs from the traditional urban runoff management design manual—in addition to providing technical information, the manual offers an in-depth discussion of institutional issues.

Traditional urban runoff management design manuals from states, regional authorities, and local governments present best management practices (BMPs) or pollution prevention practices. However, they normally offer little guidance on the institutional structure or framework necessary to ensure that BMPs are implemented and continue to function. In this manual—designed for program managers, engineers, technical staff, biologists, and others who have urban runoff management responsibility—even the technical chapters stress the program aspects of urban runoff management.

To engender support from elected officials, industry, and the general public, professionals need background information on urban runoff quantity, pollutant sources, and their associated impacts. Professionals need to ensure that decisionmakers understand the serious nature of the urban runoff problem so that the problem receives the priority and attention it deserves.

Historically, our society has lived and worked in a narrowly defined environment, only aware of relationships affecting us individually. In today's era of global communication and travel and with our increased understanding of the impacts of our activities, we can no longer ignore our effects on aquatic and terrestrial resources. Our awareness obligates—or should obligate—us to address the problems our actions cause. Information in this manual is intended to explain the impacts that urban land uses have on our receiving systems.

After presenting the fundamentals of urban runoff hydrology and the impacts of urban land use in Part I, Part II presents guidance on the various types of runoff control measures and practices available. In addition to the more traditional structural measures, the manual also presents nonstructural strategies and practices. These nonstructural practices, based largely on ordinary common sense, can both enhance the performance and longevity of more complex structural measures and, at times, even replace them. This integrated presentation of structural and nonstructural practices is only one example of the dynamic, interactive approach to urban runoff management the manual encourages.

But all these practices and best intentions will not succeed unless we work to establish an infrastructure that provides the overall framework to implement programs. Because the programmatic considerations are as important as the actual urban runoff management practices themselves, half of this manual is devoted to program-related issues.

The manual's recommendations are based on the authors' experience in the technical and programmatic aspects of urban runoff management, with a strong interaction between research and program implementation.

The manual is a summary of materials distributed at a workshop in Chicago in June 1992. This information is valuable for individuals who implement runoff requirements under the National Pollutant Discharge Elimination System, Coastal Zone Act Reauthorization Amendments, or section 319 of the Clean Water Act. Any opinions rendered are those of the authors and do not necessarily reflect the opinions of either the U.S. Environmental Protection Agency or the Terrene Institute.

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Since *all* of us contribute to the decline in our natural resources, all will need to alter our daily habits if we are to significantly improve our resource values. Native Americans demonstrate a reverence for the land worthy of emulation if true resource protection efforts are to be successful. In Delaware, the Nanticoke Indians demonstrate this reverence in their daily lives. The following quote shows how our attitudes must change if we are to succeed in addressing our environmental problems:

To the Native American people, Mother Earth is a living, breathing entity.
The rocks and coal in the soil are her bones.
The rivers and oceans are her blood.
The trees and plants are her hair, and the wind is her breath.
All living creatures are her children, they are our brothers and sisters.
If we fail to protect our brothers and sisters, we do not respect our Mother Earth.
Each step upon the Earth is a sacred dance.

Charles C. "Little Owl" Clark, IV
Nanticoke Native American
Millsboro, Delaware

Richard R. Horner
Eric H. Livingston
H. Earl Shaver
Joseph J. Skupien

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PART I

Technical Issues

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CHAPTER 1

Hydrologic Impacts of Land Use Change

Urban runoff is a by-product of the land's interaction with rainfall. Since, by definition, urban runoff remains on and moves along the land's surface, it is the most visible of the many forms into which rainfall is converted. This chapter provides the technical fundamentals of the rainfall-runoff and soil erosion processes. It also describes ways that land development alters these processes and quantifies some of the adverse impacts.

The amount or volume of runoff produced by a rain event and the rates, depths, and velocities at which it flows during and after the event depend on several factors. They include the amount and rate of the rainfall and the amount of other forms into which rain is converted. These "conversions" are related to several land characteristics, including depth, slope, and permeability of both the surface and subsurface soils; the extent and character of any surface vegetation; and the degree of moisture already present in the soil. Other important factors typically encountered when the land undergoes a use change, or development, include the extent of impermeable surfaces covering the soil and the presence and efficiency of any conveyance system created through natural processes or constructed through human processes to drain runoff from the land.

Runoff directly affects the surface it flows within and across. These effects are most readily seen as erosion and sediment, as the forces created by runoff moving along the ground surface—as well as the initial impact of the raindrops themselves—dislodge and transport surface particles downstream to slower velocity areas. When runoff velocities can no longer transport the heavy particles, they drop out of the flow and back onto the surface.

Similar to the rainfall-to-runoff process, the amount of erosion and the character of the eroded material depend on several factors, including the flow volume, rate, duration, and the character of the surface material. Soil erosion has several major consequences:

- The original sites of the eroded material are degraded, therefore, potential productivity is lessened;
- The sites of soil particle deposition are altered physically, chemically, and hydrologically; and
- The chemical and physical nature of the transporting water system is affected.

From this information, three key aspects of urban runoff now come into focus:

- Since the amount and rate of urban runoff from a given storm event depend not only on the rainfall but also on the characteristics of the land on which runoff falls, changing the land characteristics can increase the runoff amount and/or rate, sometimes with disastrous results.
- An increase in runoff amount and rate can also increase the erosion of land surfaces and stream channels and change the quality of the runoff.
- The fundamental characteristics of the rainfall-runoff and erosion-sedimentation processes are not mysterious. With the information and references presented in this chapter and some logical thinking, those involved in developing urban runoff management programs *at all levels* can base their efforts on a sound understanding of the hydrologic processes at the core of the program.

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This first chapter will provide all readers—from novices to veterans of urban runoff management—fundamental technical information on urban runoff, soil and channel erosion, and the quantitative impacts of land development. The chapter also highlights some of the unknowns and uncertainties of both processes, to the extent of our current understanding. It also discusses various computational methods and models typically used to supply quantitative answers. The chapter concludes with advice and insights into the technical aspects of developing a runoff management program.

This broad approach will not only help the reader understand the technically complex urban runoff management topics presented in later chapters, it will also help ensure that decisions on a specific runoff management program will be founded on an informed understanding of runoff fundamentals. The chapter also provides a list of recommended textbooks and other references from a large body of technical material currently available. Because of the chapter's broad scope and focus on "learning the fundamentals first," readers should use the reference material to expand their knowledge beyond the manual's pages.

Throughout this chapter, the technical information regarding urban runoff hydrology is presented not as an end in itself but to assist in developing urban runoff management programs. This style, which varies somewhat from more traditional textbooks, should make the technical information more understandable to readers unaccustomed to a traditional approach. In addition, the style also allows the more experienced reader to view the technical aspects of urban runoff hydrology from a different perspective.

Finally, while melting snowfall also produces runoff, the complexities of the melting process are beyond the technical scope of this chapter. Therefore, discussion of runoff will be limited to rain events.

Real Versus Design Conditions

In technical subject matter, important differences exist between "real" and "design" conditions. This distinction is important when establishing a technology-based regulatory program. The "real" process that actually occurs during a storm event can be extremely complex, not only in its physical or mechanical behavior, but also in the numerous and highly variable external factors and conditions influencing it.

In the case of urban runoff hydrology, for example, the mechanics of evapotranspiration are extremely complex. They are strongly influenced by numerous external factors such as rainfall amount and intensity, antecedent moisture conditions, the character and condition of the vegetation, ambient air temperature, humidity, and wind speed—all of which can vary greatly from storm to storm. This inherent complexity of the mechanical processes—and the conditions under which they function—makes it difficult to precisely compute the runoff volume from a real storm event. Determining the exact level or value of all the influencing factors that exist when a storm event occurs is overwhelming.

On the surface, this inability to precisely analyze real storm events does not bode well for a regulatory program intended to manage the resulting runoff. Fortunately, differences can be predicted using simplifications between real and "design" events—i.e., hypothetical or future events. To deal with hypothetical events, we can preset all the external factors and conditions that will exist when the future storm event occurs. We can even decide that certain factors have no significant effect. We can also assume that the actual mechanical process will not be as complicated in our design world as in the real world. These simplifications will certainly make our analysis easier. But how can we be sure that it remains accurate and workable?

To achieve simplicity, accuracy, and usable design parameters, we must be able to make simplifying assumptions that are conservative or safe. This means that the predicted results of these assumptions will be on the safe side of the real answer, if we could compute it. For example, suppose our regulatory program required temporary storage of increased runoff from a land development site, as many do. A safe assumption for the value of any influencing factor would be one that would compute a runoff volume greater than what would actually occur. This will ensure that the constructed runoff storage facility will be larger and presumably safer than what will be required.

To consistently make safe assumptions, we must understand, at least qualitatively, how the real process works and what factors influence it. If dense vegetation covering the ground results in less runoff volume, then to be safe, our analysis might assume that only a thin stand of vegetation

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exists. Or if the degree of soil moisture before the storm event affects runoff volume, for safety we might assume that this moisture level is greater than average conditions.

We cannot be sure that our assumptions—and, therefore, our programs—are safe unless we understand the technical aspects of urban runoff hydrology well enough to identify all pertinent factors and understand their effect. This is a sound argument for learning the fundamentals first.

To gain a firm understanding of the fundamentals of urban runoff hydrology, we might ask, "How safe is safe?" and, perhaps more importantly, "How safe is too safe?" As our theoretical knowledge and analytical abilities improve, we may learn that the safe assumptions that simplified our computations have resulted in conservative program measures whose size, cost, or management needs are impractical and/or unaffordable. Therefore, the urban runoff management benefits they provide may simply not be worth the expense.

Those with a cursory knowledge of urban runoff hydrology can, in time, learn to make unquestionably safe analytical assumptions. However, only those with an in-depth understanding can consistently make program assumptions and decisions with the right combination of safety, cost, and practicality. To be truly effective, an urban runoff management program must possess large doses of all three.

The Rainfall-Runoff Process

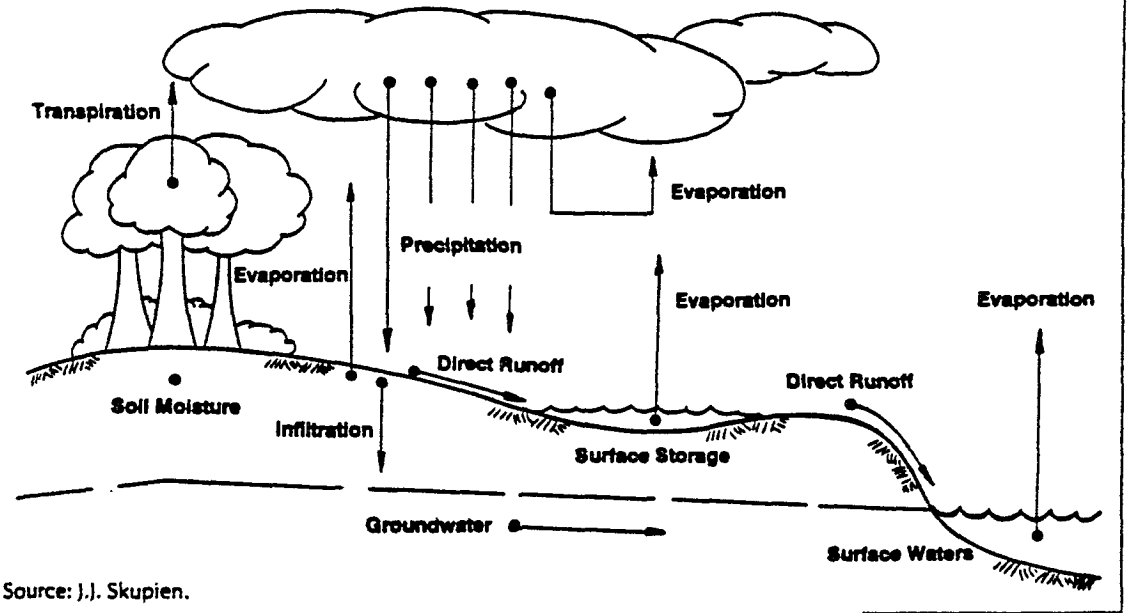
The Hydrologic Cycle

As previously explained, runoff represents a by-product of the land's interaction with rainfall. While appropriately describing an individual storm event, this conversion process is only one of many that water goes through as it continually moves over, through, or above the land. Therefore, the rainfall-runoff process is an integral part of a cyclical process—the hydrologic cycle—that the earth's water supply continually experiences.

The hydrologic cycle shows the primary components or forms that water can take (Figure 1.1). The figure represents the earth's entire surface and atmosphere, including various forms of water that exist in the atmosphere such as water vapor measured as humidity near the ground surface, clouds comprised of tiny droplets of water condensed from that vapor, and forms of precipitation—created by large droplets too heavy to remain suspended in the clouds.

After arriving on the earth's surface, water follows one of several possible routes. It is absorbed by surface soils, intercepted by vegetation, directly impounded in numerous surface features from small depressions to large lakes and oceans, or infiltrated through the surface and subsurface soils into the groundwater. Another route taken by some water falling as precipitation is runoff.

Figure 1.1—Hydrologic cycle.



Source: J.J. Skupien.

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The hydrologic cycle has two important aspects. First, the path of water movement is only half the story. Water also moves from the earth to the atmosphere, primarily through evaporation from surface waterbodies such as the oceans and evapotranspiration by vegetation. In fact, the rates of both movements over time are exactly equal. If they were not, the skies would get *very* cloudy or inland property owners would eventually have ocean or lakeside views. Although we can, and will in coming sections, focus on a single rain storm as a localized, temporary imbalance in this water transfer between the earth and its atmosphere, such a storm event is only one component of a much larger and complex process continually occurring around the planet.

Second, the hydrologic cycle is not easily broken into separate, discrete components. The cyclical process demands that the places water can be and the routes it takes between them are interrelated. Depending on conditions, the water that becomes part of the surface runoff from a parking lot may join the elevated flow in a nearby stream, or the moisture in the soil surrounding the lot, or—if it moves vertically through the soil—the groundwater moving below the lot. In fact, the water that was originally parking lot runoff and then became groundwater beneath it may eventually become streamflow, although well after the initial flooding has passed.

How do we make enough sense of this very common but complex cycle to develop a regulatory process to manage it? By defining the process by (1) the location on the ground that we may affect; (2) the land size and characteristics from which runoff will flow (or drain) to that location; and (3) the time period for which we analyze the continuously operating hydrologic cycle. To assist us, we rely on simplified design conditions to overcome unknowns or uncertainties in the real process that we must quantify in some manner. Finally, we rely on our knowledge of hydrologic fundamentals to ensure that our assumptions are safe, reasonable, and affordable. The following sections present details of these steps.

Runoff Estimation—Typical Parameters

In the previous description of routes that rainfall may follow, runoff was listed last. That is because runoff is the last form or by-product of precipitation used in most runoff estimation techniques for ungaged drainage areas after all the other processes—infiltration by soil, interception by vegetation—have been quantified. That is, we often estimate runoff produced by a given amount of rainfall by subtracting from the total rainfall those portions or percentages likely to become something other than runoff. The remainder is the estimated runoff.

The preceding paragraph uses the term "ungaged drainage area" to qualify the statement concerning runoff estimating techniques. If we were fortunate enough to have some type of gage or metering device to measure the actual runoff over an extended time period, our computations would be more direct and our interest in other aspects of the rainfall-runoff process, including rainfall itself, would be incidental at best. Using this flow data and the knowledge that runoff, like rainfall, is a random event, we could use standardized statistical and probability techniques to estimate the runoff volume, peak rate, duration, and other characteristics for runoff events of various frequencies.

For example, individuals concerned with flooding and flood plain delineation and management could choose a 100-year flood frequency event, technically defined as an event with a 1 percent chance of being equaled or exceeded in any given year. Others concerned with erosion could develop estimates of the two- or five-year flood—having a 50 or 20 percent chance, respectively. While the magnitudes are not as great as the 100-year event, they possess the right combination of frequency and magnitude to define natural channel banks and cause considerable erosion. Finally, individuals concerned with urban runoff quality and the impacts of nonpoint source pollution would probably be most interested in one-year and even more frequent events, since these have the most severe, acute, and chronic water quality effects. A 2.5 year, 24-hour flood is the most frequently used design.

However, while many streams and rivers have been equipped with flow gages by local, state, or federal agencies—including the U.S. Geological Survey (USGS)—gages are primarily meant to address flooding and water supply on a large scale. In contrast, urban runoff management must address localized issues such as construction site runoff and small stream erosion. Even if flow gages were practical on a small scale, we would need several years of actual runoff measurements before we could accurately predict future possibilities.

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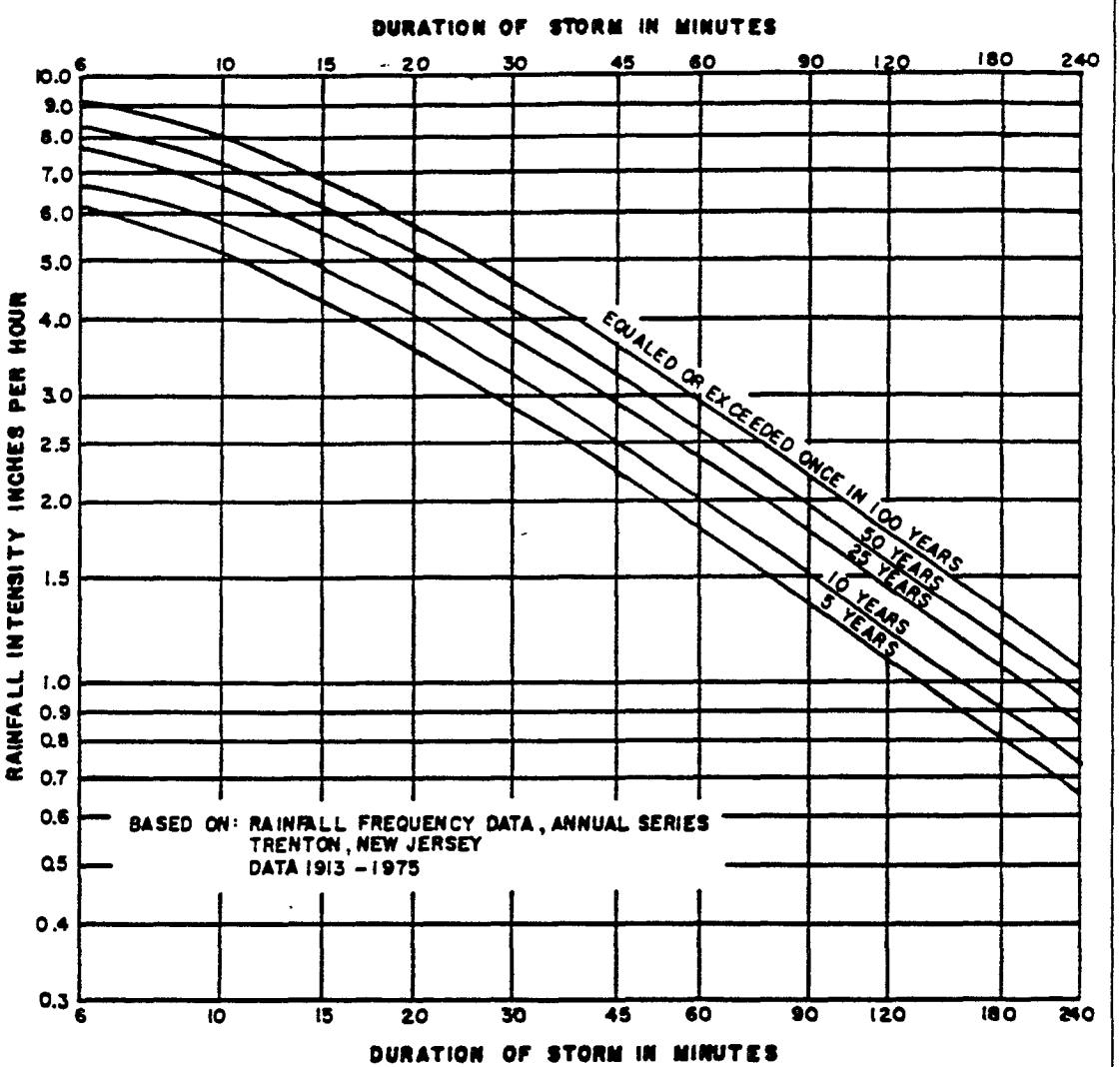
The shear impracticality of installing, operating, and analyzing runoff gages at the scale required for urban runoff management, in addition to some inherent limitations of gaged flow analysis, means that instead of focusing on runoff directly, we must focus on it indirectly by analyzing the rainfall that creates it. We must study the rainfall-runoff process closely and use the runoff by-product approach previously described.

Most runoff estimation methods use some of the following factors or parameters. They each, therefore, require at least some quantitative estimate of their effects on the final product—runoff.

Rainfall. As the most significant parameter in any runoff estimation process, rainfall is the primary input value. Actual rainfall amounts measured at gages in or near the drainage area are used to analyze real or historic rainfall events. Hypothetical rainfall amounts and intensities are typically used for design or regulatory purposes. Data collected from an actual storm event of appropriate magnitude, if available, can be used to check the design or even serve as the design storm itself. Finally, as computer and data resources increase, real, long-term data—considered the most accurate approach to estimating runoff—is increas-

Figure 1.2—Rainfall intensity–duration–frequency curves for New Jersey.



Source: New Jersey Dep. Environ. Prot. Energy, 1988.

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ingly being used and accepted in continuous rainfall-runoff simulation models.

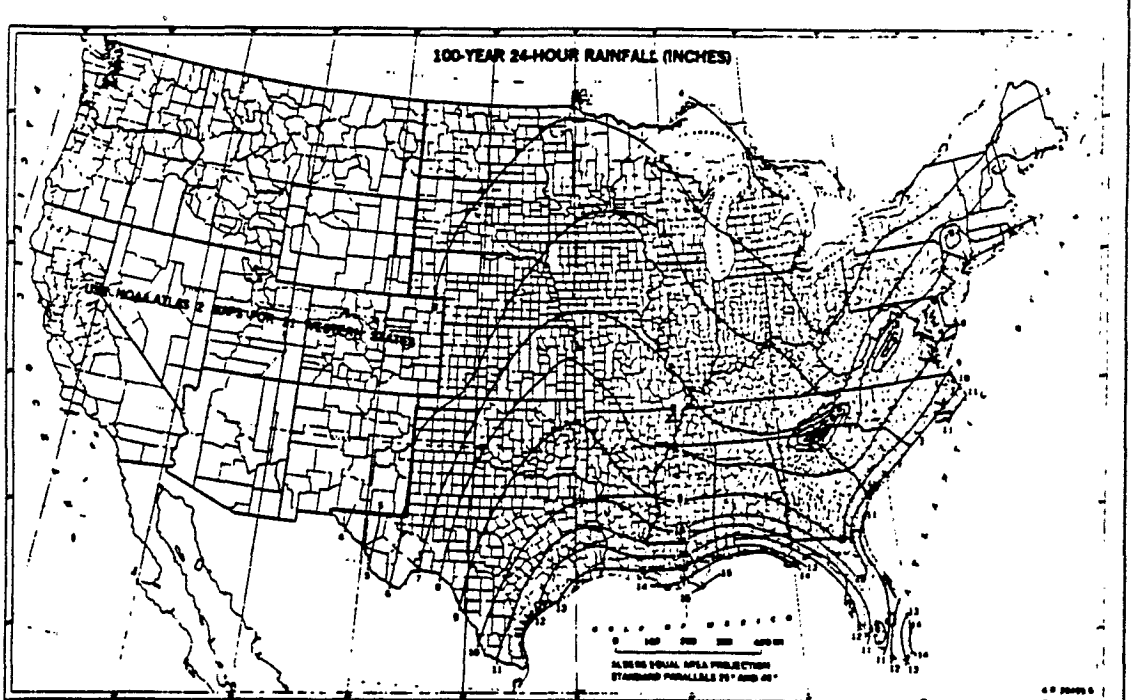
Rainfall data for hypothetical or design events is obtained from statistical compilations and extrapolations of real data collected over a statistically significant time period. Figures 1.2 and 1.3 present two such compilations. Figure 1.2 shows rainfall intensity-duration-frequency curves developed from data collected over a 62-year period at the rainfall gage in Trenton, New Jersey. The curves predict the expected average rainfall intensity for a given frequency storm event over a user-selected time period. For example, the expected five-year average rainfall intensity for a hypothetical rainfall period lasting 30 minutes is approximately 2.8 in (7.1 cm)* per hour. Thus, the total rainfall during the half-hour period will be 1.4 in (3.6 cm).

The curves in Figure 1.3 also show rainfall intensity-duration-frequency relationships, but with some significant differences. Data is presented for the entire United States east of the Rocky Mountains and is expressed for only one duration (24 hours) and frequency (100 years). The rainfall is expressed as a total amount over the time period, rather than as an intensity or rate. Using simple arithmetic, we can compute the average rainfall intensity over 24 hours. The curves in Figure 1.3 are part of a larger set for numerous storm frequencies and durations originally published in *Rainfall-Frequency Atlas of the United States (TP-40)* by the (then) U.S. Weather Bureau. Although TP-40 is out of print, the curves are reproduced in *Urban Hydrology for Small Watersheds (TR-55)*, published by the USDA Soil Conservation Service (USDA SCS). This publication has become a current standard for estimating runoff. This chapter will provide additional information on TR-55 and the USDA SCS hydrologic methodology on which it is based.

To use rainfall data such as that shown in Figures 1.2 and 1.3, the user must select not only the

* Note: Throughout this manual, English measurements are presented first with SI (metric) conversions in parenthesis, except where dual measurements would be confusing, inaccurate, or redundant or where no comparable measurement exists.

Figure 1.3—100-year 24-hour rainfall (inches).



Source: U.S. Dep. Agric. 1986.

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rainfall frequency pertinent to the analysis but also the rainfall duration. The element of time or duration is vital to any rainfall-runoff analysis and will be discussed in greater detail later. But for now, the time runoff takes to collect and flow to the point of concern on the ground surface—located at the lowest end of the area draining to that point—is key to selecting the appropriate rainfall duration.

Regarding the element of time, while the data in the figures and in similar charts are based on real storm events, they are not meant to imply any total storm duration or amount. For example, while Figure 1.2 indicates that the five-year rainfall intensity of 2.8 in (7.1 cm) per hour will last for 30 minutes, it gives no indication of the actual storm length. Instead, Figure 1.2 shows a 20 percent chance (the probability of a five-year event) exists that any rain event of at least 30 minutes will contain a 30-minute period that will produce 1.4 in (3.6 cm) of rain—i.e., rain falling at an average rate of 2.8 in (7.1 cm) per hour over a half-hour period. The figures indicate nothing about how the rain fell during the selected time period—they only indicate the total amount that fell. That is why we use the word "average" whenever we discuss rainfall rates.

As analysts, we may be required to select critical rainfall intensities and durations within an overall storm event. The specific runoff characteristic we seek (e.g., peak flow rate versus total volume) will help determine whether or not we need to select a total storm event duration.

Our rainfall discussion would not be complete without mentioning the rain that has fallen during prior storms. While the runoff from this rain may have long since drained from the watershed, some may still be present as soil moisture or stored in surface depressions. Referred to as antecedent rainfall, runoff, or moisture condition, this helps characterize a watershed's potential to produce runoff from a new storm event by describing how wet conditions are from previous storms.

Antecedent runoff conditions are particularly critical when recreating real or historic storm events and when analyzing real or hypothetical storms involving fairly small amounts of total rainfall. For simplicity, many runoff estimating techniques assume that average antecedent conditions are present in the watershed prior to the start of the storm in question. The more sophisticated techniques allow the analyst to vary the input data to reflect some other antecedent condition. Readers should keep antecedent conditions in mind when reviewing discussions of initial abstraction, surface depressions, and soil infiltration.

Time. The time element plays a critical role in both the real rainfall-runoff process and the methods used to estimate the runoff. This is not surprising, since gravitational, thermodynamic, and other natural forces involved in producing both precipitation and runoff are intrinsically dynamic and constantly changing with, and therefore influenced by, time. This chapter presents a simplified description of how time affects runoff estimates. The reader should further explore the time element through the publications referenced here and the many other excellent ones available.

Two fundamental measures or lengths of time are important when performing runoff estimates, whether for an existing or future condition. The first measure is the response time of a drainage area to a rainfall input. This response time indicates how quickly runoff drains to the bottom of the watershed and how quickly the runoff rate, created by a certain rainfall, will change as the rainfall rate changes. To a lesser degree, this response time may also help determine the runoff volume produced by the rainfall.

Several terms and definitions quantify this response time; most are applicable to a particular runoff estimating technique or method. The most common definition of watershed response is time of concentration (TC), which the USDA SCS and others define as the time runoff—once it has begun—takes to flow from the most distant point in the watershed to the point of interest at the bottom. Numerous procedures, equations, charts, and graphs can help estimate TC, including those presented in Chapter 3 of TR-55.

Remember that TC or any other watershed response time definitions are only conceptual values. A watershed's actual response time is not only affected by numerous and complex factors, it is also constantly changing in length throughout a storm. Therefore, any computed TC estimate is *only* an estimate. The reason is not only because we use simplified data and equations to compute the TC, but also because we assume that a single time represents the watershed throughout the entire storm event. This assumption is critical to remember when computing entire runoff hydrographs.

Regardless of the definition or estimating technique adopted, the most important aspect of the watershed response time is its direct effect on the rate of runoff flow. Since response time determines how quickly the runoff produced through-

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out a watershed can flow to the bottom or outlet, it determines how much *time* runoff will take to *concentrate* at the bottom. Therefore, whether we seek just the peak runoff rate from a storm event or an estimate of all the various runoff rates during and after a storm period—known as a hydrograph—we must compute a reasonable time estimate. In addition, the shorter the response time, the greater the flow rate for a given runoff volume amount. Or, we can analyze further to determine how an existing runoff rate will be changed if the watershed's response time is altered. More information regarding the impacts of such alterations from land development is presented later.

Since watershed response time also indicates how quickly the runoff rate will change due to changes in rainfall rate or intensity, response time helps us determine the length of rainfall increments needed in a runoff analysis to assure accurate results. Or, stated differently, we learn how short a time period is needed to safely assume an average rainfall rate. For example, a watershed whose outlet takes several hours to respond to the rainfall within it will show little change in runoff rate from a change in rainfall intensity lasting only a few minutes. As a result, we would waste time and effort if we based our analysis on rainfall increments of less than 15 minutes. This aspect of watershed response time helps determine the appropriate time increment for other time-dependent runoff computations such as detention basin, reservoir, and channel/flood plain routings. It can also help us select appropriate sampling and recording intervals required for runoff field studies.

The second fundamental measure or length of time in rainfall-runoff analyses is the total event time. It not only includes the total time for rain to fall, but it frequently includes the time required after the rainfall for a watershed to fully respond. For example, if we wished to compute the total runoff volume from a certain frequency rainfall, we would need to know both the average intensity and total duration. This differs from the peak rate example given in the preceding paragraph. There, we only needed to know the rainfall that fell during the time period, equal to the watershed response time, that produced the peak rate. In addition, if we need this estimate of total runoff volume to design an urban runoff detention or other storage facility at the watershed outlet, then we must extend the total event time to include the additional time the facility prolongs or delays the watershed's response time. This additional time, known as the "interevent dry period" between rain events (Wanielista and Yousef, 1993), has become increasingly important as the use of extended runoff storage times for urban runoff quality grows in popularity and the storage times increase in length.

Drainage Area. The drainage area or watershed concept is fundamental to any rainfall-runoff analysis. As such, we must determine and evaluate several key drainage area characteristics to perform runoff estimates. The first and most obvious characteristic is the drainage area size. This is usually determined by using topographic or other area maps upstream from the point of interest and actual field reconnaissance to verify available map data and supplement missing data.

Most runoff estimating techniques assume a linear relationship between drainage area size and runoff volume. Therefore, a 20 percent error in estimating the drainage area size will, among other impacts, result in a similar error in estimating runoff volume. This relationship is important when determining the required accuracy of drainage area computations and the amount of time and effort to spend achieving it. The percent of a particular drainage area that contributes runoff during a storm event will vary by antecedent moisture content, size of the storm event, and duration.

Two important drainage area characteristics, particularly for estimating runoff rates, are the shape of the drainage area and its various slopes. The previous discussion of watershed response time shows that a watershed with steep surfaces and channels allows runoff to drain to its outlet more quickly. This creates a greater peak flow than a flat watershed of similar total area. Similarly, an elongated drainage area with a longer distance from its upper reaches to its outlet may have a longer response time than a rounded one of equal size and, therefore, a lower peak runoff rate.

The term "may" conveys reservations about over-generalizing drainage area shape and slope and their effects on runoff rate, particularly for complex watersheds with major branches or tributaries. Each drainage area or watershed has its own unique shape, slope, and complexity, and each factor has a direct effect on response time and resultant runoff. Therefore, the representative response time required by the selected runoff estimating method should be computed as accurately as possible for each watershed under study and should consider all these unique characteristics.

The slope of localized areas within a watershed, particularly those that create surface de-

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pressions and other low areas, can have a direct effect on the watershed's response time and volume of runoff, especially at the rainfall onset. If the surface depressions are large relative to the rainfall volume, they can capture and store the beginning runoff, delaying its flow downstream.

This delay, combined with such effects as soil infiltration and interception by vegetation, helps produce the "initial abstraction"—the amount of rainfall converted into something other than runoff during the earliest part of the storm event. In estimating runoff, the initial abstraction is the amount of rain that must fall before runoff begins. Depending on the watershed's surface, soils, and vegetation, and the amount of rainfall analyzed, the initial abstraction can significantly affect the results. It should not be overlooked, particularly when analyzing small, frequent storm events in largely pervious watersheds.

▮ *Soils.* Since several soil characteristics in a watershed have a direct effect on the rainfall-runoff process, they are included in most runoff estimating techniques. These include soil layer thickness, permeability or infiltration rate, and the degree of moisture in the soil before the rain event. The greater the soil permeability—the ability to infiltrate rainfall to its lower strata—the less remains to become runoff. The same can be said for soil thickness, particularly above bedrock or an impermeable subsurface layer, and the degree of moisture present in the voids between the individual soil particles.

If a storm occurs in an undeveloped watershed whose soil is saturated from previous rainfalls and incapable of storing additional water, the runoff amount could be the same as that produced in a watershed completely covered with impervious surfaces such as roofs, parking lots, and roadways. This fact is particularly critical in many parts of the country in spring, when extended wet weather and prolonged snowmelt keep soil levels nearly or completely saturated. This saturation causes a high threat of flooding, since extreme flow rates and flood levels can even be caused by small storms with high probabilities or frequencies.

Soil infiltration rate and thickness data is found in numerous sources, including laboratory tests of soil samples taken from various watershed locations, borings, and other subsurface samples. USDA SCS county soil surveys are reliable sources for general soil information. Depending on drainage area size, degree of accuracy required, and importance of soil characteristics to the runoff estimating method, the data may need some degree of field verification.

As in surface depressions, the delaying effects of initial soil wetting and infiltration help to produce initial abstraction. This can significantly affect the rainfall-runoff analysis result and should be considered, when analyzing small, frequent storm events in pervious watersheds.

▮ *Vegetative Cover.* The vegetative cover directly affects the rainfall-runoff process and is an important parameter in many runoff estimating techniques. Vegetation characteristics include various types, canopies, and densities; extent of coverage; degree of residue or natural litter at the base; and degree of surface roughness. These characteristics affect the amount of rainfall that becomes runoff and the length of time the watershed takes to fully respond. For example, according to data in TR-55, sheet flow—runoff that occurs during the critical first stages of runoff movement—has an average velocity 10 times slower across a wooded area than it does across a comparable bare soil or asphalt-paved area. These effects must be considered in estimating peak runoff rates.

Vegetation data sources, frequently used in combination, include field reconnaissance and aerial photographs and satellite imagery, particularly to study large watersheds using computerized geographic information systems (GIS).

Vegetation's delaying effects of rainfall interception also help produce initial abstraction, which can significantly affect the results of a rainfall-runoff analysis in largely pervious watersheds.

▮ *Impervious Cover.* Impervious cover means that virtually all rain will become runoff. Under most conditions, impervious cover is the last factor created in a watershed. As mentioned previously, the sheet flow velocity of runoff over a smooth, impervious surface such as a road or parking lot is about 10 times faster than over a vegetated surface. These strong impacts on runoff volume and rate make impervious cover the most critical characteristic in most runoff estimating techniques. In fact, the British Road Research Laboratory (BRRL) Method considers only the impervious portions of a watershed or drainage area.

Sources of impervious cover data required for rainfall-runoff analyses range from field reconnaissance to aerial photographs to satellite imagery, particular for GIS-based studies.

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Runoff Estimation—Common Methods

In this manual, most techniques used to analyze the rainfall-runoff process and estimate runoff volumes, peak rates, and hydrographs are classified into two general types, distinguished by how each uses time in its computations.

▮ ***Steady State Methods.*** These methods assume that key parameters remain steady or constant throughout the rainfall duration. Therefore, these methods use uniform rainfall intensities, soil infiltration rates, and representative watershed response times. Rather than merely a shortcut, steady state conditions are a reasonably accurate way to estimate peak runoff rates from high to moderate frequency storms in small watersheds with relatively short response times. As a result, steady state techniques, such as the rational method, are widely accepted for such watersheds. This relative accuracy may be caused by the short response time, resulting in a short time period over which steady or constant conditions are assumed (Wanielista and Yousef [1993] recommends limiting rational method use to drainage areas with a maximum TC of 20 minutes). Unfortunately, these same assumptions limit steady state methods, such as the rational method, to computing peak runoff rates. They are less effective in estimating total event runoff volumes and hydrographs.

A modified form of the rational method estimates runoff volumes from a series of hypothetical rainfall events of similar frequency but different duration. The method is primarily used to design smaller runoff detention and other storage facilities. Unfortunately, urban runoff management is expanding beyond traditional flood control and drainage needs to address aspects such as runoff quality, nonpoint source pollution, and aquatic habitat management. These uses require more accurate estimates of total runoff volumes and hydrographs, in particular, than the methods using steady state assumptions can reliably produce. Nevertheless, their simplicity and proven—if limited—accuracy means that steady state estimating still retains a firm position in urban runoff hydrology.

▮ ***Variable State Methods.*** These methods allow such parameters as rainfall intensity, soil infiltration, and watershed response time to vary with time. As such, these methods can more accurately compute runoff characteristics from rainfalls of varying intensities in single or even multiple storm events. This makes them more suitable to compute event runoff volumes and hydrographs and more capable of accurately recreating runoff from past or historic rainfall events. These methods, then, can be more readily calibrated and verified, further improving their accuracy.

Specific runoff estimating methods based somewhat on variable state assumptions include the USDA SCS runoff equation, which assumes a nonlinear soil infiltration rate to estimate runoff volumes; and methods based on either unit hydrograph theory, originally developed by L.K. Sherman in 1932 (Sherman, 1940), or the more recent kinematic wave theory to distribute runoff volume into runoff hydrographs.

In general, to consider variations in parameters, the methods divide the rainfall event into small time periods and use separate estimates of each parameter sequentially during each time period. To be accurate, a variable state method should consider the effects of previous parameter values from preceding time periods in each current time period. Most standard methods currently available do so, at least for some parameters.

In using variable state methods, the closer resemblance to the "real" rainfall-runoff process and, consequently, the greater accuracy, broader applicability, and potentially greater benefits do not come without additional cost. These methods need more input data (e.g., an initial value for each parameter and a technique for varying it throughout the event) and more computations. This normally requires appropriate computer programs and more user knowledge and experience to maintain an acceptable level of accuracy and safety. These requirements can limit the use of some methods and the effectiveness of the regulatory programs based on them.

In developing or expanding an urban runoff management program, we must balance regulatory effectiveness and technical accuracy. But because of the current demands to manage runoff and the continued growth of hydrologic tools and techniques, all urban runoff management programs should encourage technical growth and be capable of updating their own regulations.

Runoff Estimation—Computer Models

The amount and complexity of the data and computations are overwhelming. And as the scope and complexity of urban runoff management

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grows, linking data and computed hydrologic results with hydraulic, structural, economic, and even demographic analyses is increasingly important. As a result, we must have quick computerized runoff models and other enhanced computational tools, particularly to study large, complex watersheds. Fortunately, numerous urban runoff management programs are available.

The terms computer "program" and "model" can be confusing. The runoff models described here are computer programs since they are written in a computer language and are run (or executed) on a computer. However, the term "model" implies a specialized type of computer program that simulates or models a physical process. The user must both provide input data and make informed decisions about data values, such as soil infiltration rates or extent of vegetative cover.

The model differs, then, from a simple computer program, which may perform complex arithmetic, but uses input data requiring little or no user discretion; for example, a program that computes the mean or standard deviation or that computes the closure error on a land survey. According to this definition, various estimating techniques used in urban runoff management analyses and labeled "methods" are also considered models in scientific and engineering terms. We will, therefore, refer to the computerized versions of these methods as computer models.

▮ ***Single Event Models.*** These models allow the user to analyze or simulate the rainfall-runoff process during a single event. The user must not only select the rainfall to analyze but also the conditions and factors in the watershed immediately prior to its onset. The models then estimate the resulting runoff characteristics such as volumes, peak rates, and entire hydrographs.

To develop and use a single event model, the user need only know the initial values of the factors in the runoff estimating method and how they will change over time in response to the selected rainfall. The user does not need to know how the factors will continue to change during any drying period following the selected rainfall and preceding the next one, since the model is only intended to analyze a single event. This makes these computer models ideally suited to analyze individual historic storm events and design urban runoff detention and other short-term urban runoff storage facilities primarily influenced by individual storms.

Some popular single event computer models available include HEC-1 Flood Hydrograph Package, developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers (1990); USDA Technical Release 20 (TR-20), developed by the USDA SCS (1992); and the U.S. EPA Stormwater Management Model (SWMM) (Huber and Dickinson, 1988); along with numerous others. The first two models can only be used for estimating quantitative aspects of runoff such as volumes, rates, and hydrographs. SWMM can also be used to estimate runoff quality characteristics such as pollutant concentrations and masses. References at the end of the chapter provide detailed descriptions of the models.

▮ ***Continuous Models.*** Unlike single rainfall-runoff models, these models analyze the rainfall-runoff process for a series of storm events over an extended time period—several years or even decades. Models must account for changes in watershed factors and parameters during the time *between* storms (interevent dry periods) as well as *during* storms. Such factors as temperature, relative humidity, surface evaporation and evapotranspiration, and groundwater levels and movement, all of which may significantly affect runoff response to the next rainfall in the analysis or simulation, must be considered. These factors require a similar increase in data needs and user knowledge and experience.

The additional effort and expense are often well spent, particularly to analyze or design agricultural, urban runoff management, or water supply facilities that respond slowly to rainfall and, therefore, are influenced by a long series of storm events. Single event analyses are of limited value for these facilities, since they are part of a larger, more complex picture. Also of limited value are such problems as long-term, cumulative pollutant loadings and their effects on streams, lakes, and estuaries. These phenomena occur slowly and are continuously influenced by rainfall events. Using continuous models may not only be justified, but in many instances mandatory.

One of the most familiar continuous models is Storage, Treatment, Overflow, and Runoff Model (STORM), originally developed by the U.S. Army Corps of Engineers in 1974.

Runoff Estimation—An Example

To highlight the rainfall-runoff concepts, parameters, and methods previously discussed, we have selected a sample method of a single event presented in TR-55 to estimate runoff volumes, peak rates, and entire hydrographs. The methodology

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first uses the USDA SCS runoff equation—a mathematical model of the real rainfall-runoff process—to estimate the runoff volume, expressed as a uniform depth in inches over the watershed, that would result from a specified rainfall depth. We assume that this rainfall depth falls over a 24-hour period in a hypothetical pattern developed by USDA SCS from the rainfall depth-frequency-duration data originally published in TP-40 (U.S. Dep. Commerce, 1961). The resultant runoff volume is then distributed over time using a synthetic unit hydrograph for the watershed to estimate the peak runoff rate. If we desire, we can estimate the entire hydrograph that would result from the day-long rainfall. The synthetic unit hydrograph is based on the principles and assumptions of unit hydrograph theory and, in part, on an estimate of the watershed's TC.

This is a complicated mix of theories, assumptions, and calculations. However, the USDA SCS runoff equation, synthetic storm distributions, and synthetic unit hydrographs included in the methodology are based on extensive field data, research, and experience. They are, therefore, consistent with the concepts and cautions discussed earlier for real versus design conditions. As a result, the USDA SCS hydrologic methods, including those in TR-55, have gained widespread acceptance among engineers, planners, and regulators. Details regarding USDA SCS methodology in the following example are in TR-55 as well as USDA SCS's National Engineering Handbook Section Four— Hydrology (NEH-4) (U.S. Dep. Agric. 1972).

As described in these publications, the USDA SCS runoff equation is

$$Q = \frac{(P - Ia)^2}{(P - Ia) + S} \qquad [1]$$

where: Q = Runoff depth (inches)
P = Rainfall depth (inches)
S = Potential maximum retention once runoff begins (inches)
Ia = Initial abstraction (inches)

As previously explained, the initial abstraction is the amount of rainfall that must fall before runoff begins and represents all other routes rain can take (e.g., infiltration into the soil) or forms it will assume (e.g., depression storage) during the earliest part of the storm. While the actual initial abstraction can be highly variable, USDA SCS has developed the empirical equation Ia = 0.2S. This eliminates Ia as an independent variable in equation 1 and results in the following:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad [2]$$

The parameter S is a measure of how much rainfall the watershed soils and the materials covering them can potentially hold once the initial abstraction is overcome and runoff begins. No mention is made of the rainfall amount required to reach this limit because S is related to the actual soils and covers through a runoff curve number (CN) by the equation

$$S = \frac{1000}{CN} - 10 \qquad [3]$$

TR-55 and NEH-4 have several tables of CNs for numerous ground covers and land uses in various hydrologic conditions, including lawns, meadows, woodland, impervious surfaces such as roads and roofs, and even bare soil. These tables present four CNs for each cover/use/condition. USDA SCS has classified most soils into hydrologic soil groups (HSG) based on their minimum infiltration capabilities. Soils in HSG A have the highest infiltration rates, while HSG D soils have the lowest. Conversely, HSG A soils have the lowest runoff potential while HSG D soils have the highest. The recommended CNs in the TR-55 and NEH-4 tables are also based on the assumption of average antecedent runoff conditions at the start of rainfall.

Graphic solutions to equation 2 (i.e., the USDA SCS runoff equation for Ia = 0.2S) for a range of CNs is presented from TR-55 in Figure 1.4. A summary of recommended CNs for various land uses/covers, conditions, and hydrologic soil groups taken from the extensive listings in TR-55 (Tables 2-2a and 2-2c) is presented in Table 1.1. TR-55 also contains rainfall depth-frequency-duration maps originally published in TP-40 to allow the user to select the appropriate 24-hour rainfall amount.

For example, assume a wooded, 20-acre (8.1-ha) drainage area around Chicago with good leaf cover and other natural litter on the ground. Using the previous equations and the CNs from Table 1.1, we can estimate the volume of runoff expected for a 2-year, 10-year, and 100-year storm event lasting 24 hours. We will base the computations on two alternative soil types—HSG B and D—and compare the results.

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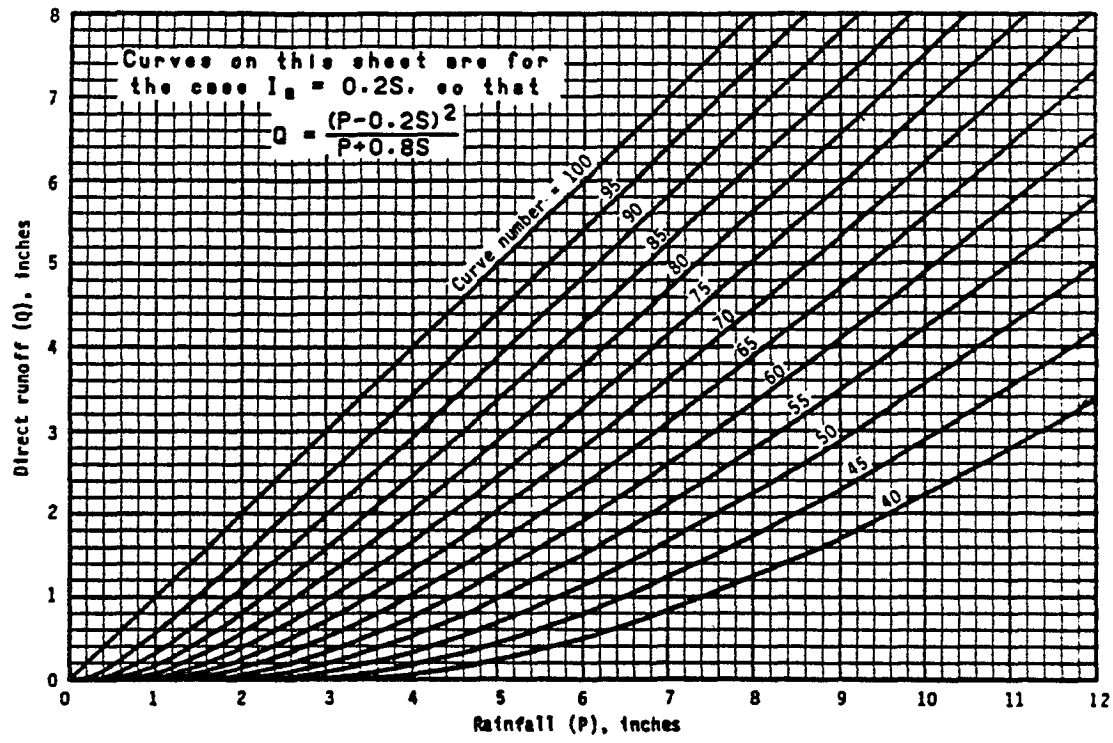
Table 1.1—Summary of recommended SCS runoff curve number for average antecedent runoff conditions.

COVER TYPE/LAND USE	HYDROLOGIC CONDITION	HYDROLOGIC SOIL GROUP A	B	C	D
Woods	Poor–no forest litter Good–litter and brush	45 30	66 55	77 70	83 77
Meadow	—	30	58	71	78
Lawns/open space	Good–full grass cover	39	61	74	80
Bare soil	—	77	86	91	94
½ acre residential (25% impervious)	—	54	70	80	85
Commercial/business (85% impervious)	—	89	92	94	95
Roofs/paved roads, drives, and parking	—	98	98	98	98

Note: Summary values are presented for example only. Refer to complete SCS tables and texts for actual CN use.
Source: U.S. Dep. Agric. 1986.

Figure 1.4—Graphic solution of Soil Conservation Service runoff equation.



Source: U.S. Dep. Agric. 1986.

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From the description and information from Table 1.1, we can safely assume that the wooded area is in "good" hydrologic condition and a CN of 55 can be used if the soils belong to HSG B. Similarly, a CN of 77 is recommended if the soils belong to HSG D. We can now perform some preliminary computations using these values, equation 3, and the USDA SCS assumption that Ia is equal to 20 percent of S:

PARAMETER	SOIL GROUP B	SOIL GROUP D
CN	55	77
S (inches)	8.18	2.99
Ia (inches)	1.64	0.60

From these computations, we can make some comparisons between the two soils right away, even before the rain begins. For instance, we have estimated that a drainage area comprised of HSG B soils can potentially retain 8.18 in (20.8 cm) of rainfall, once the initial abstraction of 1.64 in (4.2 cm) is used up and runoff begins. This is almost three times greater than if the drainage area were comprised of HSG D soils. In addition, the HSG B drainage area requires a greater amount of rainfall to overcome the initial abstraction and for runoff to begin than the HSG D drainage area.

To complete the computations, we use 24-hour rainfall values for the general Chicago area for 2-year, 10-year, and 100-year storm events from Figure 1.3 (from TR-55, Appendix B: Figures B-3, B-5, and B-8). Using these values, the preliminary computations, and equation 2, we can compute the following estimates of runoff volume:

STORM FREQ. (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)	
		B SOIL	D SOIL
2	2.8	0.14	0.93
10	4.0	0.53	1.81
100	5.8	1.40	3.30

The estimated runoff volumes from equation 2 are expressed in inches, which does not exactly meet the mathematical definition of volume. Actually, these volumes are meant to represent average runoff depths over the entire drainage area where the CN has been computed (the USDA SCS runoff equation does not have an explicit term for drainage-area size). To compute the various runoff volumes in more traditional measurement units, we can multiply the average runoff depths produced by equation 2 by the 20-acre drainage area (making sure of our units) to produce several different versions of estimated volumes:

STORM FREQ. (years)	ESTIMATED RUNOFF (inches)		ESTIMATED RUNOFF (cubic feet)		ESTIMATED RUNOFF (acre-feet)	
	B SOIL	D SOIL	B SOIL	D SOIL	B SOIL	D SOIL
2	0.14	0.93	10,019	67,518	0.23	1.55
10	0.53	1.81	38,333	131,551	0.88	3.02
100	1.40	3.30	101,495	239,580	2.33	5.50

All previous estimates for each storm frequency and HSG represent the same runoff volume—they only represent different units. Referring to runoff volumes in inches of average depth over the entire watershed or in units of acre-feet is often easier than in cubic feet.

In comparing the two HSGs, the HSG D drainage area would produce 2-year, 10-year, and 100-year runoff volumes that are 6.6, 3.4, and 2.4 times greater than those from the HSG B drainage area. This confirms our suspicions from the preliminary computations. While the HSG D runoff volumes are greater than those for HSG B in all storm frequencies analyzed, the percentage difference decreases as the storm frequency—or, more precisely, the rainfall amounts—increases. However, the USDA SCS runoff equation uses both a fixed initial abstraction value for a given CN (i.e., it does not vary with rainfall) and an exponential infiltration rate (note the squared numerator in equations 1 and 2). We will explore this important aspect of urban runoff hydrology later.

Some interesting relationships exist within each HSG. For example, in the HSG B drainage area, the estimated 2-year runoff volume represents only 5 percent of the total 2-year rainfall. This percentage increases first to 13 percent and then to 24 percent for the HSG B drainage area as

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the storm frequency/rainfall amount increases to the 10-year and 100-year levels. A similar relationship between event frequencies exists for the HSG D drainage area.

The following is a summary of the percentages for both HSGs:

STORM FREQ. (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)		RUNOFF AS PERCENT OF RAINFALL	
		B SOIL	D SOIL	B SOIL	D SOIL
2	2.8	0.14	0.93	5%	33%
10	4.0	0.53	1.81	13%	45%
100	5.8	1.40	3.30	24%	57%

These relationships show the effects of both the initial abstraction and nonlinear (i.e., exponential) infiltration rate assumptions from the USDA SCS runoff equation. The percentages also show the strong effect of soil characteristics on runoff volume from a given amount of rainfall. The data show that a much greater percentage of rain falling on the HSG D drainage area will likely become runoff than the percentage on the HSG B drainage area. For example, while we estimate that only 5 percent of the 2-year rainfall on the HSG B drainage area will become runoff, 33 percent of the same rain falling on the HSG D drainage area (with the same ground cover) will become runoff. Therefore, this hypothetical switching of HSGs clearly shows why soil characteristics are such an important parameter in runoff computations. The remaining percentage of rain that does not become runoff in either drainage area represents the sum of all the other rainfall byproducts.

We can extend this example to include estimates and comparisons of peak rates at which the various runoff volumes might flow from each drainage area. We will assume that the 24-hour rainfall will fall throughout that 24-hour period in accordance with a hypothetical USDA SCS storm distribution known as Type II. This hypothetical or "design" storm is one of four 24-hour distributions that USDA SCS has developed for various parts of the United States, with Type II recommended for the Chicago area, the location of the 20-acre drainage area in our example (TR-55, Appendix B, contains a detailed description of these distributions).

Assuming a Type II storm and an estimated TC of 0.5 hours, we use Figure 1.5 to estimate the various peak runoff rates for the different storm frequencies and soil groups (TR-55, Chapter 3, contains one of the most complete and concise presentations of both the concept and computation of TC presently available).

Figure 1.5 presents various values of the parameter, unit peak discharge (qu), expressed in units of cubic feet per second per square mile of drainage area per inch of runoff (csm/in), for various drainage area TCs and Type II storm distribution. Multiplying the appropriate unit peak discharge value by the drainage-area size (expressed in square miles) and the estimated runoff volume (expressed in inches) will yield an estimate of peak runoff rate in units of cubic feet per second (cfs). Figure 1.5 also contains one additional value, Ia/P—the ratio of the drainage area's initial abstraction to the total storm rainfall—that must be determined before estimating a peak rate (TR-55, Chapter 4, contains more instruction and insight into estimating peak runoff rates).

Summaries of the resulting computations for the 20-acre (8.1 ha; 0.03 mi^2) drainage area with a 0.5 hour TC for both HSGs follow:

FOR HYDROLOGIC SOIL GROUP B

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.14	0.59	230	1.0
10	0.53	0.41	340	5.6
100	1.40	0.28	450	19.7

FOR HYDROLOGIC SOIL GROUP D

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.93	0.21	470	13.7
10	1.81	0.15	505	28.6
100	3.30	0.10	530	54.7

In the HSG B and D tables, we note that while the estimated peak runoff rates for the HSG D drainage area are greater than those for the

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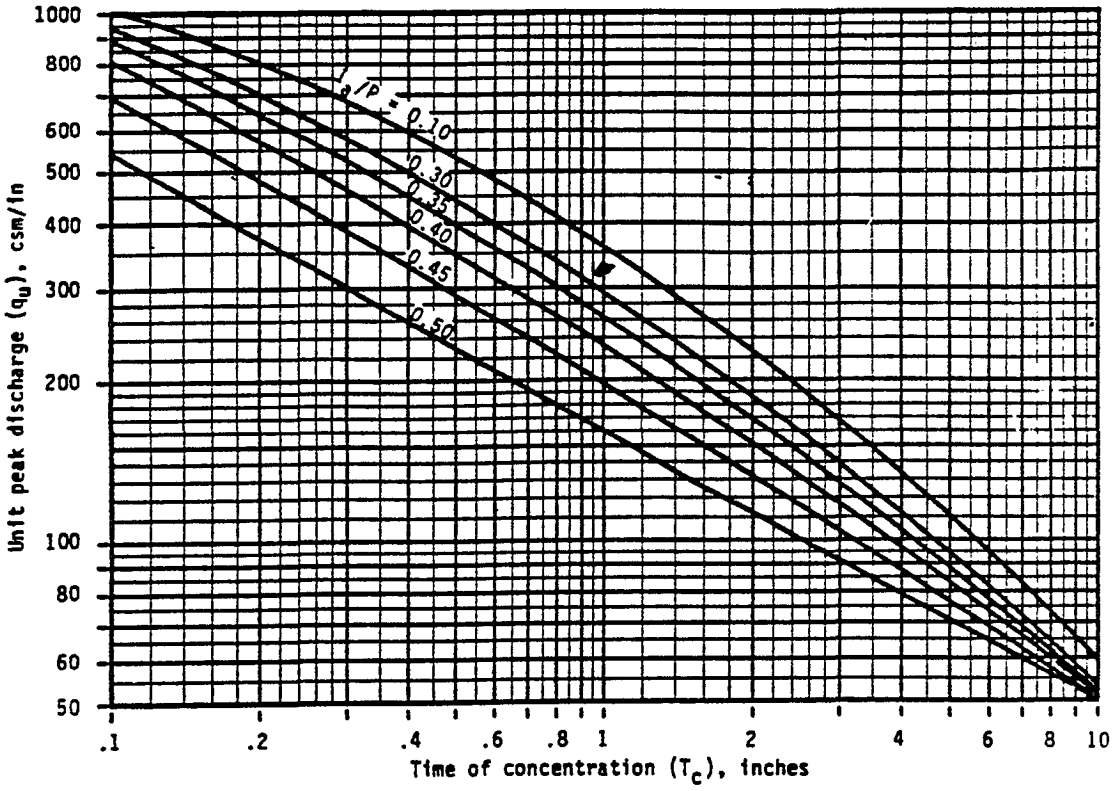
Figure 1.5—Unit peak discharge (qu) for Soil Conservation Service Type II storm.



Source: U.S. Dep. Agric. 1986.

HSG B, the ratio or percentage difference between the peak rates is greater than between the volumes. For example, the HSG D volume estimate for the 10-year frequency storm is 3.4 times greater (1.81 inches divided by 0.53 inches) than the HSG B volume. However, the HSG D peak rate estimate for the same 10-year frequency storm is 5.1 times greater (28.6 cfs divided by 5.6 cfs) than the HSG B peak rate. Similar increases for the 2-year and 100-year events show the same decreasing trend for increasing rainfall amounts. This further difference between the two HSGs is the result of several factors. These include the HSG D soil's lower initial abstraction, which results in an earlier start of runoff and has a lower Ia/P ratio and higher qu value; the variable shape of the Type II storm distribution, in which the most intense rainfalls occurs near the middle of the 24-hour duration; and the exponential character of the USDA SCS runoff equation.

The examples confirm the following points. First, the amount of runoff produced by rainfall varies nonlinearly. Consequently, as the rainfall amount increases, the amount of runoff volume will increase even more. This relationship is also true for peak runoff rates. Second, a change in drainage area or watershed runoff characteristics, as demonstrated by hypothetically varying the soils from HSG B to HSG D, can complicate both the runoff volume and rate. Finally, while we can generalize on a drainage area's rainfall/runoff relationship, we can only determine specific estimates of resultant runoff through mathematical analysis based on sound assumptions and the appropriate amount and quality of data. We will explore these relationships and the effects of drainage area changes in discussing hydrologic impacts of land development.

The Soil Erosion Process

Concepts and Theories

As previously stated, both rainfall and the runoff it produces—or is converted into—affect and are af-

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fected by the land surfaces they contact. For rainfall, this contact occurs only at the instant the raindrops strike the ground. For runoff, the contact period normally lasts considerably longer. Nevertheless, the forces exerted briefly by raindrops and longer by runoff combine to dislodge and transport soil particles, commonly known as sediment.

Chapter 2 discusses in detail the impacts of sediment on surface water quality, biota, and habitat, presenting the theoretical and technical fundamentals of the soil erosion process. A sound understanding of these fundamentals will prepare readers for the more detailed presentations to follow and will enable them to better develop and manage a comprehensive urban runoff management program. The soil erosion fundamentals are largely based on Appendix A1 of the *Standards for Soil Erosion and Sediment Control in New Jersey* (1987). The publication is one of many excellent sources for theoretical and practical information on soil erosion and its control.

Soil erosion is a three-part process, beginning the instant raindrops strike the ground surface, sometimes at velocities up to 30 mi (48.3 km) an hour. The impact force is often sufficient to dislodge soil particles from bare ground surface and begin their movement down slope. This initial stage of the soil erosion process primarily from raindrop impact is known as sheet erosion. In the sheet erosion stage, significant quantities of soil particles are mobilized from the enormous number of raindrop impacts over an area.

The exact amount of sediment produced during sheet erosion depends on several factors, including the size, mass, and texture of the soil particles; the size and slope of the ground surface; the type and degree of surface cover; and the intensity and duration of the rainfall. The shear forces created by runoff flowing across the impacted area from upslope portions of the drainage area can also dislodge soil particles from the ground surface. This increases the total quantity of sediment produced during sheet erosion.

Once the soil particles are detached from the surface, runoff primarily keeps them mobilized during the next stage of soil erosion—downslope transport. During this stage, runoff transports the sediment across the ground surface, along small rills and gullies, and through larger swales and channels. The extent of the sediment movement also depends on a large number of factors, including the volume, rate, and duration of the runoff; the size, mass, and shape of the displaced soil; and the shape, slope, and roughness of the various surfaces over which the runoff-borne sediment is moving. As previously explained, runoff moving across the ground surface also further displaces soil particles by mobilizing previously attached material. This runoff movement can create enormous amounts of additional sediment, particularly in highly erodible stream channels.

The final stage of the soil erosion process is the deposition stage, when the runoff can no longer carry the sediment and deposits it back on the ground some distance from where it originated. This can occur anywhere in the watershed—from upland surfaces, to channels, to lake bottoms. The watershed is then left with depleted upper soil layers in some portions and new soil layers in others.

The soil erosion process is extremely complex and dynamic. All three stages can and do occur continually, to varying degrees, throughout the rainfall/runoff event—which is also complex and dynamic. Since sediment produced by the soil erosion process can come from anywhere in the watershed, we must carefully manage and protect each portion and component.

Estimating Sheet and Rill Erosion

Despite the complexities of measuring sediment, research and experience have developed various methods and techniques to estimate the amount of soil loss from sheet and rill erosion. The Universal Soil Loss Equation (USLE) is generally accepted as the standard technique to estimate the effectiveness of various erosion control practices and measures. Appendix A of the *Standards for Soil Erosion and Sediment Control in New Jersey* (1987) contains a detailed presentation.

The USLE is an empirical equation used to estimate the annual amount of soil lost by sheet and rill erosion on a given parcel of land:

$$E = (R)(K)(L)(C)(P) \qquad [4]$$

where:

- E = Estimated Annual Soil Loss due to sheet erosion (in tons/acre/year).
- R = Rainfall Factor or Rainfall Erosion Index—a measure of the erosive force of rainfall occurring over the study area during a normal year. Figure 1.6 presents typical values of R for various portions of New Jersey.

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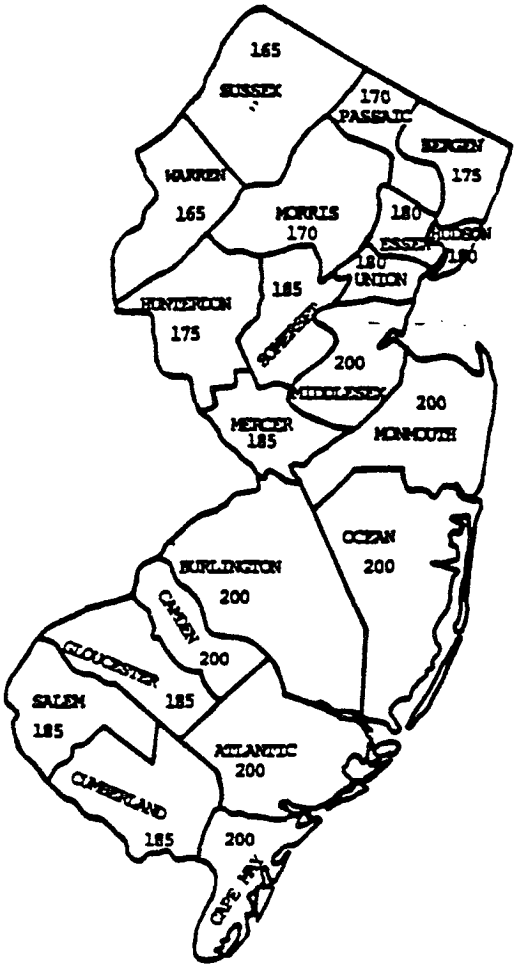
Figure 1.6—Rainfall erosion index (R) for New Jersey counties.



Source: New Jersey Dep. Agric. 1987.

TABLE 1.2—Universal Soil Loss Equation soil erodibility (K) classes and ranges.

ERODIBILITY CLASS	RANGE OF K
Low	0.17 – 0.24
Medium	0.28 – 0.37
High	0.43 – 0.49

Source: New Jersey Dep. Agric. 1987.

K = Soil Erodibility Factor—a measure of the erodibility of soils in the study area based on field tests of fallow ground with standardized slope and length. Table 1.2 presents ranges of K for various soil erodibility classes.

L = Slope Length Factor—allows adjustments to be made to K to account for the actual slopes and lengths in the study area that vary from the standardized test values.

C = Cover Index—allows adjustments to be made to K to account for the actual ground cover in the study area other than the standard fallow condition. Table 1.3 present typical values of C for various ground covers.

P = Erosion Control Practice Factor—a relative measure of the effects of various surface conditions in the study area. Table 1.4 presents typical values of P for various surface conditions found particularly at construction sites.

The USLE uses additional factors to produce estimates for periods of time less than one vear and for individual storm events of specified frequency.

The USLE is a fairly simple mathematical equation. The estimated soil loss is a function of the erosive properties of a given soil (K), as determined through standardized tests, which are then modified by a number of pertinent factors—such as rainfall and ground slope, cover, and surface character—to reflect the actual conditions in which the soil exists. In addition, the mathematical relationship between all input factors and the final result are linear—a certain percentage change in any input variable results in an identical change in the result.

The actual sheet and rill erosion process, however, is not simple and the various input factors do not behave in a simple, linear fashion. The USLE's apparent simplicity masks the complexity of the actual sheet erosion process and the difficulty of mathematical modeling. Users need to exercise caution when applying the USLE and its estimates.

The most important aspects of the USLE that relate to urban runoff management programs are the cover index (C) and the erosion control practice factor (P). These are the factors that designers, constructors, and regulators can control. For example, placing straw mulch on bare ground at the

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Table 1.3—Universal Soil Loss Equation typical cover index (C) values.

GROUND COVER	APPLICATION RATE (tons/acre)	SLOPE (%)	TYPICAL C
None	—	All	1.00
Straw or hay	1.0	0 – 10	0.20
	1.5	0 – 10	0.12
	2.0	0 – 10	0.06
	2.0	11 – 15	0.07
Crushed stone (0.25–1.50")	135	0 – 15	0.05
	240	0 – 15	0.02
Woodchips	7	0 – 15	0.08
	12	0 – 15	0.05
	25	0 – 15	0.02
Temporary seeding and straw mulch (first 6 weeks)	No mulch	—	0.70
	Mulch @ 1.0	—	0.20
	Mulch @ 1.5	—	0.12
	Mulch @ 2.0	—	0.06
	No mulch	—	0.10
	Mulch @ 1.0	—	0.07
	Mulch @ 1.5	—	0.05
	Mulch @ 2.0	—	0.05
Permanent seeding (after 2 years) and sod	—	—	0.01

Source: New Jersey Dep. Agric. 1987.

rate of 1 ton per acre will result in an 80 percent reduction of the C value in the USLE (in Table 1.3, from 1.0 to 0.2). The USLE's linear nature can produce a similar reduction in the estimated soil lost through sheet erosion from those surfaces. Proper surface conditions, demonstrated in the typical P values in Table 1.4, can achieve more limited results.

Table 1.4—Universal Soil Loss Equation typical Practice Factor (P) values.

SURFACE CONDITION WITH NO COVER	TYPICAL P
Compacted and smooth Machine scraped along slope	1.3
Compacted and smooth Machine raked along slope	1.2
Compacted and smooth Machine scraped across slope	1.2
Compacted and smooth Machine raked across slope	0.9
Rough and irregular Random machine tracks	0.9
Loose and smooth Deeper than 12 inches	0.9
Loose and rough Deeper than 12 inches	0.8

Source: New Jersey Dep. Agric. 1987.

The second aspect of the USLE and sheet erosion is the time the erosive condition is allowed to exist in the field. Regardless of the ground cover, surface conditions, or any other USLE sheet erosion factor, limiting erosion to the shortest practical exposure time attains the least soil loss. Chapter 4 recommends techniques and regulations to minimize losses.

USDA is in the process of replacing the USLE with the Water Erosion Prediction Program (WEPP). Currently, the Revised Universal Soil Loss Equation (RUSLE) is being adopted nationwide. RUSLE is based on updated rainfall cover index and erosion control practice factors.

Estimating Channel Erosion

The sediment created by sheet erosion is only part of the soil erosion process. Once the runoff across the ground surface exceeds a certain depth, gravity moves the runoff toward collection in progres-

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sively larger conveyance devices. These range from small rills to large gullies and finally to stream and river channels. As gravity forces runoff to flow downslope, it creates further erosion and collects additional sediment from the soils on the banks and bottoms.

Whether runoff causes such erosion and how much sediment it creates depends on a number of interrelated and dynamic factors. These include the velocity and duration of flow; weight, shape, and location of the soil particles; the degree of sediment already suspended in the runoff; and the channel's shape, length, slope, and irregularity.

Although estimating soil losses due to channel erosion is beyond the scope of this and most similar manuals, the rate of channel erosion is partly a function of the channel's flow velocity. While all velocities do not cause erosion, a channel is generally considered to be stable up to some conceptual flow velocity, called the maximum permissible velocity. This flow velocity should be thought of as the channel erosion equivalent of time of concentration—that is, a conceptualization that can be practically used.

Once this maximum permissible velocity is exceeded, erosion of soil particles on the channel banks and bottom will begin and continue as long as the velocity is maintained. As the flow velocity increases, the rate of erosion will also increase. While we cannot determine an upper limit on the erosion rate, the quantity of sediment produced by channel erosion can be enormous, as an inspection of natural stream channels immediately following a major flood event can show.

Impacts of Land Development

Impacts on Urban Runoff

Typically, a land development project in a drainage area or watershed involves replacing or modifying at least some of the existing surface cover with roads, roofs, driveways, and other impervious material. Since the existing cover material is usually more permeable, particularly if it existed naturally, this change will result in a greater percentage of rainfall becoming runoff. We can use the USDA SCS runoff equation (equation 2) and the recommended runoff curve numbers (CNs) from Table 1.1 to quantify this.

We will assume that the 20-acre (8.1-ha) wooded drainage area in the earlier example has now been converted into half-acre residential lots with an average impervious coverage of 25 percent and, for simplification, contains soils in HSG B. According to values from Table 1.1, the CN would increase from 55 in the wooded state to 70 when the homes, lots, and roads are constructed and the lawns and other landscaped areas are fully established. Equations 2 and 3 produce the results shown in Table 1.5.

Table 1.5—Comparison of runoff volume between undeveloped and developed conditions.

PARAMETER	UNDEVELOPED CONDITIONS	DEVELOPED CONDITIONS
CN	55	70
S (inches)	8.18	4.29
Ia (inches)[2]	1.64	0.86

STORM FREQUENCY (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)	
		Undeveloped	Developed
2	2.8	0.14	0.60
10	4.0	0.53	1.33
100	5.8	1.40	2.64

STORM FREQUENCY (years)	24-HOUR RAINFALL (inches)	ESTIMATED RUNOFF (inches)		RUNOFF AS PERCENT OF RAINFALL	
		Undevel.	Devel.	Undevel.	Devel.
2	2.8	0.14	0.60	5%	21%
10	4.0	0.53	1.33	13%	33%
100	5.8	1.40	2.64	24%	46%

The increase in impervious coverage has reduced the drainage area's initial abstraction by nearly a half—from 1.64 in (4.2 cm) to 0.86 in (2.2 cm)—and less rainfall is needed to produce runoff from the drainage area. This results in a greater amount of runoff from storms that already produced runoff from the drainage area and an increase in the total number of future runoff-producing storms. Among other impacts, this increase in runoff means decreased amounts of rain infiltrating into the soil. This can produce lower groundwater levels and diminished or totally eliminated dry weather or base flows in streams.

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The increased impervious coverage further increases runoff volume by increasing the runoff production rate once the initial abstraction is overcome and runoff begins. We see this clearly by comparing the estimated percentages of rainfall that becomes runoff in undeveloped and developed conditions. The 2-year storm percentage increases fourfold—from 5 percent to 21 percent. The 10-year and 100-year percentages also increase, with the 10-year nearly tripling and the 100-year almost doubling. This indicates, however, that land development impacts on runoff volume will be more acute for the smaller, more frequent storm events—a problem for channels and streams, which are sensitive to these storm events.

Another effect of land development is a decrease in the drainage area's response time or TC. This effect results from the faster flow of runoff across the impervious surfaces and the installation of more efficient (i.e., faster) conveyance measures—gutters, storm sewers, and impermeably lined channels—replacing the natural measures present prior to development. If these measures resulted in a new TC for the 20-acre (8.1-ha) drainage area of 0.25 hours, we can use charts and data from TR-55 to estimate the following changes to the peak runoff rates from the drainage area:

UNDEVELOPED CONDITIONS
Woods in Good Hydrologic Condition

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.14	0.59	230	1.0
10	0.53	0.41	340	5.6
100	1.40	0.28	450	19.7

DEVELOPED CONDITIONS
Half-Acre Residential

STORM FREQUENCY (years)	ESTIMATED RUNOFF (inches)	Ia/P	qu (csm/in)	ESTIMATED PEAK DISCHARGE (cfs)
2	0.60	0.31	620	11.6
10	1.33	0.22	660	27.4
100	2.64	0.15	710	58.6

These estimates indicate that the peak runoff rates from the drainage area increase because of development activity, with the estimated 2-year, 10-year, and 100-year peak rates increasing by factors of approximately 10, 5, and 3, respectively. The impacts of these peak flow increases include increased depths in the streams and rivers downstream, which can aggravate existing flood problems and create new ones in previously safe areas.

As shown in the previous chart, land development impacts on the rainfall-runoff process typically include an increase in the volume of urban runoff created by a given amount of rain, a decrease in the time it takes for runoff to drain from the land, and consequently, an increase in peak rate. These increases can produce more frequent and deeper flood depths, threatening the safety and property of those residing and working downstream. In addition, the increased volume of runoff typically means a decrease in groundwater levels and base flows in the streams and rivers, which also threatens aquatic organisms and their habitats and water supply resources.

Impacts on Soil Erosion

The impacts of land development activity on soil erosion can be devastating. Soil erosion can accelerate to levels higher than geologic norms. These impacts begin during the construction phase, primarily in the form of sheet erosion, and often persist after construction. Increases in sheet erosion during construction are caused by removing natural vegetation during site clearing, exposing surface soils to the impacts from raindrops, and the shear forces of the resultant runoff.

For example, a typical C value for grass cover ranges from approximately 0.10 for temporary grass cover after six weeks of growth to 0.01 for established grass cover or sod (Table 1.3). However, the C value for bare ground is 1.00—10 to 100 times larger. Since the USLE considers the average annual soil loss (E) from an area linearly related to C, the soil lost to sheet erosion during construction can be as much as 100 times greater than from the natural, undisturbed area. This makes up to 100 times more sediment available for runoff to transport into downstream waterways.

However, this estimate does not include the effects of bare soil in increasing the volume and rate of runoff that can dislodge and transport even more sediment. In Table 1.1, the CN for bare soil

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in HSG B is 86, greater than the CN of 70 that reflects final developed conditions in the drainage area. Therefore, the construction phase of land development not only increases the quantity of erodible sediment but also the rate and volume of runoff to transport it.

The increased rate and volume of runoff from development activity can also aggravate existing or create new channel erosion, initiating additional sediment loadings. For the more frequent 2-year and 10-year storms, greater impervious coverage and a shorter drainage area response time produce peak runoff rates 5 to 10 times greater after development. These increased peak runoff rates will, in turn, produce higher peak runoff velocities in the downstream waterways. If these increased velocities exceed a certain critical level, channel erosion will likely occur in previously stable, undisturbed channels. For channels already experiencing erosion, these increased velocities will increase the problem.

Sediment is typically deposited in a flatter, slower reach of the waterway or at the bottom of a wetland, lake, or estuary. Sediment recovery in the lower reaches can also have devastating effects. Chapter 2 discusses the qualitative effects of the erosion and sedimentation process.

Summary and Conclusions

The chapter's purpose is to enable those developing urban runoff management programs to make informed decisions about their programs and increase their effectiveness and applicability.

The chapter's key messages are

1. The rainfall-runoff and soil erosion processes are dynamic and complex. No perfect analytical models or methods can exactly reproduce past runoff or erosion events or predict future ones.

2. Because urban runoff management must consider the quantitative impacts of land development on runoff quality, its complexity significantly increases. These impacts exacerbate any weaknesses or inaccuracies in the analytical models and methods.

3. Through research and a sound understanding of the fundamentals, we can make simplifying assumptions about these hydrologic processes that enable us to produce reasonable, practical, and safe runoff and soil erosion estimates.

4. Everyone involved in developing an urban runoff management program must understand the fundamentals of urban runoff hydrology. Experienced professionals in the field must be included in the development process, particularly in selecting technical standards, methodologies, and measures.

5. The growth of computer resources and capabilities has increased the accuracy and applicability of methods and models and the effectiveness of urban runoff management programs. However, the need for more comprehensive data and expanded user knowledge has increased likewise, further highlighting the importance of technical knowledge and experience.

6. While general information can be a useful guide, the complexity of the hydrologic processes demands site-specific data and methods to identify, define, and/or address urban runoff management problems or concerns.

7. The interrelationships of the rainfall-runoff and soil erosion processes emphasize the need for a comprehensive, watershed approach to all aspects of urban runoff management, ranging from individual site designs to comprehensive regulatory programs.

Recommended Reading

The following publications were influential in developing this chapter. We strongly recommend them to readers wishing to expand their knowledge of the rainfall-runoff and soil erosion processes.

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CHAPTER 2

Water Quality Impacts of Urban Land Use

Urban runoff carries with it a wide variety of pollutants from diverse and diffuse sources. Representing all recognized classes of water pollutants, these runoff contaminants originate not only from land activities in the drainage catchment where runoff is collected but also from atmospheric deposition as either "dryfall" or "wetfall." Moreover, surface and groundwaters can exchange. This chapter focuses on water quality by examining the characteristics, sources, and patterns of urban runoff pollutants and discusses assessment techniques.

Contaminants originating below ground (e.g., landfill leachate, effluent from failing septic systems) can enter surface runoff, while runoff can enter groundwater through sinkholes or drainage wells. Pollutants originating on the surface can also percolate through the soil and contaminate groundwater.

These general sources of urban runoff pollution on, above, and below the surface represent a complex set of watershed conditions. They determine the effects that drainage from the watershed will have on a natural receiving water, and represent a challenge for management. Figure 2.1 illustrates the relationships between watershed activity and its consequences in the receiving water. The complex of watershed conditions determines the characteristics of the habitats that will develop in the receiving waterbody. For example, if the base geological material is relatively insoluble and erosion resistant, a stream draining that area will likely have a substrate of relatively large cobbles, or even bedrock, and a low level of nutrition. The aquatic biota evolve in direct response to the types of habitats produced by the watershed conditions. In this example, the biota will likely consist of diatoms at low biomass levels among the attached algae. Populations of invertebrates and fish, though probably quite diverse, are likely to be relatively small in both numbers and sizes of the individual organisms. The dashed arrow at the top of Figure 2.1 shows that living organisms do have some ability to modify their environment.

The lower portion of Figure 2.1 links watersheds in which humans are active to the systems to which they drain. Numerous pollutants in the watershed, here represented by only two, can stress organisms and interact to varying degrees. This interaction can either reinforce or reduce the stress of the participating agents. Water pollution is not the only condition in the watershed that causes stress. Chief among other stresses is modified hydrology from increased wet weather flow volumes and peak rates discharged from altered landscapes. Conversely, stress can come from decreased dry weather base flows resulting from reduced groundwater recharge in urban areas.

In Figure 2.1, water pollutants go through various kinds of processing before they create some effect on an aquatic organism. During their transport on land and in water, losses such as sedimentation can reduce the total stress burden on water column organisms, although the reduction may not be permanent (e.g., sediments can resuspend). Of course, organisms dwelling among the sediments often become more affected by these processes. Physical, chemical, or biological processes can also cause transformations to different physical (particulate versus dissolved) or chemical forms. Transformation can cause enhanced or reduced stress potential.

Finally, the biota, or receptors, are affected by the various stresses in whatever form they ar-

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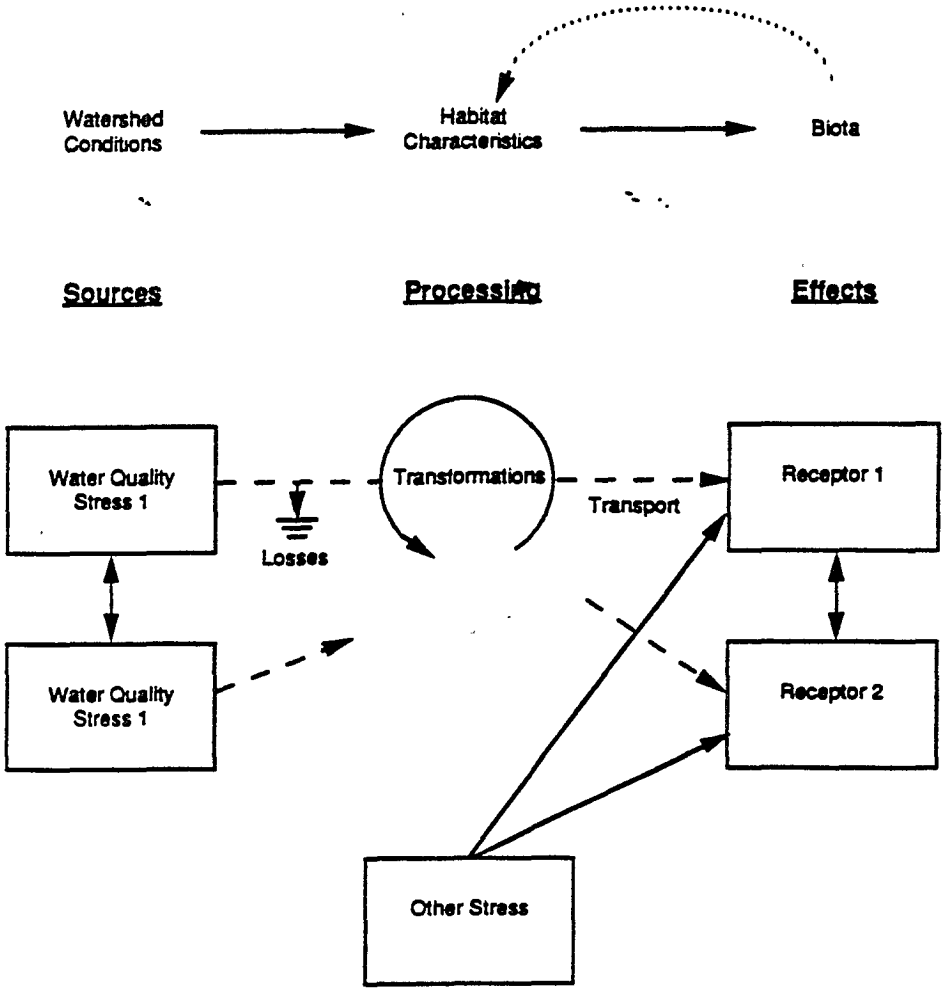
Figure 2.1—Watershed habitat-biological linkages in aquatic ecosystems.



Source: R.R. Horner.

rive. A receptor will have an easier time dealing with a few rather than many stressors, especially when they reinforce each other. Of course, populations of aquatic organisms do not live in isolation but interact with other species, especially in predator-prey relationships. This relationship is represented by the arrow linking the two receptors in the simple system. These interactions have many implications for the ecosystem. For example, the loss of one species from a pollution problem will likely result in the decline or elimination of a major predator of that species.

This illustration sets the stage for discussions in this chapter and in Chapter 3, Aquatic Biological Impacts of Urban Land Use. Substantial complexities exist at every level of the system from pollutant generation to ultimate effects on aquatic ecosystems. Therefore, predicting the result of a particular event or action in the watershed is problematic. However, by carefully tracing the progression of problems and their interrelationships, we can make some judgments to improve our success in ecosystem protection. While this chapter focuses on water quality, Chapter 3 discusses the water quality and hydrologic stresses that disrupt habitats and harm aquatic life.

Characteristics of Urban Runoff Pollutants

Substances in Urban Runoff

Table 2.1 lists pollutant categories commonly found in urban runoff that can harm receiving wa-

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ters and the specific measures that express them. Pollutants other than solids and pathogens are found in either a solid or dissolved state. In urban runoff, most pollutants occur as solids or are associated with soil or other natural particulates. This condition differs among the specific pollutants. For example, depending on overall chemical conditions, each metal differs in solubility. For instance, lead (Pb) is relatively insoluble, while zinc (Zn) is in solution form. The nutrients phosphorus (P) and nitrogen (N) typically differ substantially from one sample to another in dissolved and particulate forms.

Table 2.1—Urban runoff pollutants.

CATEGORY	SPECIFIC MEASURES
Solids	Settleable solids (SS) Total suspended solids (TSS) Turbidity (Turb)
Oxygen-demanding substances	Biochemical oxygen demand (BOD) Chemical oxygen demand (COD) Total organic carbon (TOC)
Phosphorus (P)	Total phosphorus (TP) Soluble reactive phosphorus (SRP) Biologically available phosphorus (BAP)
Nitrogen (N)	Total nitrogen (TN) Total Kjeldahl nitrogen (TKN) (ammonia + organic) Ammonia-nitrogen (NH_3-N) Nitrate + nitrite-nitrogen (NO_3+NO_2-N)
Metals	Copper (Cu), lead (Pb), zinc (Zn), cadmium (Cd), arsenic (As), nickel (Ni), chromium (Cr), mercury (Hg), selenium (Se), silver (Ag)
Pathogens	Fecal coliform bacteria (FC) Enterococcus bacteria (Ent) Viruses
Petroleum hydrocarbons	Oil and grease (O + G) Total petroleum hydrocarbons (TPH)
Synthetic organics	Polynuclear aromatic hydrocarbons (PNAs) Phthalates Pesticides Polychlorobiphenols (PCBs) Solvents

Source: R.R. Horner.

Besides these pollutants, other water quality characteristics affect the behavior and fate of materials in water. These characteristics include

- Temperature (Temp);
- pH—an expression of the relative hydrogen ion concentration on a logarithmic scale of 0-14, with 0-6.99 representing a preponderance of hydrogen relative to hydroxyl ions (acidic conditions), 7.00 being neutral, and 7.01-14 representing a preponderance of hydroxyl ions (basic conditions);
- Dissolved oxygen (DO);
- Alkalinity (Alk)—the capacity of a solution to neutralize acid of a standard pH, usually the result of its carbonate and bicarbonate ion content, but conventionally expressed in terms of calcium carbonate equivalents;
- Hardness—an expression of the relative concentration of divalent cations, principally calcium (Ca) and magnesium (Mg), also conventionally expressed in terms of calcium carbonate equivalents; and
- Conductivity (Cond)—a measure of a water's ability to conduct an electrical current as a result of its total content of dissolved substances (often expressed as salinity in estuarine and marine waters).

These characteristics affect pollutant behavior in several ways. Metals generally become more soluble as pH drops below neutral and hence more available—bioavailable—to harm organisms. Depleted dissolved oxygen can also make some metals more soluble. Anaerobic conditions in the bottom of lakes release phosphorus from sediments, as iron changes from the ferric to the ferrous form. Elements creating hardness work against the toxicity of many heavy metals. Water quality standards take this relationship into account by varying the permitted level as a function of hardness.

Quantifying Water Pollutants

Water pollutants are quantified by concentrations and loadings. Concentration is the mass of pollutant per unit volume of water sample, usually expressed as mg/L or µg/L. It is a measure of the pollutant content at the instant the sample is taken. If the pollutant level is higher than an aquatic organism can tolerate, the concentration represents an acute effect that could be lethal or affect the performance of some physiological function as long as the concentration persists. The effects of pollutant concentrations have been

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established through bioassays exposing test organisms in standard laboratory procedures. However, these simple, static tests completely omit the dynamic patterns and other complexities associated with urban runoff.

Loading is the mass of pollutants delivered to a waterbody over a period of time and is usually given on an annual basis as kg/year (kg/y) or lbs/y. When ascribed to a particular land use, loading—sometimes termed yield or export—is stated per unit area of the land use (kg/ha-y or lbs/acre-y). It represents the cumulative burden over the extended period and hence the potential chronic effects on receptor organisms. With few exceptions (e.g., phosphorus loading to lakes), testing has not established the biological significance of loadings and the way they are delivered to a waterbody. Thus, loading is mainly used to

Table 2.2—Pollutant concentration statistics for general urban and highway runoff.

CONSTITUENTS	GENERAL URBAN RUNOFF MEAN	GENERAL URBAN RUNOFF RANGE*	HIGHWAYS RUNOFF MEAN	HIGHWAYS RUNOFF RANGE*	LIMITS FOR PROTECTION OF AQUATIC LIFE**
Suspended Solids (mg/L)	150[2]	2-2,890	220[3]	14-522	10 if background ≤ 100 mg/L 10% of background if background > 100 mg/L
BOD (mg/L)	9[1]	0.41-159	•	•	•
COD (mg/L)	65[1]	< 10-1,031	124[3]	34-1,291	•
Lead (µg/L)	140[1]	3-28,000	550[3]	10-3,775	34
Copper (µg/L)	34[1]	4-560	43[7]	13-288	6.7
Zinc (µg/L)	160[1]	10-5,750	380[3]	40-25,500	30
Cadmium (µg/L)	0.7[8]	0.7-30	•	•	0.2
Chromium (µg/L)	7[8]	< 10-110	•	•	2
Nickel (µg/L)	12[8]	< 2-126	•	•	25
Arsenic (µg/L)	13[8]	10-130	•	•	50
Organic Pesticides (µg/L)	•	0.002-0.35[8]	•	•	•
Phthalate Esters (µg/L)	•	0.06-160[8]	•	•	4-DBP, 0.6-DEHP 0.2-all other PAEs
Phenols (µg/L)	•	8-115[8]	•	•	•
Oil & Grease (mg/L)	7.8[4]	up to 35.7	30[6]	•	•
Total Hydrocarbons (mg/L)	3.7[5]	1.8-43	•	•	•
Polynuclear Aromatic Hydocarbons (µg/L)	•	< 0.01-12	3.7[6]	•	0.01 BaP
Total Nitrogen (mg/L-N)	1.5[1]	0.34-20	2.72[3]	up to 3.4	•
Total Phosphorus (mg/L)	0.33[1]	0.01-4.3	0.59[3]	up to 0.7	0.005-0.015***
Alkalinity (mg/L)	38.2[4]	5.5-87	•	•	recommend > 20
pH	•	6.2-8.7[4]	•	6.6-8.0[6]	6.5-9.0

- • No data reported.
- * Range of actual values reported in literature from various studies unless otherwise indicated.
- ** Maximum concentrations for the protection of freshwater aquatic life as reported in "Approved and Working Criteria for Water Quality," British Columbia Ministry of Environment (1989), when the receiving water hardness is 50 mg/L $CaCO_3$ (average for Fraser River in Lower Mainland).
- *** For lakes with salmonids as predominant fish species.
- [1] U.S. Nationwide Urban Runoff Program database.
- [2] U.S. EPA database.
- [3] Median of U.S. Federal Highways Administration database.
- [4] Light Industrial Catchment in British Columbia.
- [5] General Urban Catchment in Philadelphia.
- [6] Highway runoff in England.
- [7] Highway runoff in Washington State.
- [8] Data from Metro Seattle.

Source: British Columbia Res. Corp. 1992.

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make relative comparisons, for example, of total pollutant burden before and after development or with and without a certain control strategy.

Table 2.2 presents concentration statistics on several pollutants in general urban and highway runoff and water quality criteria to protect aquatic life. While concentrations generally range widely, the mean values tend to be low. Highway runoff is similar to urban drainage, but means and maximums are generally higher. Urban runoff usually does not exceed water quality criteria with reasonable dilution in the receiving water, but it could. These criteria stem from laboratory testing and represent continuous flow discharges, such as industrial and municipal sewage treatment plant effluents, better than runoff.

Table 2.3 presents typical loadings for a number of pollutants and land uses. Although this table presents no ranges or statistics on the possible dispersion of these numbers when measurements are made, the variation is always substantial from place-to-place in the same land use and from year-to-year at the same place. The general order of loading production, from highest to lowest is

> Industrial and commercial > freeway > higher-density residential > lower-density residential > open land.

However, the construction phase can produce far higher loadings of solids and pollutants in soil, like phosphorus, than any finished land use. These data, however, were derived from 10-year-old studies and should be used with caution. For example, substantial evidence indicates that the values for lead have considerably declined in urban runoff with the much reduced use of leaded gasoline.

Metals and synthetic organics are of particular interest because of their potential for toxicity to human consumers of water and to aquatic life. They make up most of EPA's priority pollutants list. Table 2.4 lists the priority pollutants most frequently detected in samples collected during EPA's Nationwide Urban Runoff Program (NURP) in the early 1980s. Three metals (lead, zinc, and copper) were found in almost all samples, and four additional metals were detected in approximately half. Phthalate, the most common synthetic organic, was found in only 22 percent of the samples. Present in 10 to 19 percent were three chlorinated hydrocarbons (two pesticides and a wood preservative) and four polynuclear aromatic hydrocarbons (PNAs).

Table 2.3—Typical pollutant loadings (lbs/acre-y) from urban land uses.

LAND USE	TSS	TP	TKN	NH_3-N	NO_2-N	BOD	COD	Pb	Zn	Cu
Commercial	1,000	1.5	6.7	1.9	3.1	62	420	2.7	2.1	0.4
Parking lot	400	0.7	5.1	2.0	2.9	47	270	0.8	0.8	0.04
High-density residential	420	1.0	4.2	0.8	2.0	27	170	0.8	0.7	0.03
Medium-density residential	190	0.5	2.5	0.5	1.4	13	72	0.2	0.2	0.14
Low-density residential	10	0.04	0.03	0.02	0.1	NA	NA	0.01	0.04	0.01
Freeway	880	0.9	7.9	1.5	4.2	NA	NA	4.5	2.1	0.37
Industrial	860	1.3	3.8	0.2	1.3	NA	NA	2.4	7.3	0.50
Park	3	0.03	1.5	NA	0.3	NA	2	0.005	NA	NA
Construction	60,000	80	NA	NA	NA	NA	NA	NA	NA	NA

NA not available.

Source: Pitt, 1991; Horner and Mar, 1982.

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Table 2.4—Most frequently detected priority pollutants in Nationwide Urban Runoff Program samples.

INORGANICS	ORGANICS
DETECTED IN 75% OR MORE	
94% Lead 94% Zinc 91% Copper	None
DETECTED IN 50-74%	
58% Chromium 52% Arsenic	None
DETECTED IN 20-49%	
48% Cadmium 43% Nickel 23% Cyanides	22% Bis(2-ethylhexyl)phthalate 20% α-Hexachloro-cyclohexane
DETECTED IN 10-19%	
13% Antimony 12% Beryllium 11% Selenium	19% α-Endosulfan 19% Pentachlorophenol[a] 17% Chlordane[a] 15% Lindane[a] Pyrene[b] 14% Phenol 12% Phenanthrene[b] 11% Dichloromethane 10% 4-Nitrophenol 10% Chrysene[b] 10% Fluoranthene[b]

[a] Chlorinated hydrocarbon
[b] Polynuclear aromatic hydrocarbon

Source: U.S. Environ. Prot. Agency, 1983.

Sources of Urban Runoff Pollutants

Table 2.5 summarizes urban runoff pollutant sources and shows that most pollutant categories have diverse sources. Likewise, the major sources emit contaminants in most pollutant categories. The atmosphere also contributes some pollution to runoff. Thus, urban runoff is a multifaceted and complex problem to manage.

Synthetic organics represents an exceptionally large and diverse category of chemicals. They include hundreds of specialized products for industrial and commercial uses and compounds produced incidentally through chemical reactions. Examples of the latter group are the PNAs, by-products of fossil fuel combustion, that appear in vehicle exhausts and lubricants and smokestack emissions. New chemicals also form through environmental reactions after the release of a material.

Stormwater management can also be the source of pollutants. During large flows, poorly maintained facilities—like catch basins, conveyance systems, sedimentation ponds, and belowground vaults—can release surges of sediments trapped during small storm events. Galvanized pipes and other parts of drainage systems, commonly used to convey runoff, can also add zinc, a ubiquitous metal in the environment.

Urban Runoff Water Quality Patterns

While pollutant magnitudes in urban runoff follow characteristic patterns over short and long time spans, they vary greatly over space and time. The short term spans a period of hours during one or a sequence of storm events. Measurements at discrete points through such a period often reveal a pattern of pollutant concentration similar to that illustrated in Figure 2.2. During the first minutes, first flush of runoff contains a relatively high concentration of contaminants. The concentration then drops substantially and fluctuates at a lower level for the remainder of the runoff event. The first flush sometimes does not appear, or is less pronounced, when rainfall is not intense or follows soon after an earlier storm that cleans the surfaces. A secondary spike can appear if a sudden burst of intense rain drives material off surfaces not completely cleaned by the initial runoff. Runoff concentrations assume an almost infinite variety of patterns depending on rainfall intensity, antecedent period length and conditions, deposition during the antecedent period, and surface characteristics.

The event concentration-time graph (Figure 2.2) shows the stress created by a single pollutant on a receptor organism. The concentrations represent a series of acute stresses, the most significant of which is the maximum concentration often reached during the first flush. Experts do not fully understand the consequences of a short-duration elevated concentration, even one above water quality criteria, and of the fluctuating stress-filled environment of runoff receiving waters on their resident organisms.

Because of the difficulty in characterizing pollutant concentrations during dynamic flow

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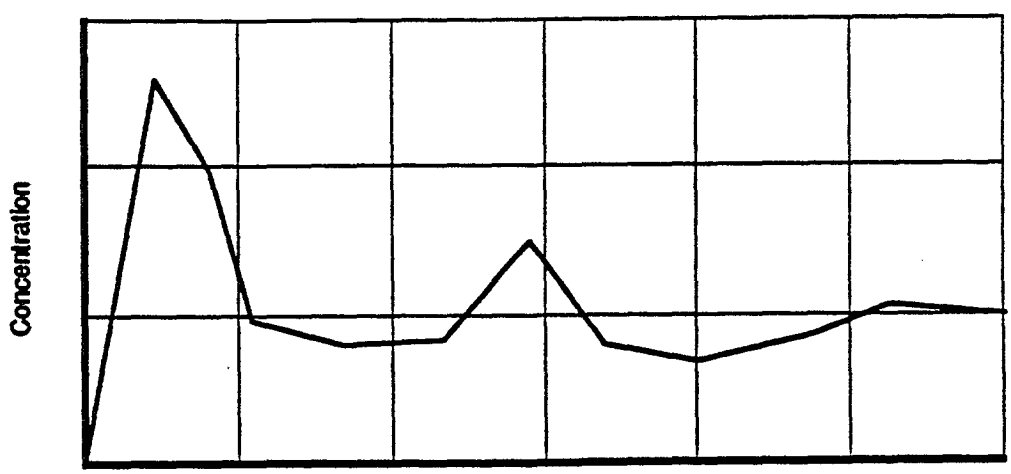
Table 2.5—Urban runoff pollutant sources.

POLLUTANT CATEGORY SOURCE	SOLIDS	NUTRIENTS	PATHOGENS	DO DEMANDS	METALS	OILS	SYNTHETIC ORGANICS
Soil erosion	X	X		X	X		
Cleared vegetation	X	X		X			
Fertilizers		X					
Human waste	X	X	X	X			
Animal waste	X	X	X	X			
Vehicle fuels and fluids	X		X	X	X	X	
Fuel combustion						X	
Vehicle wear	X			X	X		
Industrial and household chemicals	X	X		X	X	X	X
Industrial processes	X	X		X	X	X	X
Paints and preservatives					X	X	
Pesticides				X	X	X	
Stormwater facilities	X				X		

Source: R.R. Horner.

Figure 2.2—Typical pollutant concentration pattern during a storm event.



Source: R.R. Horner.

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conditions, the expense of sampling, and the analysis required to produce even a partial picture, the accepted practice is to determine an event-mean concentration (EMC). This value is found by analyzing a single sample composited from a series of samples taken at points throughout the runoff event and combined in proportion to the flow rate existing at the time of sampling (termed a flow-proportional composite sample). In addition to its expediency, basing impact assessment on the EMC is justified from a biological standpoint. This will be further explored in Chapter 3.

The flow pattern of an event is customarily pictured on a hydrograph—a graph of flow rate (water volume per unit time) versus time. The integrated area under the curve is the total event runoff volume; the product of volume and EMC is the pollutant loading for the event. The sum of loadings for all events in an interval (e.g., a year) represents the cumulative pollutant burden during that time.

Analysis of climatological data in a number of U.S. locations reveals that most of the total annual runoff is produced by numerous small storms and the initial runoff from large storms. For example, Livingston and Roesner (in press) used Cincinnati data to show that the first 0.5 in (1.27 cm) of runoff from all storms represents more than 90 percent of the total annual runoff volume and encompasses all but four or five events in an average year. Theoretical reasons and some empirical demonstrations indicate that the majority of pollutant loadings is also generated by these smaller flow volumes. Hydrologic criteria for runoff treatment system design are based on these patterns. For example, a pond needs sufficient volume to treat the first 0.5 or 1 in (1.27 or 2.54 cm) of runoff, or the runoff associated with the six-month return frequency, 24-hour duration precipitation event.

Urban Runoff Water Quality Estimation

We need a quantitative estimate of water quality to assess impacts from development actions or to predict the benefits of a management plan. This estimation process is called water quality modeling. although this term is sometimes restricted to the more sophisticated approaches. Assessments are based on annual pollutant loading estimates, although short-term loadings or concentrations are sometimes needed. Long-term loadings tend to diminish the large fluctuations to which short-term phenomena, like instantaneous or event-mean concentrations, are subject. Therefore, we can estimate long-term loading with more assurance than concentrations.

Estimating Concentrations

Since concentrations have a high variation level, they must be estimated based on probability—i.e., the ability to state the probability of exceeding any selected concentration. Estimating the probability of concentrations can theoretically be used to estimate maximum (or any other level), but it is usually restricted to the EMC. To estimate even the EMC, we need a large data set to establish the underlying probability distribution for the locale or an assumption of the distribution and a smaller local data set to fit the distribution.

NURP and other data conclusively demonstrated that urban runoff pollutant concentrations fit a log-normal probability distribution—i.e., their logarithms are normally distributed. This is the characteristic distribution of data like those in Table 2.2, where the distribution range is much higher than the mean, and most values are in the lower portion. Figure 2.3, taken from highway runoff data in Washington State, illustrates such a distribution. It shows that the concentration of total suspended solids (TSS EMC) reached as high as 550 mg/L, but exceeded 300 mg/L in less than 10 of more than 130 storms.

Figure 2.4 graphs a highway runoff lead distribution (untreated) on a log-probability plot. The horizontal probability axis expresses the chance of exceeding any concentration selected from the vertical axis. For example, the probability of exceeding 0.12 mg/L in untreated, undiluted runoff is 50 percent, and the chance of surpassing 0.24 mg/L is 10 percent. Treatment or dilution capable of reducing the concentration by 50 percent would decrease the probability of exceeding 0.12 mg/L to 10 percent. Adding the water quality criteria permits performing the analysis from a regulatory perspective. For example, if the receiving water is a drinking water source, the concentration must be reduced by 90 percent to have no more than a 0.5 percent chance of violating the then current standard (the standard is lower now).

NURP produced graphs like Figure 2.4 for each pollutant to determine the EMCs at each site and the EMC medians from all sites nationwide (U.S. Environ. Prot. Agency, 1983). These plots

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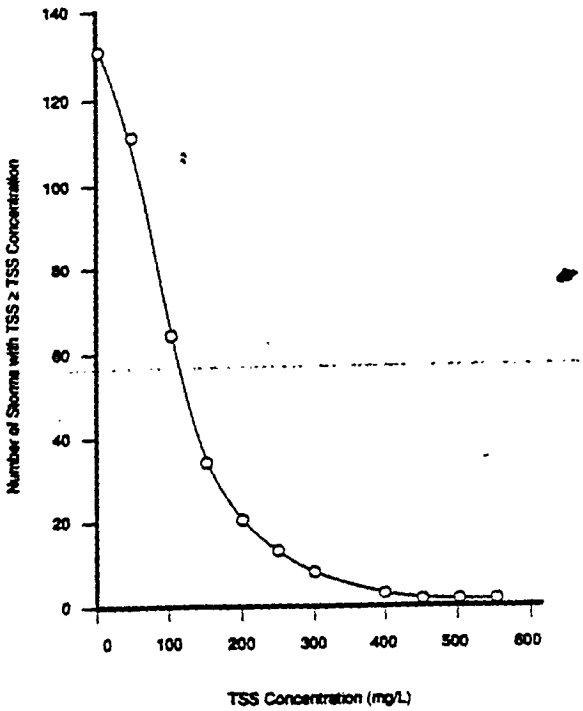
Figure 2.3—Cumulative frequency distribution of TSS concentrations in runoff from a Washington State interstate highway site.



Source: Little et al. 1983.

can help estimate concentration exceedance probabilities at other locations. Such estimates are best made with data from a site with climatological, land use, geological, and other characteristics similar to those of the location of interest. Using the nationwide plot of median values is less satisfactory.

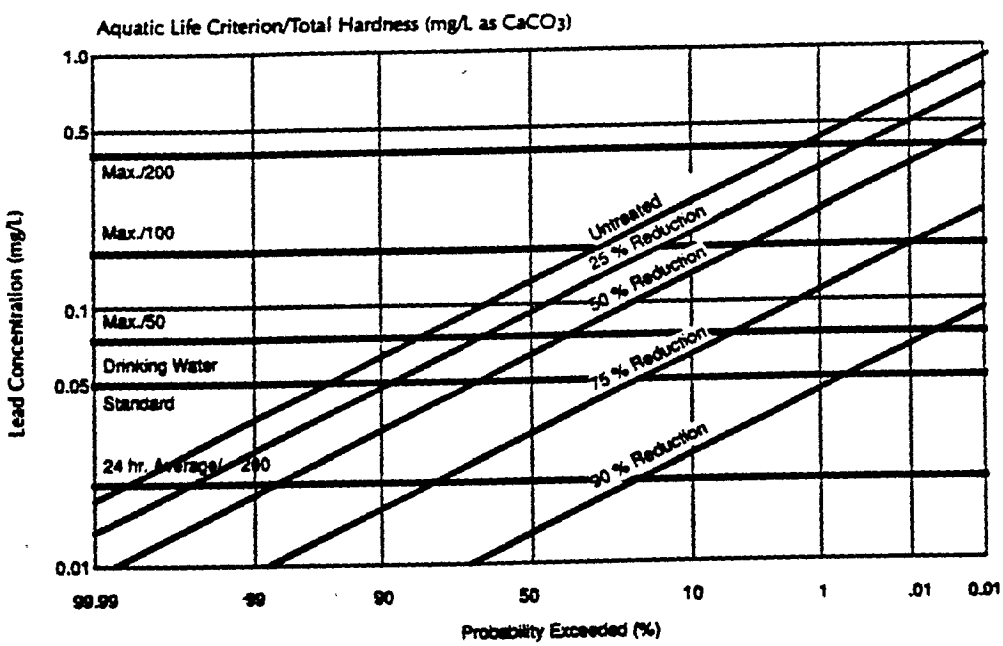
Estimating Loadings

We can estimate cumulative (usually annual) pollutant loadings for a catchment in five ways, from the least to the most complex method:

1. Using published yield values;
2. Using a simple empirical model;
3. Using published regression equations;
4. Computing from site-specific or modeled flow data and either local or published concentrations; and
5. Using a computerized, mechanistic model.

Method 1—Published Yield Values. This simple method is least likely to give accurate results because of the general lack of fit between the catchment of interest and the data collection lo-

Figure 2.4—Lead concentration-probability distribution graph.



Source: Horner and Mar, 1982.

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cation(s). To apply this method, consult a reference like Table 2.3, select the areal loading rate for each land use, multiply by the areas in each use, and sum:

$$L = \sum a_i \cdot l_i \quad [1]$$

where: L = Total loading;
a_i = Area in land use i;
l_i = Areal loading from land use i.

We can improve this method by producing some measure of uncertainty or error in the estimates. To do so, we establish ranges of areal loadings from the literature, estimate maximum and minimum and mean or median values of L, and then evaluate to determine if uncertainty or error could change the conclusions. For example, uncertainty makes little difference in managing a watershed if we are assessing to identify critical pollutant source areas, and one or more clearly stand out in magnitude.

Table 2.6 presents loading rate ranges compiled by Horner (1992). The author drew values from the general literature and data collected in the Pacific Northwest. The regional data provided values for total phosphorus and total nitrogen for most land uses and all pollutants in road runoff, except fecal coliforms. Accordingly, the regional data have narrower ranges than the remainder. This table should be as discriminately used as others, especially since most pollutants are generally lower in Pacific Northwest runoff than elsewhere. Horner found that ranges estimated from this table

Table 2.6—Pollutant loading ranges[a] for various land uses.

LAND USE	TSS	TP	TN	Pb	Zn	Cu	FC	COD
Road	281	0.59	1.3	0.49	0.18	0.03	7.1E+07	112
	723	1.50	3.5	1.10	0.45	0.09	2.8E+08	289
	502	1.10	2.4	0.78	0.31	0.06	1.8E+08	201
Commercial	242	0.69	1.6	1.60	1.70	1.10	1.7E+09	306
	1,369	0.91	8.8	4.70	4.90	3.20	9.5E+09	1,728
	805	0.80	5.2	3.10	3.30	2.10	5.6E+09	1,017
Single family low density	60	0.46	3.3	0.03	0.07	0.09	2.8E+09	NA
	340	0.64	4.7	0.09	0.20	0.27	1.6E+10	NA
	200	0.55	4.0	0.06	0.13	0.18	9.3E+09	NA
Single family high density	97	0.54	4.0	0.05	0.11	0.15	4.5E+09	NA
	547	0.76	5.6	0.15	0.33	0.45	2.6E+10	NA
	322	0.65	5.8	0.10	0.22	0.30	1.5E+10	NA
Multifamily residential	133	0.59	4.7	0.35	0.17	0.17	6.3E+09	100
	755	0.81	6.6	1.05	0.51	0.34	3.6E+10	566
	444	0.70	5.6	0.70	0.34	0.51	2.1E+10	333
Forest	26	0.10	1.1	0.01	0.01	0.02	1.2E+09	NA
	146	0.13	2.8	0.03	0.03	0.03	6.8E+09	NA
	86	0.11	2.0	0.02	0.02	0.03	4.0E+09	NA
Grass	80	0.01	1.2	0.03	0.02	0.02	4.8E+09	NA
	588	0.25	7.1	0.10	0.17	0.04	2.7E+10	NA
	346	0.13	4.2	0.07	0.10	0.03	1.6E+10	NA
Pasture	103	0.01	1.2	0.004	0.02	0.02	4.8E+09	NA
	583	0.25	7.1	0.015	0.17	0.04	2.7E+10	NA
	343	0.13	4.2	0.010	0.10	0.03	1.6E+10	NA

[a] For each pollutant and land use, loadings are listed as kg/ha-y (except no./ha-y for FC) in the order minimum, maximum, median.

NA Not available.

Multiply loadings in kg/ha by 0.89 to get lbs/acre.

Source: Horner, 1992.

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almost always bound estimates made independently by Hydrologic Simulation Program-Fortran (HSPF) computer modeling (see Method 5).

▮ ***Method 2—Simple Empirical Model.*** The best example of this method is Schueler's Simple Model (1987):

$$L_i = 0.23 \cdot P \cdot Pj \cdot Rv \cdot C \cdot A \quad [2]$$

where: L = Loading (lbs);
0.23 = Conversion factor;
P = Precipitation depth (inch) over the desired time interval;
Pj = Factor that corrects for storms that produce no runoff;
Rv = Runoff coefficient;
C = Pollutant EMC;
A = Area of the contributing catchment (acres).

For annual loading estimation, P is the area's average annual precipitation. Schueler recommends using 0.9 for Pj for annual and seasonal loading calculations. He uses NURP and Washington, D.C., area data to derive a regression equation ($r^2 = 0.71$) for Rv:

$$Rv = 0.05 + 0.009 \cdot I \quad [3]$$

where: I = Percentage of the catchment area that is impervious.

Relative to C, Schueler notes that NURP data analysis finds no statistically significant differences in EMCs among sites and no correlations between EMCs and storm volume or intensity. Therefore, for rough estimates, these national NURP average EMCs can be used:

Total phosphorus	0.46	mg/L
Total soluble phosphorus	0.16	mg/L
Total nitrogen	3.31	mg/L
Total Kjeldahl nitrogen	2.35	mg/L
Nitrate-nitrogen	0.96	mg/L
Chemical oxygen demand	90.8	mg/L
Biochemical oxygen demand	11.9	mg/L
Zinc	0.176	mg/L
Lead	0.180	mg/L
Copper	0.047	mg/L

Of course, EMCs from local measurements should yield superior estimates. Data from other sources (like Table 2.2) can supplement this listing. A recent comparison of several West Coast watersheds found that Simple Model loading estimates usually agreed, within a factor of two, with estimates made by much more involved and expensive modeling procedures. Either approach will produce the same management conclusions (Chandler, 1993).

▮ ***Method 3—Published Regression Equations.*** The regression method is best represented by an extensive compilation made by the USGS using its own and NURP data (Driver and Tasker, 1990). This analysis produced multiple regression equations for three national regions for runoff volume and pollutant loadings and concentrations as functions of several independent variables. Independent variables include various meteorological, land use, and other characteristics. Standard errors for the equations were provided as a measure of uncertainty. For a detailed reference, refer to Driver and Tasker's large and complex tables.

▮ ***Method 4—Site-Specific or Modeled Flow Data.*** To use this method conveniently, arrange the calculations on computerized spreadsheets. Depending on local data, calculations can be performed in several ways. The best situation is to have continuously recorded local flow data and a series of representative local EMC readings. Assuming a log-normal distribution of EMCs, calculate the mean of the EMCs (a) using a statistical equation appropriate for the distribution (Marsalek, 1990). First, take the natural logs (ln) of the EMC values and compute the mean (μ) and variance (s^2) of the natural logs. Then

$$a = e^{(\mu + s^2/2)} \quad [4]$$

where: e = Base of natural logarithms.

Calculate the confidence interval (C.I.) of the mean EMC estimate using the following equation:

$$C.I. = a \cdot e^{\pm \theta \cdot [s^2/n + 2 \cdot (s^2)^3/(n-1)]^{0.5}} \quad [5]$$

where: + Is used for upper confidence limit;
− Is used for lower confidence limit;
θ = 1.96 for 95% confidence interval and 1.69 for 90%;
n = Number of EMC values used to find μ.

Consult a flow record to obtain the total flow volume for the loading estimate period. Multiply that volume by the mean EMC to get the loading; then multiply it by the upper and lower confidence limits to get the estimate bounds.

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Lacking a flow record, use a hydrologic model to estimate (see Chapter 1). One option is to use Schueler's formula for the runoff coefficient, Pj = 0.9, and the average precipitation for the period, demonstrated in Method 2. This method can also be used with a flow record but no local concentration data by using NURP or other published average EMC values.

▮ ***Method 5—Mechanistic Model.*** This method includes comprehensive computerized models like the Storage, Treatment, Overflow, and Runoff Model (STORM) created by the U.S. Army Corps of Engineers; Storm Water Management Model (SWMM) and Hydrologic Simulation Program—Fortran (HSPF), both sponsored by U.S. EPA; and Illinois Urban Drainage Area Simulation (ILLUDAS) developed by the Illinois State Water Survey. Detailed coverage of these models is beyond this manual's scope, but the manual does describe their general elements. The models contain hydrologic and water quality components and have mathematical algorithms that represent the mechanisms generating and transporting runoff and contaminants. The hydrologic components of both SWMM and HSPF stem from the Stanford Watershed Model, first introduced almost 25 years ago, and produce continuous hydrograph simulations.

The models structure the water quality components on a mass balance framework that represents the rate of change in pollutant mass as the difference between pollutant additions and losses. Additions, considered to be pollutant deposition, are computed as a linear function of time. Soil erosion is usually calculated according to the Universal Soil Loss Equation (see Chapter 1). Losses are represented by a first-order washoff function (i.e., loss rate is considered to be a function of pollutant mass present); other losses are modeled in mathematically similar ways. For example, both organic matter decomposition and bacterial die-off are considered first-order reactions.

Some models, like SWMM, have both a receiving water and runoff component. These models treat some of the transformation processes that can occur in water (e.g., dissolved oxygen depletion according to the Streeter-Phelps equation). However, no model can comprehensively represent these numerous and complex processes.

These models require substantial local data to set variable parameters in the calibration step and to verify them for the intended application. They also require considerable skill and commitment from personnel. Therefore, only agencies prepared to commit the resources for database development and expertise should embark on using these models. Agencies that need to estimate urban runoff water quality should determine their objectives and select the most appropriate method.

Aquatic Sediment Impacts

At some point in their life cycle, many aquatic organisms have their principal habitat in, on, or near sediment. Sediments also hold pollutants introduced by urban runoff. Pollutants enter sediments in several ways. The most direct path is the settling of solids—this physically changes sediment quality and carries along other pollutants that change sediment chemistry or biology. Dissolved pollutants also move out of solution and into sediments by such mechanisms as adsorption of metals and organics at the sediment surface; ion exchange of heavy metals in water with native calcium, magnesium, and other minerals in sediments; and precipitation of phosphorus.

Most aquatic sediments have a large capacity to receive such contaminants through these processes. Also, many of the pollutants are conservative—once in sediments, they do not decompose or significantly change form. These conservative pollutants include refractory organic chemicals relatively resistant to biodegradation and all metals. Consequently, these types of pollutants progressively accumulate in sediments. Over the long term, discharge of even modest quantities of pollutants can result in sediment concentrations several orders of magnitude higher than in the overlying water. These contaminant reservoirs can be toxic to aquatic life to which they come in direct contact, and can also contaminate reservoirs far beyond the benthic (bottom-dwelling) organisms by biomagnification through the food web.

Historically, water quality has received more attention than sediment contamination. In the past 10 to 15 years, this view has changed because of mounting evidence of environmental degradation in areas that meet water quality criteria. However, sediment toxicity investigations are limited because we do not understand the factors that control contaminant bioavailability and we lack accepted testing methods. The result is an approach that emphasizes bioassay exposure techniques either in situ or in the laboratory along

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with chemical analysis of the sediments, overlying water, and/or sediment interstitial water (see Chapter 5).

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CHAPTER 3

Aquatic Biological Impacts of Urban Land Use

A wide array of pollutants entering aquatic ecosystems along with urban runoff causes numerous potential biological effects. These substances often change in transport. Other stresses often associated with hydrologic changes also accompany urbanization. These different stressors interact, and the receptor organisms under stress can interact with one another. How an urban runoff discharge might affect the biota in a receiving water is thus very complex, imperfectly understood, and hard to forecast with assurance.

This chapter focuses on the most numerous, complex, and difficult-to-manage aquatic ecosystem impacts. Table 3.1 provides a general summary of impacts and their causes. The table shows that impacts include chemical effects such as degraded water quality; physical effects such as altered hydrology, degraded habitat, and sediment transport; and biological effects such as altered biotic interactions and death of organisms.

Chapter 3 presents illustrations that cover key issues and the complex, interdisciplinary nature of aquatic biological impacts. Subjects covered include hydrologic and related physical impacts, the role of urban runoff in lake eutrophication, metals and their effects on aquatic organisms, thermal impacts of urbanization and urban runoff management, and fish habitat impacts and managing for habitat protection.

Water quality criteria are a regulatory attempt to avoid adverse impacts on aquatic systems by setting limits on concentrations of specific chemical pollutants that can reach receiving waters. However, relying on these criteria to manage urban runoff is often not an effective strategy, because biological damage can occur even when chemical water quality criteria have been met.

Several factors can explain this dilemma. Based in conventional toxicity, criteria do not represent the variable exposure pattern related to urban runoff or the cumulative effects of pollutant loadings over time. They also cannot account for transformations between release and the point of impact or for the many potential interactions in an ecosystem.

As previously noted, pollutant concentrations are often not high enough in urban runoff, which is diluted in receiving waterbodies, to directly or rapidly harm aquatic organisms. However, continued runoff drainage with relatively low contaminant levels can eventually cause biological damage in two ways:

- Cumulative water quality stress can result in chronic effects; and
- Pollutant accumulations in aquatic sediment can especially affect organisms that inhabit or spend considerable time in or on the streambed or lake bottom.

While this chapter does not cover sediment toxicity and its effects, Chapter 5 discusses both sediment monitoring and using monitoring results to assess biological effects. In addition, Burton (1991) has published an extensive review of information on assessing toxicity of freshwater sediments.

Hydrologic and Related Physical Impacts

Although water quality deterioration from urban runoff is often considered the leading cause of ecological damage, this is not always true.

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Table 3.1—Environmental concerns and impacts associated with urban runoff.

RESOURCE/ WATER USE	CONCERN	POTENTIAL NEGATIVE IMPACT ON RESOURCE/WATER USE	CAUSE
Groundwater	Lower dry-season reserves	Lower dry-season base flow in watercourses Lower drinking water reserves	Increased impervious catchment surface area
Aquatic Habitat	Erosion	Physical destruction of habitat	Peak discharge, high runoff volume
	Fluctuating water levels and velocities	Altered thermal and mixing characteristics Reduced habitat diversity Erosion	High peak discharges and runoff volumes Low dry-season groundwater reserves
	Low dry-season base flow	Elimination of spawning beds Reduced habitat Reduced dilution capacity	Low dry-season groundwater reserves
	Sedimentation	Smothering of bottom communities and spawning beds Filling of stormwater impoundments Transport of particulate–associated pollutants	Erosion Suspended solids
	Turbidity	Lower dissolved oxygen,reduced prey capture, clogging of fish gills	Suspended solids
	Low dissolved oxygen	Lethal and nonlethal stress to aquatic organisms	Biodegradable organic material
	Metals, organic contaminants, chlorides	Lethal and nonlethal stress to fish and other aquatic organisms in water column and bottom sediments Bioaccumulation of contaminants and related food chain effects Osmotic stress Groundwater pollution	Urban pollution
	Increased water temperature	Lethal and nonlethal stress to sensitive cold water aquatic organisms Increased metal toxicity and hydrocarbon solubility	Solar heating of urban surfaces and stored runoff water
	Bacteria	Diseases of aquatic organisms Shellfish contamination	Fecal contamination
	Eutrophication	Algae blooms and nuisance aquatic plant growth Low dissolved oxygen Odors	Nutrient enrichment
Public Water Supply	Lower dry-season reserves	Reduced water supply	Lower dry-season groundwater reserves
	Turbidity	Taste, appearance	Suspended solids
	Metals, organic contaminants, nitrates, chloride	Taste, odor, public health	Urban pollution
	Bacteria	Public health	Fecal contamination
Wildlife Habitat	Flooding and erosion	Physical destruction of environment Dewatering and flooding of key habitat areas at critical times Reduction in streambank cover vegetation	High peak discharges and runoff volumes Sedimentation
Recreation and Aesthetics	Nature enjoyment	See Aquatic Habitat and Wildlife Habitat	See Aquatic Habitat and Wildlife Habitat
	Bacteria	Public health in body contact waters Degradation of fisheries and shellfish beds	Fecal contamination
Agricultural, Residential, and Industrial Land Use	Flooding and erosion	Public safety Damages to crops and farmland Damages to buildings and contents Reduction of useable land area	High peak discharges and runoff volumes Sedimentation

Source: British Columbia Res. Corp. 1992.

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Urbanization alters the hydrologic regime of surface waters by changing the way water cycles through a drainage basin. In a natural setting, precipitation is intercepted or delayed by the forest canopy and ground cover. Vegetation, depressions on the land, and soils provide extensive storage capacity for precipitation. Water exceeding this capacity travels via shallow subsurface flow and groundwater and eventually discharges gradually to surface waterbodies. In a forested, undisturbed watershed, direct surface runoff occurs rarely or not at all because precipitation intensities do not exceed soil infiltration rates.

Urbanization effects are multifaceted. Tree removal reduces or eliminates interception storage and the water reservoir in soils. Loss of vegetation and duff from the understory takes away another storage reservoir. Regrading eliminates natural depressions. Impervious surfaces, of course, stop any infiltration and produce surface runoff. Even when surfaces remain pervious, building often removes, erodes, or compacts topsoil. The exposed soil retards infiltration and offers much less storage capacity. Development replaces natural drainage systems with hydraulically efficient pipe or ditch networks that shorten the travel time of runoff to the receiving water.

Adjacent to waterbodies, floodplain encroachment eliminates another storage zone needed to diminish high flows. Clearing bank vegetation removes the wood supply that helps slow down the flow and often helps prevent bed and bank erosion. Clearing also eliminates shade, refuge, and food supply. Urban residents and high stream flows remove remaining wood, further decreasing the stream's opportunity to dissipate energy without flooding or damaging the channel.

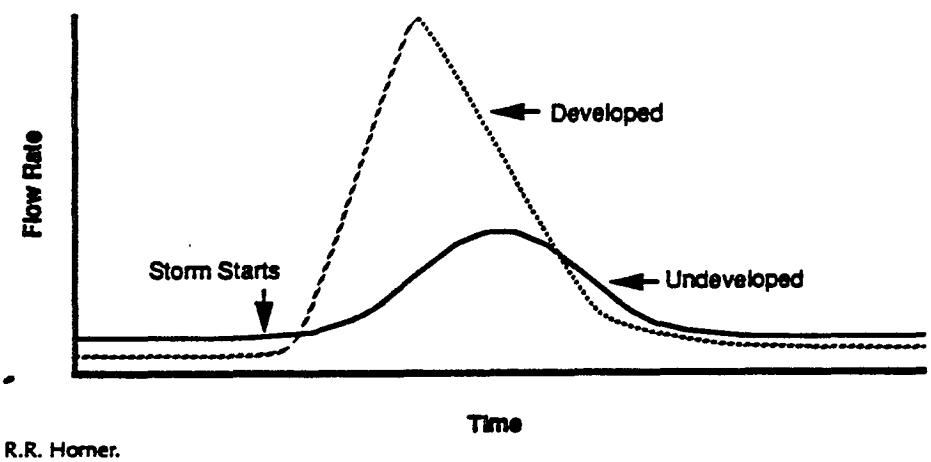
An extensive study comparing an urban and a nonurban stream in western Washington State found that hydrologic changes from urbanization were the principal reasons that the urban stream failed to match its nonurban counterpart in diversity and size of salmonid fish populations and other biological indices (Richey, 1982).

In the Pacific Northwest, the importance of hydrologic alteration and its effects on stream habitats and the salmonid resource is widely recognized. A significant share of the urban runoff management effort goes into controlling runoff water quantity to attempt to retain predevelopment hydrologic patterns. In most other U.S. urbanized areas, with respect to resource protection, less attention is paid to controlling quantity to maintain stream channel integrity and more is paid to quality control. Yet, the same hydrologic modification problems have been noted elsewhere; e.g., Mississippi (Wilson, 1967), Long Island (Seaburn, 1969), and Maryland (Hammer, 1972).

The many changes brought on by urbanization tend to alter stream flow patterns in characteristic ways. Figure 3.1 illustrates typical hydrographs (flow rate versus time) for a stream before and after watershed urbanization. The hydrograph emphasizes the higher peak flow rate of urbanized settings compared to preurban conditions. A two-to-five-fold increase is common (Leopold, 1968), although some streams show even greater rises, especially in arid areas.

When the channel cannot contain the greater flow, flooding results. If the flow is largely

Figure 3.1—Hydrograph patterns typical of developed and undeveloped watersheds.



Source: R.R. Horner.

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contained, high flow rates within the same area increase velocities. This can cause large shear stresses that erode streambeds and banks. Shear stress roughly increases proportionately to the square of the velocity (Hynes, 1970). The doubling of velocity could, for example, increase the erosion potential by approximately four. Loss of the stabilizing wood previously in the channel magnifies the effect of flow magnitude.

The hydrograph also indicates the urban stream's faster response to precipitation. Less obvious is the greater total volume, represented by the integrated area under the urban stream curve. When watersheds urbanize, a common runoff volume increase for any given storm is at least 50 percent (Leopold, 1968). Thus, changes in watershed hydrology not only create more friction on the stream channel materials at any instant in time, but that stress also exists for a longer period while the greater volume passes downstream. Runoff quantity control efforts to hold total volumes within predevelopment levels can only be achieved with infiltration equivalent to that in the undeveloped watershed. If storage volume and outlet are sized properly, detention can restrict peak flow rates to those levels, but it will not maintain lower volumes without the needed infiltration. Therefore, even the best quantity control programs often cannot avoid stream channel damage.

The left side of Figure 3.1 shows that while urban streams usually have higher flows during and following rain storms, they also commonly have lower baseflows between storm events. In urban landscapes, baseflow decrease is a consequence of water's rapid transport downstream before it can recharge the groundwater that supplements streams in dry periods. During droughts, baseflow deficit can have an especially severe ecological impact.

These are short-term hydrologic patterns. Urbanization impacts with longer time frames are even more evident. The frequency of recorded high flows increases even more than the flow levels. In one Washington State stream, the flow rate that had been reached only once in 10 years on average before development increased in frequency to about every two years after urbanization (Scott, 1982).

A computer model capable of continuous simulation was applied to another western Washington basin (Booth, 1991). It compared a fully forested basin with a developed 40 percent impervious area. The model predicted that the predevelopment discharge, which occurs only once in five years, would occur in 39 of 40 years after development. Moreover, the model forecasted that in an average year, this discharge level could be reached five times, separated by less than one month in the wet season. The model estimated that the predevelopment five-year discharge could occur bimonthly following development. This 60-fold frequency increase dwarfs the 3.5 times increase predicted for 10-year peak flow rates.

A Long Island study revealed the extent of seasonal hydrologic shifts in urban streams. In several predevelopment streams, baseflow constituted 95 percent of the annual discharge; that proportion dropped to 20 percent after development (Simmons and Richard, 1982).

Some studies have measured urbanization levels that cause significant hydrologic changes. In a study of several Maryland watersheds, Klein (1979) found hydrologic alteration evident with 12 percent impervious area and severe with 30 percent.

Ecological Consequences of Hydrologic Changes

Along with extensive hydrologic modifications, the ecological effects of urbanization on water quantity are also significant. These effects come mostly from habitat damage accompanying hydrologic alteration.

The most basic change is from erosion of the stream channel that sweeps away various habitats and expands the channel, increasing both width and depth. While these increases can be steady and gradual, they frequently occur abruptly in response to particular storms (Hammer, 1972; Leopold, 1973; Booth, 1991). Even in areas where the stream has been stable for years, massive changes in channel dimensions can occur in the first large storm after urbanization, affecting the stream's entire course and profile. The regular meander and pool-riffle patterns of streams not in highly confining substrates will be modified as erosion and deposition increase in magnitude and speed.

Rapid, nearly uncontrolled downcutting, known as incision, can be especially dramatic (Booth, 1990). Incision results when increased flow and loss of the woody debris that dissipates energy occur in relatively steep channels with an easily erodible substrate. While all channel damage is ecologically harmful, incision is especially problematic because it removes virtually all habitat and supplies great quantities of sediment that do further damage downstream.

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Research in several humid locations suggests that flows larger than the five-year frequency discharge are sufficient to create large-scale channel disruption (Carling, 1988; Sidle, 1988). More than anything else, the greatly increased incidence of these flows explains the ecological vulnerability of urban streams.

Even without the spectacular phenomenon of incision, habitats are still damaged by complex physical effects from elevated urban stream flows. Impacts can include the following:

- Sediment deposits on gravel substrates where fish spawn and rear young and where algal and invertebrate food sources live;
- Sediment that fills pools where fish feed, take refuge from predators, and rest;
- Direct effects of suspended sediment on aquatic organisms, like abrading gills and other sensitive tissues, reducing light for photosynthesis, reducing visibility for catching food and avoiding predators, and transporting metallic, organic, oxygen-demanding, bacterial, and nutrient pollutants;
- Loss of riparian vegetation, as banks erode, along with the loss of shade and refuge it provides; and
- Loss of the protective qualities of the large woody debris.

Reduced baseflow produces its own set of impacts. Summer temperatures increase because less water absorbs heat, and dissolved oxygen declines from the lower oxygen solubility of warmer water. Less dilution of pollutants results in higher concentrations, and shallower flow can interfere with fish migrations and localized movements.

In the Washington State comparison of urban and nonurban streams, Kelsey Creek, an urban stream, experienced twice the bed scour of its nonurban counterpart, Bear Creek (Scott, 1982). As a consequence, sediment transport was three times as great in Kelsey Creek (Richey, 1982), and fines were twice as prevalent in its substrates (Scott, 1982). The invertebrate communities in different benthic locations produced 14 to 24 taxa in Bear Creek but only six to 14 in Kelsey Creek (Pedersen, 1981; Richey, 1982).

Salmonid fish diversity also differed. Bear Creek had four salmonid species of different age classes, whereas Kelsey Creek had only one nonanadromous species mainly represented by the 0- to 1-year age class (Scott, 1982; Steward, 1983). While both creeks generally met water quality criteria that protect aquatic life from toxicity, differences still occurred. Although we cannot explicitly determine the relative roles of hydrology and water quality, much evidence shows that hydrologic alteration and the related sediment transport were most responsible for the biological effects (Richey, 1982).

King County (Washington) Surface Water Management Division (unpublished data) has examined various aspects of urban hydrology's influence on the valued salmon. Data show a significant decrease in young salmon survival in both large and small streams when events occur that are equal to or larger than the five-year frequency discharge. Since the frequency of events increases tremendously after urbanization, salmonids experience great difficulty even in relatively clean urban streams.

The King County investigations also pointed out the relationship between urbanization level and biological integrity. The study rated channel stability along numerous stream reaches and related it to the proportion of the watershed's impervious areas. Stability was significantly lower with more than 10 percent imperviousness (Booth and Reinelt, 1993). The study rated habitat quality along 87 miles (140 km) of streams in two basins according to four standard measures. Marked habitat degradation occurred at 8 to 10 percent impervious area. Population data on cutthroat trout and less tolerant coho salmon from streams draining nine catchments did not show a distinct threshold. They indicated, however, that population shifts are measurable with just a few percent of impervious area and become substantial beyond 10 to 15 percent (Lucchetti and Fuerstenberg, 1993).

King County also studied urbanization impacts on freshwater wetlands. Gage readings determined mean water level fluctuations (WLF), and a geographic information system related them to various watershed variables. Biological measures were analyzed using mean WLF. The richness (species representation) of both plants and amphibians significantly decreased when mean WLF exceeded 20 cm (7.8 in). WLF depends on various watershed and wetland morphological conditions, but typically surpasses 20 cm when impervious areas are around 10 percent (Taylor, 1993).

Information consistently indicates that placing impervious surface on some 10 percent of a

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watershed creates significantly negative hydrologic, habitat, and ecological responses. To complicate the picture, development located immediately adjacent to rather than away from a waterbody changes the circumstances. Nonetheless, information of this type provides a basis for protective watershed management through planning and zoning.

Urban Runoff in Lake Eutrophication

Eutrophication is the process through which algal biomass increases overall—especially during "bloom" periods—from increased loading of the nutrient that had previously been in shortest supply relative to need (limiting nutrient). The limiting nutrient in lakes around the world is usually either phosphorus or nitrogen, but is most often and most consistently phosphorus (P) in freshwater lakes. In addition to promoting larger quantities of algae, enrichment typically changes the composition of the algal community. One-celled diatoms give way to filamentous green forms, followed by blue-green forms with a larger nutrient supply.

Eutrophication degrades lake ecosystems in several ways. The filamentous algae are poorer food than diatoms to herbivores because of their structure and, sometimes, bad taste and toxicity. Filamentous algae clog water intakes and boat propellers and form odorous masses when they wash up on beaches. They also reduce water clarity, making swimming unpleasant. When a large biomass dies at the end of the bloom, its decomposition by bacteria creates high oxygen demand. In summer, eutrophic lakes that thermally stratify usually have little or no oxygen in the bottom stratum of water.

As discussed in Chapter 2, urban areas have a number of nutrient sources, and nutrient loadings increase with the development level. The following hypothetical case study discusses the potential of urbanization to change the trophic status of a lake. It compares the lake's trophic state at 10, 50, and 75 percent watershed urbanization. The case assumes the following conditions:

Lake area—100 ha (271.1 acres)

Lake mean depth—3 m (9.84 ft)

Lake water residence time—1 year

Watershed area—5 km^2 (12.36 acres)

Walker (1987) developed a regression equation (r^2 = 0.69, standard error = 24) from Minnesota watersheds relating P export to urbanization:

P export (kg/km^2) = 1.02 · (percent urban) + 2.92

Although this equation is quite simplified and omits impervious area and other specifics of the urbanization type, it gives a rough indication of urbanization effects. This example refers to a lake originally in an oligotrophic state. Actual lakes differ in their trophic states even without anthropogenic effects.

The export for the different urbanization levels can be estimated and expressed in terms of its distribution over the lake area, as summarized in Table 3.2. Vollenweider and Dillon (1974) categorized trophic status using data from a number of lakes. They found that boundaries between oligotrophic (relatively unenriched) and mesotrophic (moderately enriched) systems, and between mesotrophic and eutrophic systems (highly enriched), could be drawn by considering the relationship between P loading over the lake area and the ratio of mean depth/water residence time (Figure 3.2).

Table 3.2—Phosphorus loadings associated with hypothetical case study conditions.

% URBAN	ANNUAL TOTAL (kg/y)	DISTRIBUTION OVER LAKE AREA (kg/ha · y)
10	50	0.5
50	250	2.5
75	375	3.75

The graph, tabulated data, and mean depth/water residence time ratio of 3 can be used to see that 10 percent urbanization, which would be equivalent to a few percent impervious area, keeps the lake safely in the oligotrophic region. Urbanization at the 50 percent level places the lake in the mesotrophic zone. The highest level of urbanization takes the lake into the eutrophic area.

The exercise can be extended to consider how much P loading control would have to be provided in some way to reach certain lake water quality protection objectives. The typical P loading of a 75 percent urban watershed would need to be reduced 47 percent to keep the lake from passing from its position of 10 percent urban land use into the mesotrophic zone. To keep it more safely in the oligotrophic area—for example, at a loading of 1.5 kg/ha · y—a 60 percent reduction would be needed. This efficiency is very hard to achieve with urban runoff treatment practices (see Chapter 8). Even with this level of control, how-

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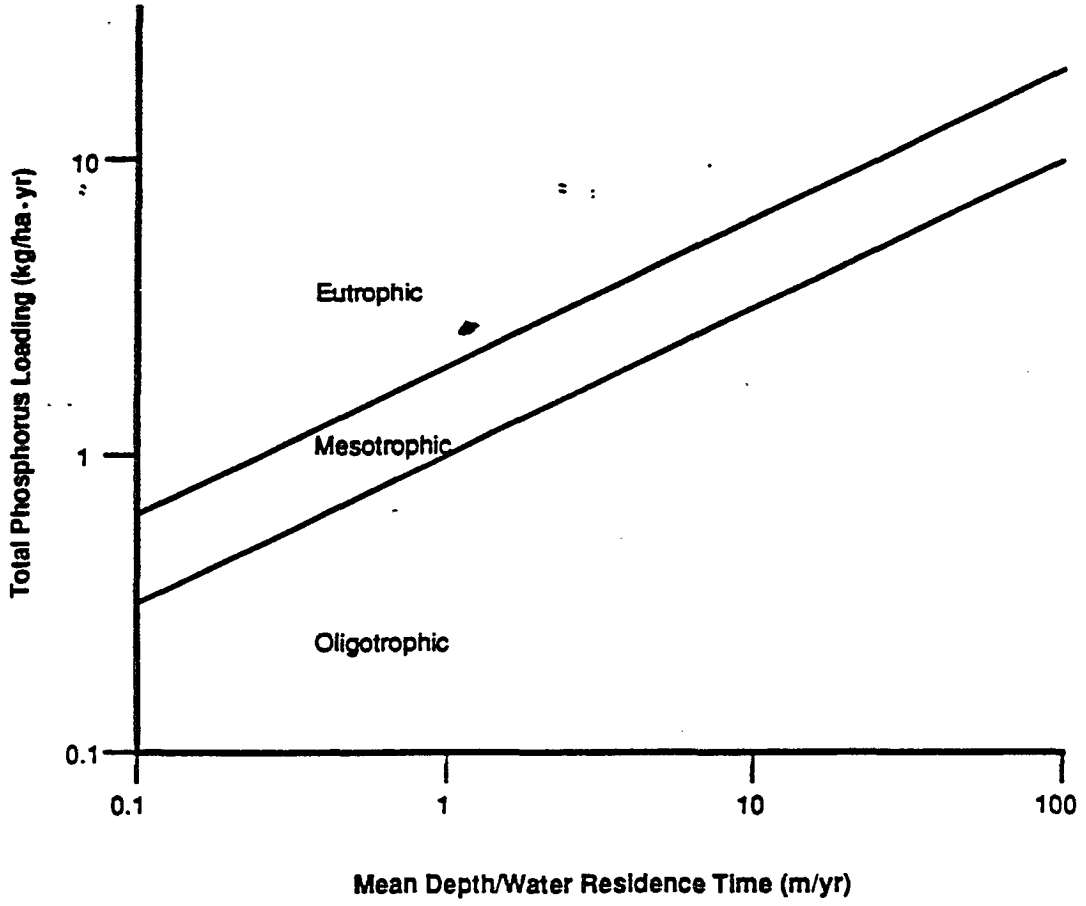
Figure 3.2—Lake trophic state in response to phosphorus loading.



Source: Vollenweider and Dillon, 1974.

ever, the loading would still be three times the amount at 10 percent urbanization.

A version of this analysis was performed for Lake Sammamish, Washington, using pollutant loading coefficients mostly derived from local data instead of the regression equation. Also, a model was developed to simulate the lake's response to P loading and calibrated with data taken in the lake itself (Welch et al. 1985; Shuster et al. 1986). Planning agencies estimated that urbanization would increase from 16 percent of the watershed in 1975 to 46 percent in 2000, in the form of single- and multiple-family residential and commercial land uses. On the basis of median values of the loading coefficients, P loading per unit area of the lake surface was projected to rise from 4.3 to 7.5 kg/ha · y in that time—a 74 percent increase. These levels are higher than those in the hypothetical case because the watershed of the main tributary to Lake Sammamish has relatively high natural soil sources of P. Nevertheless, the lake's mean depth of 17.7 m (58.1 ft) and water residence time of 1.8 years give it a ratio sufficient to place it low in the mesotrophic zone (Figure 3.2) in 1975. Increased urbanization would send it into the eutrophic area. The projections were used to devise strategies for P source control and runoff treatment.

The Effects of Metals on Aquatic Organisms

Metals are the toxic contaminants most commonly found in urban runoff. Because the exposure patterns of runoff differ from the standard laboratory procedures traditionally used to gage toxicity,

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metals' role in causing toxic reactions in aquatic organisms is unclear. Different types of experiments are needed to develop a clearer picture and, eventually, more appropriate water quality criteria for waters affected by urban runoff.

For now, clues come from some completed experiments. Davies (1986) summarized a series of experiments with rainbow trout. Although the focus was on mining discharges, results provide some useful insights to consider toxicity in urban runoff. The following account of the findings contains remarks on the significance for urban runoff, which appear in italics.

Note: LC_{50} (96 h) means the concentration lethal to 50 percent of the test organisms in a 96-hour exposure.

Metals Toxicity to Fish

1. Increases in pH, alkalinity, and hardness decrease metal toxicity.

HARDNESS (mg/L as $CaCO_3$)	ALKALINITY (mg/L as $CaCO_3$)	RAINBOW TROUT LC_{50} (96 h) (mg Zn/L)
315	227	7.21
102	81	1.00
23	20	0.56

Hardness (Ca^{+2} and Mg^{+2}) antagonizes toxic metal uptake at the gill surface by competing for uptake sites. Alkalinity plays a role in bioavailability by providing bicarbonate and carbonate ligands under pH control to complex metals in either soluble or insoluble form, removing them from the toxic ionic state. In alkaline waters, metals are not acutely toxic until enough are present to overwhelm the bicarbonate-carbonate buffering system that precipitates lead carbonate complexes. Organic ligands may also form complexes of low toxicity, a subject that has not been well studied. Particulate metals and those adsorbed to particles are relatively nontoxic.

Therefore, runoff discharge to well-buffered waters with most metals in the solid state creates less toxic reactions than dissolved metal discharge to soft waters.

2. Metal toxicity generally increases as temperature increases because of increased chemical activity and metabolism.

TEMPERATURE (°C)	RAINBOW TROUT LC_{50} (96 h) SOFT WATER (mg Zn/L)
6	0.83
10	0.41
15	0.24

Therefore, runoff discharge in the winter and runoff to shaded or groundwater-fed waters in the summer create less toxic reactions than into warm waters.

3. Smaller, younger organisms are more sensitive to metals, and fish are generally more sensitive than macroinvertebrates.

Therefore, runoff discharge during rearing periods creates more toxic reactions than during adult stages.

4. If exposed during the embryonic stage in soft water, fish can acclimate to metals and are less sensitive to higher exposures later. Rainbow trout were approximately four times more sensitive to both cadmium (Cd) and zinc (Zn) when not exposed embryonically, compared to fish that were exposed (chronic effect/no-effect concentrations of approximately 1 µg Cd/L and 50 µg Zn/L for unexposed fish, compared to approximately 4 and 200 for exposed trout). Acclimation ability was confirmed by two-week and one-year experiments in a zinc-contaminated reservoir. However, acclimation does not appear to occur with lead (Pb) and silver (Ag), nor in hard water.

Therefore, relatively low continuous exposures throughout life can somewhat insulate fish from periodic elevated exposures in runoff.

5. Metal toxicity increases as exposure period lengthens.

EXPOSURE (DAYS)	RAINBOW TROUT LC_{50} SOFT WATER (mg Pb/L)
4	1.17
14	0.20

Therefore, fish can better tolerate a high exposure for a short interval than continuous delivery. This observation, however, says nothing about the potential reaction to repeated, periodic exposures, as with urban runoff discharge.

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6. The apparent mechanism of acute (one to four days) metal toxicity in fish is gill irritation by the ionic metal, causing mucus secretion and internal destruction of gill epithelium, resulting in suffocation. Chronic (one-week to one-year) toxicity can negatively affect reproduction, growth, physiological and behavioral development, and/or cause death through the breakdown in metabolic or other biochemical functions.

7. "Free" metals include the most toxic ionic forms, as well as other labile forms. Most or all metals present can be free in soft waters, but can be a small fraction of total metals in hard waters, thus allowing fish in hard waters to withstand much higher total metals in acute exposure. However, toxicity of free metals is similar in soft and hard water.

HARDNESS (mg/L as $CaCO_3$)	RAINBOW TROUT LC_{50} (96 h) (mg Pb/L)	
	TOTAL	FREE
290	471	1.47
385	542	1.32
32	1.17	1.17

8. Chronic toxicity exhibits trends similar to acute toxicity with respect to free and total metals, but at much lower levels.

WATER	EFFECT/NO-EFFECT PHYSIOLOGICAL ABNORMALITY (µg Pb/L)	
	FREE	TOTAL
Hard	18.2–31.6	120.0–360.0
Soft	7.2–14.6	7.2– 14.6

9. Complexation, which reduces the more toxic free metals, is not instant (e.g., two days for cadmium to come to equilibrium), and mortality increases in tests with unaged water.

   Urban runoff dynamics do not allow time to complete complexation, and therefore buffering is a smaller benefit with intermittent than with continuous releases.

10. "Toxic" concentrations are frequently measured in natural water samples, but fish still live. This contradiction probably stems partly from acclimation and partly from comparing a standard meant for continuous exposure with a condition that is only intermittent. However, the contradiction is also a function of using acid to preserve samples, which frees metals from soils and other particles, and from using the nonselective atomic absorption technique.

11. The use of a dissolved metals measurement can only approximate the toxic forms because some are solubilized over time. "Potentially dissolved" metals can be determined in runoff by waiting to filter for 8 to 96 hours after acidifying the sample, but this method has not been well tested.

    Realistic water quality criteria for waters affected by urban runoff require considering duration and frequency of exposures, chemical forms, and species.

Aquatic Invertebrate Response to Zinc Exposure

Horner (in press) performed experiments with the invertebrate amphipod *Hyalella azteca* that further clarify the observations in points 4 and 5, summarized in Figure 3.3. Organisms were given two types of zinc exposures—continuous and intermittent (three times for 24 hours each)—at the same concentration. Total loadings were close (122 mg with continuous and 90 mg with intermittent). The number of organisms in the continuously exposed community declined gradually at first but stabilized by the end of the 18-day experiment, with a mean survival for individuals of 11.3 days. The concentration was lower than the chronic aquatic life criterion. In contrast, the periodically exposed community declined in steps with each exposure and went extinct by the end (mean survival was 8.5 days).

The same type of experiment was run with a higher loading level (approximately 210 mg) produced by either continuous exposure at 65 µg/L or intermittent exposure in the same pattern as the first experiment at 350 µg/L. The continuously exposed community reacted much as in the first experiment, although the higher concentration caused a more rapid initial die-off that reduced mean survival to 9.6 days. Still, the surviving number was about the same as in the first experiment, despite the higher concentration and loading. The intermittent exposure caused extinction after the second treatment, and mean survival was only 5.0 days.

These results clearly indicate that organisms in the same species tolerate metal toxicity differently. Stronger organisms can survive continuous

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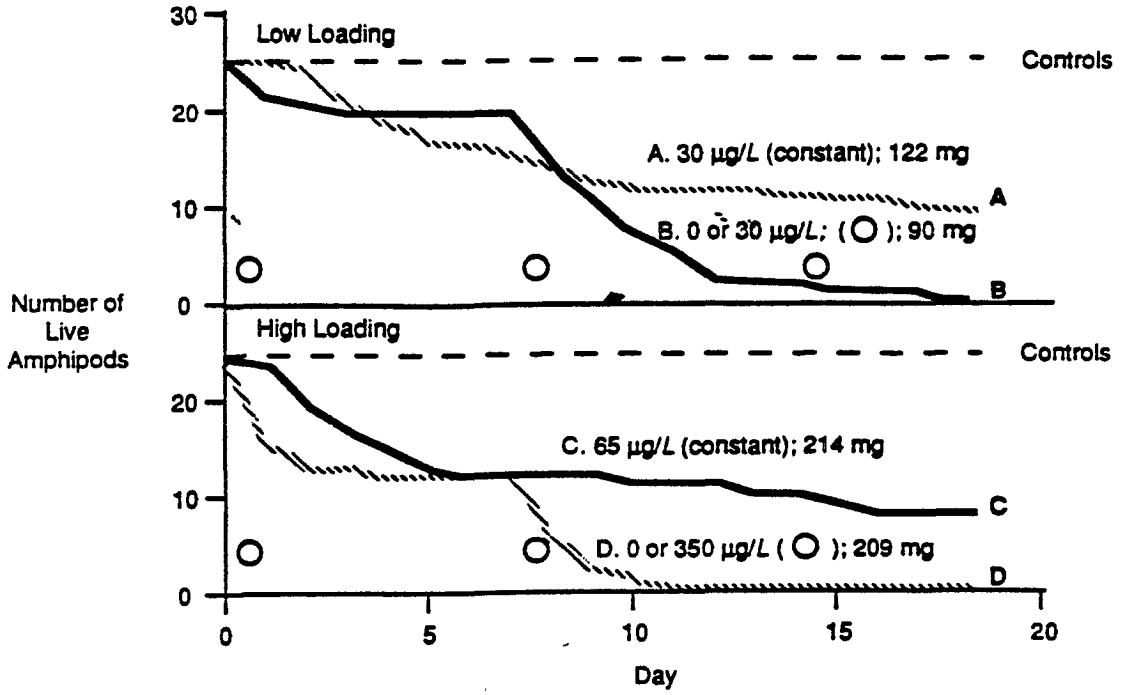
Figure 3.3—Responses of *Hyalella azteca* to constant and intermittent exposures to zinc.



NOTE: Zinc exposures were delivered either at constant concentrations (given in the units µg/L) or intermittently for a 24-hour period on the day, indicated by the circular symbol. The mass values (given in the units mg) represent the total zinc loadings for the entire experimental period.

Source: R.R. Horner.

exposure to concentrations that kill others. In the first experiment, inability to tolerate the same concentration, if intermittent, suggests that, when a threatening condition continues, acclimation defenses may develop over time. Once past the initial period, these defenses probably allow stronger organisms to continue to survive and stabilize the community. Response to the first intermittent exposure in the second experiment shows that, even if the effect to some is severe, the remaining organisms can persist. However, they cannot withstand a second episode of severe shock.

These experiments demonstrate that the important factor is not necessarily pollutant loading but how it is delivered. The findings have substantial implications for urban runoff management—criteria should specify both maximum concentrations for several lengths of exposure, as they do now, and maximum lower concentrations not to be repeated more than once in certain intervals. However, much more work is needed to arrive at the appropriate criteria. A second implication is that the common practice of managing by trying to restrict loading increases may not be successful if we do not develop and incorporate our knowledge of how loading is generated.

Thermal Impacts of Urban Runoff

Aquatic life forms have characteristic temperature preferences and tolerance limits. Fish of interest to humans, like trout and salmon, and their preferred invertebrate food sources have lower ranges and maximums than others. In summer, urban runoff can warm receiving waters to the detriment of these organisms because of lower oxygen concentration in the water. The warmer the water, the less dissolved oxygen can be absorbed by the water and be available to the fish. Urban runoff management facilities can further aggravate the situation when they hold water for an extended time in hot weather. These conditions exist in most of the nation, excluding a narrow band along the Pacific coast west of the Sierra and Cascade Mountains. The Metropolitan Wash-

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ington Council of Governments (Galli, 1991) investigated the local thermal impacts of urban runoff and its management and reached the following conclusions:

1. Air temperature was the strongest influence on stream water temperature.
2. Average stream temperature increased linearly with impervious area percentage.
3. Some temperature criteria violations occurred with 12 percent impervious area; they increased in severity and frequency with more imperviousness.
4. All structural treatment practices tested that had a surface discharge caused some violations of temperature criteria under both baseflow and storm runoff conditions.
5. The order of the practices in both raising receiving water temperatures and causing violations, from least to most serious, was

   Infiltration basins < extended-detention wetlands < extended-detention dry ponds < wet ponds.
6. Based on the findings from a literature review, the investigators concluded that the thermal conditions produced by urban runoff and treatment facilities could cause algal succession from cold-water (mainly diatoms) to warm-water filamentous green and blue-green species, as well as severe impacts on cold-water invertebrates and fish, where they exist.
7. The findings have important implications for facility selection and design, especially to shade pools and outlets.

Fish Habitat Impacts and Habitat Protection

Effective, comprehensive management of any natural resource has several prerequisites:

1. Setting clear objectives for the effort;
2. Understanding what chemical and physical (including habitat) characteristics organisms need to meet the objectives;
3. Understanding what can disrupt these characteristics; and
4. Understanding what can cause these disruptions and how to overcome the problems.

The following case study illustrates points two and three, summarizing habitat requirements of trout and salmon and citing limits tolerated by various organisms. While salmon are located in only a small area of the nation, trout are prevalent and valued throughout the northern portion and higher altitude, cooler areas farther south. Protecting diversity in aquatic systems requires knowledge of the variation in species requirements. Chapters 2 and 3 discuss causes of reduced diversity; other chapters deal with strategies to overcome these problems (point 4).

Life Cycle Characteristics

Managers must pay attention to organisms' life cycles, which can differ significantly even among closely related species. Table 3.3 summarizes the life-cycle characteristics of six ocean-going Pacific salmon species. Different fish carry out their migrations, reproduction, and rearing at different times and have freshwater stages of various lengths. Management must ensure that the sensitive young fish have the conditions they need at the right time and that barriers to migration do not bar passage of either the returning adults or sea-running young.

Habitat Requirements

Following is a summary of physical and chemical requirements of various salmonid species and life stages that define their habitat requirements, drawn from Bjornn and Reiser (1991), except as noted. As with life cycle characteristics, substantial differences exist among species.

For migration of anadromous adults

Temperature maximum: 15.6°C, except for chinook (dependent on seasonal run—13.3°C spring, 20.0°C summer, 19.4°C fall).

Depth minimum: 0.18 m, except for chinook (0.24 m).

Velocity maximum (sustainable for 5-8 minutes/sustainable in extended cruising, both in meters/seconds) (after Kerr Wood Leidal Associates Ltd. and D. B. Lister and Associates Ltd., 1980):

Coho	3.2/2.7
Chinook (fall)	3.3/2.7
Sockeye	3.1/1.0
Steelhead	4.2/1.4

Dissolved oxygen minimum: Reduced performance when below saturation; sharply reduced when below 6.5-7.0 mg/L; lower limit 5.0 mg/L.

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Table 3.3—Life cycle characteristics of anadromous salmonid fish.

SPECIES	ADULT MIGRATION	SPAWNING	EMERGENCE	FRESHWATER STAGE	DIET	JUVENILE MIGRATION
Coho	September–November	October–December	April–May	1 year	Insects Fish fry	May–June
Chinook (fall)	September–October	October–November	March–April	2–3 months	Insects	May–July
Sockeye	August–September	September–October	April–May	1 year (lake)	Zooplankton	April–June
Pink	August–September	September–October	April–May	None	In sea	April–May
Chum	September–December	October–January	April–May	None	In sea	April–May
Steelhead	All months	January–May	June–July	2–3 years	Insects Fish fry	April–June

Source: Kerr Wood Leidal Assoc. and D.B. Lister Assoc. 1980.

Barriers: Ideal falls height to pool depth = 1:1.25; maximum falls height 2.1-2.4 m, except for steelhead (3.4 m) (0.8 m for nonanadromous brown trout).

For spawning adults

Stream flow: Weighted usable (spawning) area (WUA) is a function of depth, velocity, and substrate and is related to discharge by In-stream Flow Incremental Methodology (IFIM) species models.

Dissolved oxygen minimum: 7 mg/L (Welch 1980).

Temperature maximum:
Anadromous: coho and steelhead—9.4°C, sockeye—12.2°C, chum and pink—12.8°C, chinook—13.9°C.
Nonanadromous: brown trout—12.8°C, cutthroat trout—17.2°C, rainbow trout—20.0°C.

Redd area/spawning pair: Dependent on species and space availability; ranges from order 0.1-1.0 m^2 for nonanadromous trout, to 1-10 m^2 for steelhead and smaller salmon, to 10-20 m^2 for chinook.

Depth minimum:
Anadromous: sockeye and pink—15 cm, coho and chum—18 cm, steelhead and chinook—24 cm (except 30 cm for summer chinook).
Nonanadromous: cutthroat trout—6 cm, rainbow trout—18 cm, brown trout—24 cm.

Velocity range:
Anadromous: generally 20-40 cm/s minimum to approximately 1 m/s maximum.
Nonanadromous: cutthroat trout—11-72 cm/s, brown trout—21-64 cm/s, rainbow trout—48-91 cm/s.

Substrate size range:
Anadromous: 1.3-10.2 cm (except 0.6 cm minimum for steelhead).
Nonanadromous: rainbow trout—5.2 cm maximum, brown trout—7.6 cm maximum, cutthroat trout—10.2 cm maximum (0.6 cm minimum in each case).

For egg incubation

Temperature maximum:
Anadromous: 13.3°C, except for chinook (14.4°C) (Welch, 1980, recommended 12.8°C for all salmon and trout).

Substrate size minimum: Data show that embryo survival declines from near 100 percent with near 0 percent fines < 6.35 mm, to approximate 50 percent with 20-40 percent fines (species dependent—order 20 percent for cutthroat, 30 percent for rainbow, 40 percent for chinook and steelhead), to near 0 percent with > 50-60 percent fines.

Dissolved oxygen minimum: Percent survival exhibits a linear relationship with DO for some species (e.g., steelhead); percent survival drops below 50 percent when DO < 8-9 mg/L and low DO reduces size and a threshold relationship for others (e.g., coho, where the threshold is approximately 8-9 mg/L).

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For juvenile rearing

Temperature preferences:
Anadromous: 12-14°C, except for steelhead (10-13°C).
Nonanadromous: 14-16°C for brook trout.

Dissolved oxygen minimum: Data show a threshold relationship generally exists, with the threshold at approximately 4 mg/L and a very rapid decline in survival below that level.

Space minimum: Depends on age and size; anadromous fish with a short freshwater rearing period need 0.01-0.1 m^2/fish and those with an extended freshwater rearing period need 0.5-5 m^2/fish; nonanadromous fish need 5-100 m^2/fish.

Streamflow: IFIM models also exist for rearing.

Depth range: Highly variable; mostly in range 30-75 cm.

Velocity maximum: Variable with few data showing preferences above 40 cm/s.

Substrate size minimum: Embedding large substrate with fines (< 6 mm) reduces juvenile densities (faster in winter than in summer); density decreased to about half of maximum with about 30 percent embeddedness in winter for steelhead and chinook.

Cover: Cutthroat trout biomass exhibited an exponential decline with cover loss in one study; in another study steelhead and chinook biomass was higher with more diversity in cover types and benefited most with increased amounts of side overhang and brush.

Examples of Management Strategies

1. Culverts are a common impediment to fish movements. Considerations are depth, length and velocity in relation to the fish's ability to swim against the velocity long enough to pass through the culvert, and vertical drop at the downstream end. For example, smaller, slower-swimming sockeye salmon adult migrants would need a lower velocity and smaller vertical jump than steelhead. Table 3.3 also shows that favorable conditions would have to be maintained at different times (late summer for sockeye and throughout the year for steelhead).

2. A frequent mistake in protecting and restoring fisheries habitat is to underestimate the space needed for a pair to spawn and each juvenile to rear. Successful spawning for larger fish and those with a longer residency requires that substantial suitable bed space be created or protected. For example, to provide for spawning and rearing of brown trout, 0.1-1.0 m^2 of substrate with 0.6-7.6 cm material must be provided for each spawning pair. The water should be no warmer than 12.8°C, at least 24 cm deep, and have at least 7 mg/L DO and velocity in the range 21-64 cm/s. Each juvenile would need much more space (5-100 m^2), however, at comparable conditions (except lower velocity). Anadromous fish would need more territory for spawning but less for rearing.

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CHAPTER 4

Water Quality Monitoring

To obtain conclusive data on urban runoff and its effects on the watershed is difficult and expensive. Therefore, monitoring programs that collect data must be carefully designed to be cost-effective. This chapter suggests a general process for designing water quality monitoring programs, whether the monitoring subject is water quality, sediments, or biological organisms.

This process comes mainly from research to improve monitoring program design in urban runoff and other nonpoint source fields. Consult Reinelt, Horner, and Castensson (1992); Reinelt, Horner, and Mar (1988); Mar et al. (1986); and other references and sources for more details. Guidance on sediment and biological monitoring programs follow in subsequent chapters.

The suggested analytical process has five steps:

1. Specify monitoring program objectives;
2. Determine the level of effort to devote to the analysis;
3. Perform a systematic analysis appropriate to the problem and objectives;
4. Use the analysis results to tentatively specify monitoring program elements; and
5. Evaluate the tentative monitoring program for cost-effectiveness and finalize according to evaluation results.

Monitoring Program Design Steps

1. Specify monitoring program objectives

Establishing objectives is essential, even though they cannot always be specified in great detail. The most thoughtful statements, agreed upon by all stakeholders, should guide the monitoring program design and conduct. Objectives stem from the nature of the problem or decisionmaking need that requires data collection. Urban runoff management problems include the following:

- Defining the water quality status of a discharge or waterbody;
- Identifying problem areas, their sources, or both;
- Selecting locations to apply problem abatement strategies;
- Evaluating alternative abatement strategies both prior to and after implementing control techniques;
- Calibrating and verifying runoff simulation models; and
- Researching (e.g., to identify ways that contaminants affect organisms).

Every monitoring program should, if possible, formulate objectives at two levels—general and specific. General objectives describe what must be accomplished to solve the overall problem or meet the need. For example

- Obtaining a baseline definition of the effect a proposed development will have on water quality in a lake.
- Determining long-term trends in sediment accumulation of metals in a poorly flushed bay.

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- Finding the contamination source that has closed a shellfish bed to harvesting.

Specific objectives relate directly to measurements and produce results to meet the general objectives. Some examples related to the third general objective—finding the contamination source—are

- Determining the annual fecal coliform loadings contributed by agricultural, septic drain field, and urban runoff sources.

- Identifying the three largest sources of fecal coliform loading to the shellfish bed area.

These objectives can be stated in more detail and more specifically, particularly regarding measurements (e.g., zinc and chromium as the specific metals; percent Ephemeroptera [mayflies] + Plecoptera [stoneflies] + Trichoptera [caddisflies] as the macroinvertebrate measure) when step 3 of the general design process is completed. Using this process ensures careful decisionmaking at each step and counters the tendency to use a generic monitoring strategy that may not relate to the program goals. Exercising discipline to make careful assessments is the best way to be cost-effective in monitoring.

2. Determine the level of effort

A monitoring program can range from simple and inexpensive to thorough and costly, depending on the objectives for the particular program. The effort expended depends on the quantity and type of information available, the detail of additional information needed, the resources of the designers, and the urgency to begin monitoring.

Available information can help target new monitoring and substantially reduce costs. Therefore, designers should incorporate this information in their analysis, using techniques in this manual. Some problems may not be worth extensive effort, while others demand it. For example, merely determining whether a problem exists at a particular place is often straightforward and may not need extensive analysis. On the other hand, monitoring to allocate resources for solving problems in a large, complex watershed may require a substantially greater level of analysis.

Even if little guidance information exists, and the designer has limited time and resources, at least the basic analytical process should be applied. After developing a preliminary information base, the designer can always review the systematic analysis of the problem and objectives in more detail later.

3. Perform a systematic analysis

As the core of the process, step 3 represents the most effort. The analyst should give priority to key factors causing the problem.

This systematic analysis is often referred to as a watershed analysis. The term watershed broadly signifies an area, large or small, that drains a land surface to a point of interest. While a watershed can be a small catchment with a simple drainage system, for now we will consider a watershed as a landscape of some size and complexity draining through a network of artificial and natural conveyances to a natural waterbody. Thus, the analysis involves surveying watershed characteristics, identifying the most critical potential problems and sources, and highlighting the most critical places, times, and biological units that manifest the problems.

A watershed inventory involves collecting the appropriate level of data according to the needs of the project. While the level of detail may vary, your inventory should include developing a basin map; identifying such features as land uses, soils, topographic information, and hydrologic data; and identifying potentially critical problem source locations (e.g., earth-moving activity, industrial areas, major traffic concentrations) or areas potentially sensitive to problems (e.g., fisheries and other productive resource areas, rare or endangered resources, stream reaches vulnerable to major channel damage). Obtaining any available data on these features and field reconnaissance are key tasks in a watershed inventory.

Identifying critical problems and sources should be a systematic process of formulating a broad list and then narrowing it by prioritizing items, with the level of effort chosen in step 2 dictating the scale of the analysis. For example, to find the principal sources of water quality deterioration in a river draining a large watershed, we may suspect that certain areas and activities need our attention. However, this judgment should be tested by some quantified, comparative estimates of pollution quantities like those models suggested in Chapter 2. Although such a model may be overly generalized, simplified, and not calibrated locally, its purpose is not to reach a final decision, but to guide the design of a monitoring program. Even with a small effort level, the simplest model can often bring objectivity and rigor to the analysis.

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Identifying critical places, times, and receptor organisms presents a more difficult problem. We must at least conceptualize the relationship between problem occurrence and timing and the potential damage for habitats, species, and life stages. While models can sometimes help, they are usually too simple or inconvenient. Ideally, the specialists (e.g., water quality engineer, hydrologist) will work closely with an ecologist familiar with the waterbody, its ecology, and natural history to judge these critical factors.

Reviewing the original objectives for their continued appropriateness is a good practice. Objectives will likely need to be modified or made more specific with the increased knowledge.

4. Specify monitoring program elements tentatively

If performed properly, the systematic analysis of step 3 will provide sufficient information to give tentative shape to the monitoring program. In designing the program, determine

- What to sample;
- Where to sample;
- When to sample;
- How many samples to take on each occasion (replicates);
- How to sample; and
- What to analyze in samples.

The design should set objectives, identify potentially critical problems, and target the monitoring program, considering cost-effectiveness. Thus, the objectives and analytical findings should dictate the media to be sampled, the locations and times of sampling, and the analyses to be performed. This philosophy rejects working from prescribed sampling scopes and frequencies and standard lists of analytical measures. It advocates tailoring the program to a specific level of effort to meet stated objectives developed from a systematic analysis—all to advance program cost-effectiveness. The tentative decisions on monitoring program design are further evaluated in step 5 before they are finalized.

Deciding when to sample includes planning and scheduling a number of visits to each sampling location. Use careful judgment to select the initial number of visits rather than automatically specifying periodic intervals (e.g., biweekly or monthly). Natural phenomena do not occur at evenly spaced intervals. Most places, for example, have seasonal differences in the type, amount, and/or intensity of precipitation. Accordingly, stratify sampling to consider these events. For instance, visits might be scheduled for times of highest runoff when pollutant delivery is greatest and at lowest flow when pollutants concentrate most. Transitional periods would get less coverage.

How to sample is discussed in the guidance following step 5.

5. Evaluate the tentative monitoring program and finalize

Evaluate the step 4 tentative monitoring program according to its number of samples. The sample numbers and the analyses specified are factors that directly determine the program's cost and probable effectiveness. Monitoring programs frequently fail to provide the desired information, even when performed flawlessly, because the samples are insufficient to achieve an accepted level of statistical assurance. This failure results from the high variability in runoff and natural aquatic systems. For example, variability prevents us from attaining a high level of statistical confidence that an average water quality condition meets a criterion or that a new discharge creates a change in a biological community.

Sources of variability include spatial differences in a landscape or waterbody, differences over time (temporal variability), and measurement error. Measurement errors can be reduced by using better techniques, if they exist. Otherwise, collecting replicate samples quantifies the measurement error component. Increasing sample numbers can overcome natural spatial and temporal variability, unless they are enormous; but that strategy raises cost.

The basic task is to determine the number of samples (stations, occasions, and replicates) needed to meet the objectives, considering variability and budget limits. Using the optimal number of samples to reach a conclusion will produce the maximum confidence level for a set budget, or a minimum cost for a set assurance level. These options, representing two ways to maximize the monitoring program's cost-effectiveness, can only be applied if some data are already available to give statistical measures of central tendency (e.g., mean or median) and variance. In that case, statistical methods can be applied to the optimization

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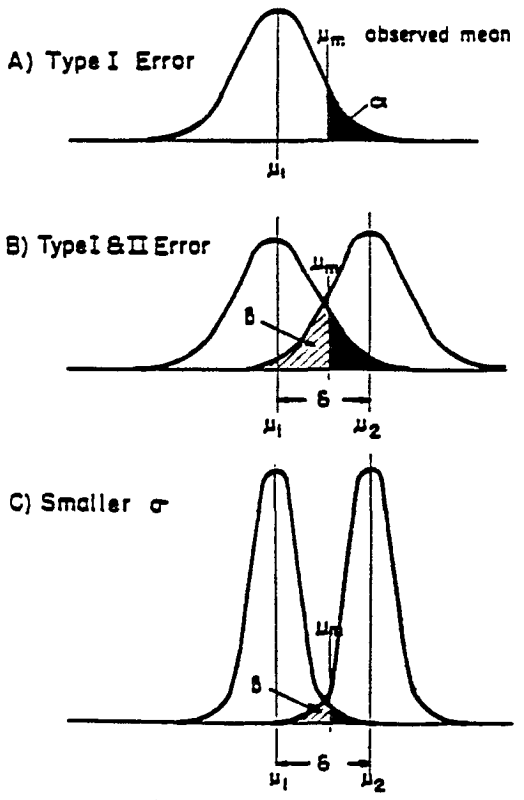
problem. Mar et al. (1986) reviewed the following appropriate methods for common situations in monitoring program designs.

Determining a Mean Value

Determining a mean value applies, for example, when an average water quality condition is compared to a regulatory criterion. In basic statistics, t-distribution defines the confidence interval for the mean of a normal population (set of values) as estimated from a data set. The t-distribution is used to determine sample numbers if the data are demonstrated or assumed to have a normal probability distribution (Figure 4.1A), or if they can be transformed (e.g., by taking their logarithms) to yield a normal distribution.

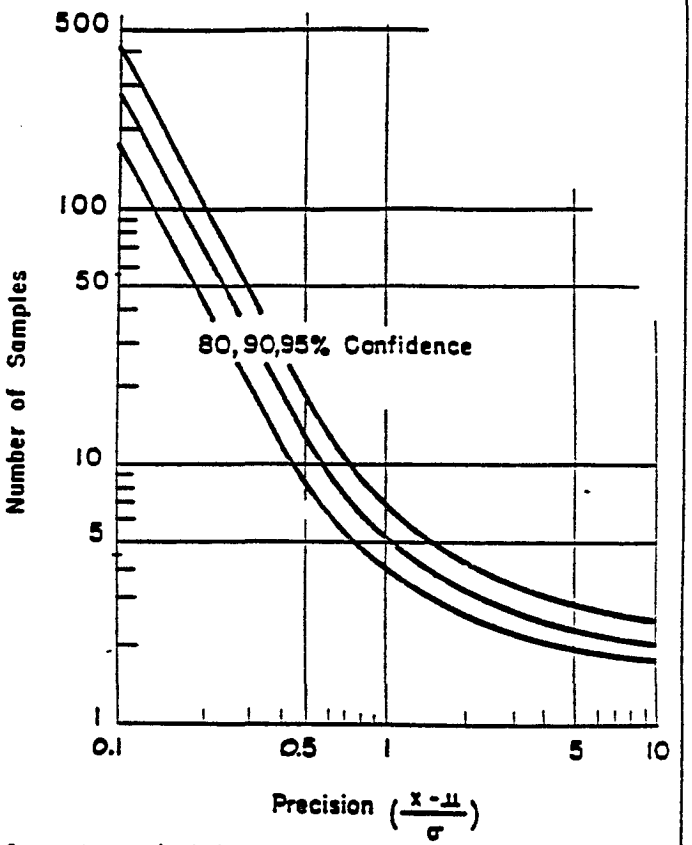
Figure 4.1—Hypothesis-testing fundamentals.
μ_1 and μ_2 are the means of two populations of measurements; their difference represents a change—delta. Alpha and beta are the probabilities of the Type I and Type II error, respectively.



Source: Mar et al. 1986.

Figure 4.2 shows an analysis result based on the t-distribution for three confidence levels. The curves show the number of samples required as a function of precision. Precision is the ratio of the difference in the estimated and actual mean (the error that will be accepted) to the standard deviation (the variation or noise in the data). To use the graph, the monitoring program designer consults available data to get estimates of the mean and standard deviation and decides on the acceptable error and confidence level. For the case of an acceptable error equal to the standard deviation (precision = 1) and an 80 percent confidence, four samples are needed. But demanding a precision of 0.1 requires hundreds of samples.

Figure 4.2—Number of samples versus precision for three confidence levels. Precision is the ratio of the allowable error to the standard deviation of the population of measurements.



Source: Mar et al. 1986.

Detecting Change

Detecting change applies, for example, when the size or composition of a biological community is evaluated at two different points in time. Programs designed to detect change require different statistics than those that simply identify means. This type of problem is phrased as a statistical hy-

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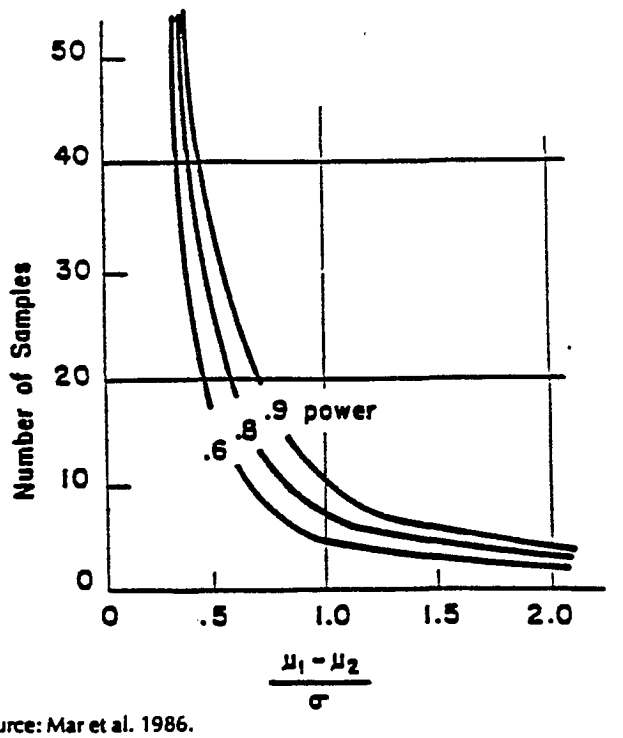
pothesis test in which the null hypothesis (H_0) is that the populations at the two times are from the same distribution; the alternative hypothesis (H_1) is that they are from different distributions.

Figure 4.1 illustrates terminology needed for this type of evaluation. The shaded area of Figure 4.1(A) represents the probability (alpha) of a Type I error (H_0 was rejected when it was, in fact, true). Figure 4.1(B) shows distributions at both points in time, in which the difference in means represents an apparent change of magnitude (delta). The hatched area represents the probability (beta) of a Type II error (H_0 was accepted when it was, in fact, false). The quantity (1-beta) is termed the power of a statistical hypothesis test. Figure 4.1(C), in comparison to the other two graphs, illustrates the variation effect, as represented by the standard deviation, on power. For a given change, delta, the power increases as the standard deviation decreases.

Figure 4.3 provides a graphic way to establish the number of samples needed to detect change. To use the graph, the monitoring program designer consults any available data to estimate the standard deviation and decides on the magnitude of change to be detected (delta = $\mu_1 - \mu_2$) and the power. This plot shows that to detect changes to less than 50 percent of the standard deviation, the program requires a large number of samples.

Figure 4.3—Power curves relate number of samples to change to be detected. Sigma is standard deviation.



Source: Mar et al. 1986.

Monitoring Costs

The statistical methods previously illustrated show how to measure the program effectiveness value of added information in the form of more samples. However, to optimize the program, cost estimation must accompany these methods. Given the cost and value of added data, a trade-off analysis can be performed to obtain the most cost-effective program within the existing constraints. Costs are accounted as follows:

$$TC = C_o + T \cdot C_t + S \cdot T \cdot C_s + R \cdot S \cdot T \cdot C_r \quad [1]$$

where:
- TC = Total cost;
- C_o = Fixed overhead cost;
- C_t = Fixed cost for each sampling occasion;
- C_s = Cost associated with visiting each sampling station;
- C_r = Cost to collect and analyze each sample;
- T = Number of sampling occasions;
- S = Number of sampling stations; and
- R = Number of replicates on each occasion at each station.

Note that $R \cdot S \cdot T$ = the total number of samples. For a given total, the three quantities can be varied so long as their product remains the same. If measurement error is larger than natural variation, then adding replicates would reduce uncertainty more than adding stations or occasions. However, if spatial or temporal variation dominates, adding stations or occasions, respectively, would be a better strategy.

Optimization Example

Suppose three variables—A, B, and C—are monitored to establish their means with 90 percent confidence. Table 4.1 gives the measurement and variability costs of each. Considering three bases to design the monitoring program illustrates optimizing for a given budget (Designs 1 and 2) and a given level of assurance (Design 3):

▮ ***Design 1.*** Three samples will be collected for each variable (fixed cost of $333). What is the minimum error that can be attained in each case?

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■ ***Design 2.*** Four samples will be collected for each variable (fixed cost of $444). What is the minimum error that can be attained in each case?

■ ***Design 3.*** A fixed error of 24 percent of the mean is required for each variable. What design (sample numbers) provides this level of certainty at the minimum cost?

Table 4.1 summarizes the evaluation. Design 2, as compared to Design 1, indicates that an increased but equal number of samples would only slightly improve the estimate of the mean for each variable, and the estimate for variable B would still be uncertain relative to the others. However, as shown by Design 3, allocating more samples to the variable with the greatest variation, and where the most improvement results per dollar spent, provides a more cost-effective design.

In most actual cases, a simple analysis like this is insufficient since uncertainties can result from several factors, including measurement errors and spatial and temporal variability. Then, a sensitivity analysis should be performed to investigate each cost and variance component and its effect on the design in order to allocate the effort among sampling locations, occasions, and replicates. Mar et al. (1986) gives an example of such an analysis.

Table 4.1—Monitoring program optimization example.

INPUT DATA	VARIABLE		
	A	B	C
Cost per sample	$100	$ 1	$10
Standard deviation (percent of mean)	10	100	20

DESIGN 1 (3 samples of each variable)

VARIABLE	COST	PRECISION[a]	ERROR[b] (% OF MEAN)
A	$300	2.4	24
B	3	2.4	240
C	30	2.4	48
TOTAL	$333		

DESIGN 2 (4 samples of each variable)

VARIABLE	COST	PRECISION[a]	ERROR[b] (% OF MEAN)
A	$400	2.2	22
B	4	2.2	22
C	40	2.2	44
TOTAL	$444		

DESIGN 3 (fixed allowable error of 24 percent of the mean for each variable)

VARIABLE	ERROR (% OF MEAN)	PRECISION[c]	NO. SAMPLES[a]	COST
A	24	2.4	3	$300
B	24	1.2	5	50
C	24	0.24	56	56
			TOTAL	$406

[a] From Figure 4.2 for 90 percent confidence.
[b] Error = Precision X standard deviation.
[c] Precision = Error/standard deviation.
Source: Mar et al. 1986.

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Additional Considerations

Stratification of sampling, as discussed under step 4, can help reduce the variability that complicates monitoring. Values will fit in tighter bounds within a single season if all values are lumped for the entire year. The analysis can be performed separately for the respective seasons and sampling occasions allocated accordingly.

If no data are available, monitoring program designers have several choices. They can conduct a pilot program to obtain a limited data set; however, this would require spending time and money. A second choice is to use data from a similar location or estimate values using professional judgment. Either course has obvious drawbacks in accuracy, but both may be superior to making an educated guess of the sample number with qualitative, but no quantitative, analysis. Even that option is better, though, than blindly choosing the number of sampling occasions without any analysis.

In some cases, uncontrollable natural variability will be too great to achieve confidence in some program element with any feasible budget. The designer must then either delete the element or reduce costs in other areas to direct resources to the element. The options, illustrated by the cost equation, are to reduce the number of sampling stations, the analyses prescribed, the various cost functions representing program elements, or some combination. This decision is often unpalatable because it can demand, for example, cutting geographic coverage or not analyzing for a water quality measure traditionally included. However, the designer must choose and target the program according to objectives and circumstances, rather than conducting a program that gives inconclusive or misleading answers.

Water Quality Monitoring Program Guidance

Flow Measurement

Measuring Flow in Uncontrolled Open Channels

Flow, or discharge, is a basic hydraulic characteristic affecting morphological development of stream channels, flooding behavior, bed and bank erosion, and sediment deposition. A flow measurement is needed to estimate pollutant mass flux—the product of pollutant concentration and flow. Flow is measured manually or by continuously recording automatic instruments. Recording instruments require a controlled section such as a pipe, weir, or flume (see following section).

The common manual methods of flow measurement in uncontrolled channels are current meter surveys, staff gages, and float and tracer surveys (U.S. Dep. Inter. 1977). The current meter technique involves determining flow for a cross section of the channel. Current velocity and depth data from several points along the cross section are summed to obtain total flow. A staff gage provides an instant reading of water stage (i.e., level of water surface relative to a known point or datum). A stage-discharge curve must be developed to estimate flow from the staff gage reading. The curve is developed by correlating flows determined from current meter surveys with stages over a range of flow conditions. Estimating flow from timed float travel measurements can be inaccurate. Using this method should be limited to low or high flow conditions when the current meter cannot be employed. Tracers include biodegradable dyes and salts detectable by photometric and conductometric measurements, respectively. Tracer surveys are less convenient and more time consuming in natural waters than current meter methods.

▮ ***Site Selection Criteria.*** Select a representative location to establish a station for monitoring flow. Proper site selection improves the accuracy of flow measurements at all discharge levels. Consider the following criteria when establishing a discharge measurement station. However, all criteria listed can rarely be met. Be aware of the site's limitations and possible effects on measurement.

The station should be located in a channel reach (i.e., longitudinal section) with the following characteristics:

- The channel should be straight for 328 ft (100 m) upstream and downstream of the staff gage station.
- Flow should be confined to one channel at all discharge stages (i.e., the channel should contain no surface or subsurface bypasses).
- The bed should be subject to minimal scour and relatively free of plant growth.
- Banks should be stable, high enough to contain maximum flows to be measured, and free of brush.

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- The station should be located a sufficient distance upstream so that flow from tributaries and tides does not affect stage/discharge measurements.
- All discharge stages should be measurable within the reach, but low and high flows at the identical cross section need not be measured.
- The site should be readily and safely accessible.

The cross section in which a station is located within a channel reach should have the following characteristics:

- Banks should be relatively high and stable.
- The channel should be straight with parallel banks.
- Depth and velocity must meet minimum requirements of the method and instruments used.
- The bed should be relatively uniform with minimal boulders and without heavy aquatic growth.
- Flow should be uniform and free of eddies, slack water, and excessive turbulence.
- Sites should not be located downstream of areas with rapid changes in stage or velocity.

Measurement Procedure Using a Current Meter

1. Extend a measuring tape at right angles to the direction of flow and measure the width of the cross section. Record measurements on a data sheet. Leave the tape strung across the stream.
2. Divide the width into segments using at least 20 points of measurement. If previous flow measurements have shown uniform depth and velocity, fewer points may be used; smaller streams may also require fewer points. Measuring points should be closer together where depths or velocities are more variable. Cross sections with uniform depth and velocity can have equal spacing.
3. Record the distance from the initial starting bank and the depth.
4. Record the current velocity at each measuring point. Horizontal (from left to right bank) and vertical (top to bottom) variation of stream velocity may influence streamflow measurements. To correct for vertical differences, hydrologists have determined depths that can yield acceptable estimates of the mean velocity over a vertical profile. If the depth exceeds 0.8 m (2.5 ft), velocities should be measured at 20 percent and 80 percent of full depth and averaged to estimate mean velocity. In the depth range 0.1 to 0.8 m (0.3 to 2.5 ft), take the velocity at 60 percent of the full depth (measured from the surface) as an estimate of the mean over the profile. Measuring velocity in water shallower than 0.1 m (0.3 ft) is difficult with conventional current meters. If much of the reach of interest is very shallow, or flow is too slow for current meter measurement, consider installing a control section and V-notch weir.
5. Calculate flow as a summation of flows in partial areas (Figure 4.4) using the following equation:

$$q_n = v_n d_n \frac{(b_{n+1} - b_{n-1})}{2} \qquad [2]$$

where:

b_{n-1} = Distance from initial point to the preceding point (m [ft]);
b_{n+1} = Distance from initial point to the following point (m [ft]);
d = Mean depth of partial area n (m [ft]);
v = Average current velocity in partial area n (m/sec [ft/sec]); and
q = Discharge in partial area n (m^3/sec [ft^3/sec]).

Measuring Flow in Controlled Open Channels

An open channel is any conveyance where flow is not constrained or under pressure. Therefore, closed pipes and culverts can be open channels if they are not flowing full, a normal situation in runoff conveyance systems. When the channel geometry is regular and absolutely stable, it is termed controlled, as in pipes, culverts, many lined ditches, and channels where a weir or flume can be installed. In those situations, a recording automatic flow meter can be used.

Flow meters measure in several different ways. The most common way to measure runoff is to sense flow depth and convert to flow rate by some known relationship. Other techniques are electronic and ultrasonic.

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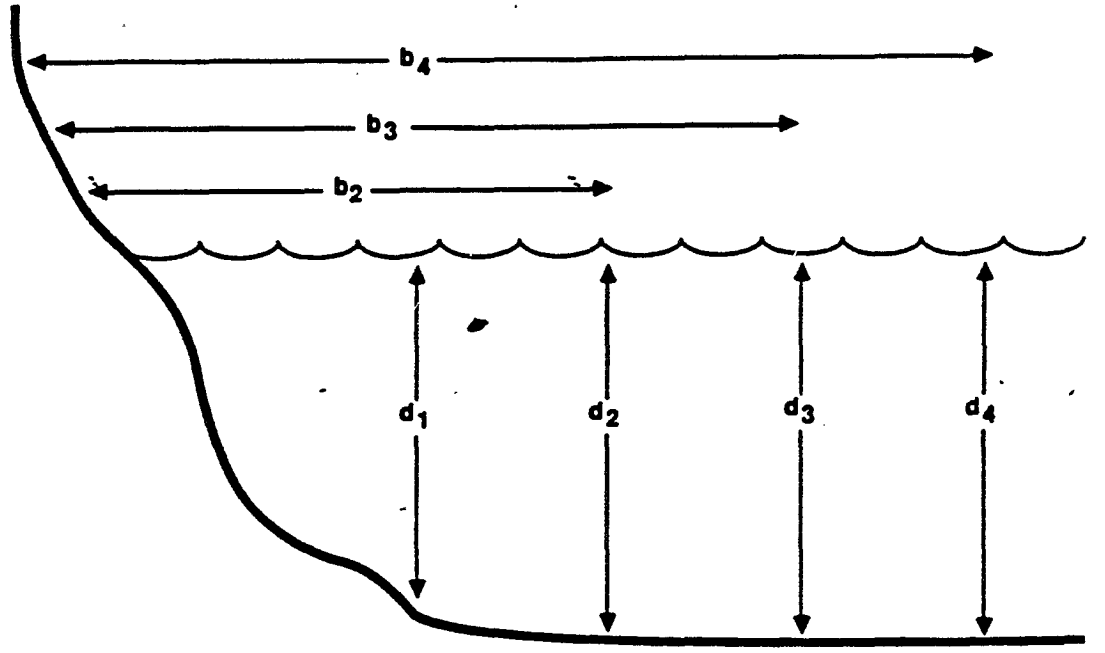
Figure 4.4—Variables used to calculate stream discharge using the current meter method.



Source: R.R. Horner.

Among the most common means of sensing depth is by releasing a regularly spaced stream of air bubbles at the channel invert and detecting the back pressure resisting the bubble release—a function of depth. The bubble tube must be installed exactly as the manufacturer prescribes to get reliable measurements. How the depth measurement is converted to flow rate depends on the conduit. Standard weirs and flumes have well-established equations to simply compute flow rate from geometry and depth. Without a primary control device such as a weir or flume, flow rate must either be related to depth through a calibration using a current meter or, more commonly, by the standard equation of open channel flow—Manning's equation:

$$Q = A \cdot R^{0.67} \cdot s^{0.5}/n \qquad [3]$$

where: Q = Flow rate (m^3/s);
A = Channel cross-sectional area (m^2);
R = Hydraulic radius (m) = A/wetted perimeter;
s = Water surface slope (m/m); and
n = Manning's roughness coefficient (dimensionless).

In the English system of units, a multiplier of 1.49 on the right side of the equation gives Q in ft^3/s if geometry is in ft and ft^2.

Because of uncertainties in estimating slope, depth, and n—the latter of which comes from tables—the accuracy obtained from using Manning's equation is not as great as with a weir or flume. When using the equation, place the depth sensor in the channel where

- The cross section is uniform;
- The slope and roughness are constant;
- The channel is free of rapids, bends, abrupt falls, contractions, expansions, and backwater; and
- The channel is straight for at least 200 ft (60 m) upstream.

Modern recording automatic flow meters can make depth-to-flow rate conversions, accumulate a continuous flow-rate record, and provide the total flow volume over a period. The operator programs the appropriate flow conversion equation in the meter—using a weir or flume equation, Manning's equation, or a calibration equation derived from empirical data. These flow meters can also control an automatic sampler to collect flow-proportional composite samples.

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Water Sampling Guidelines

The essential tasks in sampling natural waters and runoff are to obtain a sample that meets the program requirements and to prevent its deterioration and contamination before and during analysis. Water can be collected either as discrete or composite samples. Discrete samples are collected at a specific point in time and space; composite samples are made by combining a number of samples taken at different locations and/or different times. For flowing water sampling, flow-proportional composited samples better represent average water conditions than discrete samples or multiple samples taken at different times and composited without regard to flow.

Integrated samples refer to spatial composites. While composites can be taken over any dimension, compositing over depth is most common. In variable-depth composites, a series of grab samples are combined in proportion to flow velocities over the depth profile.

Sampling can be performed manually or with automatic collectors that collect a series of discrete samples, time-proportional, or flow-proportional composites. Flow measurements, required to produce flow-proportional composites, can be performed manually or with a continuously recording meter. Simple manual depth-integrating samplers approximately adjust for velocity differences as the sampler is lifted through the water column.

Manual Grab Sampling

The principal problem is obtaining a sample that represents the conditions being investigated. The guidelines for obtaining representative samples differ for flowing and standing water. Further information concerning lake sampling is available in Cooke et al. (1993) and Vollenweider (1974).

Water Sample Handling

To avoid mistakes, label a sample bottle with an indelible marker before going into the field. Sample labels must include station designation, date, collector's name, and any preservative added. The label can also include analyses to be performed and any pertinent remarks.

A tracking record for each sample registers possession as the sample travels from collection through analysis, making misplaced samples easier to find. Samples involved in litigation may require formal sample tracking, or chain-of-custody records.

Samples must be preserved and analyzed within a certain period to avoid deterioration. Recommended preservation methods and holding times, given in Table 4.2 were derived from American Public Health Association (APHA) and U.S. EPA (1983).

Water Quality Analytical Methods

Analytical methods and detection limits for commonly analyzed variables are given in Table 4.3. These methods are covered in both the American Public Health Association (1992) and U.S. EPA (1983) manuals.

Select an analytical laboratory carefully. A good laboratory will advise and help with aspects of the program beyond the analyses, such as sample container preparation and labeling. If an accreditation program is in effect, use a laboratory accredited for water analyses. Write detailed specifications on sample handling procedures, methods, detection limits, and quality assurance/quality control (QA/QC) requirements, using this chapter's recommendations.

Quality Control

The effectiveness of any monitoring effort depends on its quality control (QC) program. The QC program provides quantitative measurements of the "goodness" of the data. For some variables, QC involves calibrating instruments with known standards. To obtain accuracy and precision, QC also further involves analyses of blanks, replicate samples, control samples, and spiked samples. QC definitions of terms are included in this chapter.

Table 4.4 gives QC guidelines. State specific QC requirements explicitly in any contract, and conduct discussions among project managers and field and laboratory personnel concerning the QC project requirements before a contract is signed. Requirements differ among projects — a project involving enforcement actions or litigation can have more stringent QC requirements than one involving routine ambient monitoring. More information is available in U.S. EPA (1979) and American Public Health Association (1992).

Definitions Used in QC Practice

- ***Field replicates.*** Separate samples collected simultaneously at the identical source location and analyzed separately. Field replicates assess total sample variability (i.e., field plus analytical variability).

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Table 4.2—Recommended sample sizes, containers, preservation techniques, and holding times for measurement of water quality variables.

VARIABLE	MINIMUM SAMPLE SIZE (mL)[a]	CONTAINER[b]	PRESERVATION	HOLDING TIME[c]	
				RECOMMENDED	MAXIMUM
Temperature	1,000[d]	P, G	None	Zero[e]	Zero[e]
Conductivity	100	P, G	Cool, 4°C[f]	28 days	28 days
Dissolved oxygen	300	G (BOD bottle)	Fix with reagents, store in dark	8 hours	8 hours
pH	25[g]	P, G	None	Zero[e]	Zero[e]
Alkalinity	100	P, G	Cool, 4°C[f]	24 hours[h]	14 days
Total hardness	100	P, G	HNO_3 to pH < 2	6 months	6 months
Total suspended solids	1,000[i]	P, G	Cool, 4°C[f]	7 days	7 days
Turbidity	100	P, G	Cool, 4°C[f]	24 hours	48 hours
Ammonia-nitrogen	125	P, G	H_2SO_4 to pH < 2 Cool, 4°C[f]	24 hours	28 days
Nitrate + nitrite - nitrogen	125	P, G	H_2SO_4 to pH < 2 Cool, 4°C[f, j]	24 hours	28 days
Total phosphorus	50	P, G	H_2SO_4 to pH < 2 Cool, 4°C[f]	48 hours	28 days
Orthophosphate-phosphorus	50	P, G	Filter onsite Cool, 4°C[f]	24 hours	48 hours
Fecal coliform bacteria	125	P, G[k]	Cool, 1-4°C[f]	6 hours	30 hours
Metals	1	P[m]	High-purity HNO_3 to pH < 2	6 months	6 months

[a] Recommended field sample size for one laboratory analysis of the given variable.
[b] P = polyethylene, polypropylene, or fluoropolymer; G = glass.
[c] Analyze within the recommended time if possible, but in all cases within the maximum. The holding times given are for routine monitoring work.
[d] Measuring directly in waterbody is preferred.
[e] Analyze immediately.
[f] Holding at 4°C implies holding in the dark.
[g] Increase the volume to rinse the pH electrodes several times, especially in low-alkalinity waters.
[h] Some agencies prefer to analyze low-alkalinity waters in the field, while the greater analytical control available in the laboratory is preferred in other agencies.
[i] Volume given is the maximum needed to filter for analysis of low concentrations. A smaller quantity (100-250 mL) is adequate for most samples.
[j] If nitrate-nitrogen data are needed, a separate, nonacidified sample is required. The nonacidified sample must be analyzed for nitrite-nitrogen within 48 hours. Nitrate-nitrogen is determined by subtracting nitrite-nitrogen from nitrate + nitrite-nitrogen.
[k] Container must be able to withstand autoclaving at 121°C for 20 minutes.
[l] Depends on number of metals to be analyzed and the analytical method. 2 liters is sufficient to analyze all EPA priority metals by atomic absorption (AA), while inductively coupled plasma (ICP) would require less.
[m] Fluoropolymer preferred.

Source: Tetra Tech et al. 1988.

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Table 4.3—Recommended analytical methods and detection limits.

VARIABLE	UNIT	DETECTION LIMIT[a]	METHODS
Temperature	°C	—	Mercury-filled thermometer, digital probe
Conductivity	µmhos/cm[b]	1	Conductivity meter
Dissolved	mg/L	—	Azide-modified Winkler, membrane electrode
pH	pH units	—	Electrometric
Alkalinity	mg/L as $CaCO_3$	1	Titrimetric
Total hardness	mg/L $CaCO_3$	1	EDTA titrimetric
Total suspended solids	mg/L	—	Gravimetric
Turbidity	NTU[c]	1	Nephelometric
Ammonia-nitrogen	µg/L	10	Automated phenate[d]
Nitrate + nitrite - nitrogen	µg/L	10	Automated cadmium reduction Cadmium reduction[d]
Total phosphorus	µg/L	5	Automated ascorbic acid, Heteropoly blue ascorbic acid (following persulfate digestion)[d]
Orthophosphate-phosphorus	µg/L	2	Automated ascorbic acid, Heteropoly blue ascorbic acid[d]
Fecal coliform bacteria	colonies/100 mL	1	Membrane filter
Metals	µg/L	e	Inductively coupled plasma, Inductively coupled plasma-mass spectroscopy, Graphite furnace atomic absorption, Flame atomic absorption

[a] Report results below the detection limit as less than the detection limit.
[b] Microsiemans/cm (µS/cm) are used in the SI system. 1 µmho = 1 µS.
[c] NTU= Nephelometric turbidity units.
[d] Both automated and nonautomated procedures are recommended for nutrient analyses because some laboratories have not been converted to automated techniques.
[e] Depends on metal and method. New inductively coupled plasma-mass spectroscopy methods (ICP-MS) have sub-part per billion detection limits.

Source: Tetra Tech et al. 1988.

▮ ***Laboratory replicates.*** Repeated analyses of a variable performed on the contents of a single sample. Laboratory replicates assess analytical precision. Duplicate analyses usually suffice for well-proven procedures in the laboratory.

▮ ***Calibration samples.*** Samples from distilled-deionized water that contain a known concentration of a specific substance or will produce a known instrument response. Calibration samples analyzed during an analytical run are often re-

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Table 4.4.—Calibration and quality control guidelines for water quality variables.

VARIABLE	GUIDELINES[a]
Temperature	Check thermometer against a thermometer certified by American Society for Testing and Materials or National Institute of Standards and Technology.
Conductivity[b]	Calibrate in the laboratory with two standard KCl solutions representing the expected conductivity range of the samples. Check calibration using one standard KCl solution (with conductivity in the sample range) per batch in the laboratory or whenever the meter is set up in the field.
Dissolved oxygen[b]	For the azide-modified Winkler method, run one 100 percent saturated calibration sample/batch. For studies where low DO concentrations are expected, a calibration sample containing zero DO may be used. For the membrane-electrode method, calibrate with a sample of known DO concentration (determined using the azide-modified Winkler method) and with a sample containing zero DO. Calibration is required prior to the start of every series of measurements and whenever the meter is moved or turned off.
pH[b]	Calibrate with two buffers and check with a third every three hours. Use neutral, acid, and basic buffers (e.g., pH 4.0, 7.0, and 10.0) prepared according to National Bureau of Standards Special Publication 260-53.
Alkalinity[b]	Calibrate pH meter as above. Check titrant normality with self-prepared and U.S. EPA standard solutions (one check/batch).
Total hardness[b]	Check titrant molarity with self-prepared and U. S. EPA standard solutions (one check/batch) and run one blank/batch. Run one spiked sample/batch if interference is suspected.
Total suspended solids[b]	Check balance calibration monthly and oven temperature daily. Balances should have annual preventive maintenance checks.
Turbidity[b]	Calibrate with commercial standard in same range as samples. Recalibrate with every range change.
Manual nutrients[b]	Run calibration curve with a blank and standards at 0.2, 0.35, 0.5, 0.75, and 1.0 cu[c]. Entire range of sample concentrations must be included in the calibration curve. Run control samples at 0.2 and 0.9 cu with each batch. Run two blanks/batch and one spiked sample/batch.
Automated nutrients[b]	Run calibration curve with a blank and standards at 0.2, 0.5, and 1.0 cu. Entire range of sample concentrations must be included in the calibration curve. Run control samples at 0.2 and 0.9 cu with each batch. Run two blanks/batch and one spiked sample/batch.
Fecal coliform bacteria	Run a transport blank. Randomly split 10 percent of the samples for analysis at another laboratory. Field and laboratory replicates should both be included at a frequency of 10 percent.

[a] A batch is a group of no more than 20 samples.
[b] Field replicate samples should be collected and analyzed at a frequency of 5 to 10 percent. Laboratory replicates should be analyzed at a frequency of 5 to 10 percent.
[c] cu = Upper limit of expected concentration range.
Source: Tetra Tech et al. 1988.

ferred to as control samples or check standards. The distilled-deionized water used in calibration samples should meet Type 1 water quality criteria specified by American Public Health Association (1992) Method 107.4.

Blanks. Samples prepared from distilled water, perhaps with reagents added, to represent zero concentration of a specific substance or to produce an instrument response indicating zero concentration.

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A transport blank is required for fecal coliform bacteria studies and may be useful in nutrient studies. A transport blank is transported to the sampling location and treated like a sample thereafter.

▮ ***Spiked samples.*** Samples prepared by adding known concentrations of a specific substance.

▮ ***Accuracy.*** The agreement between the measurement of a variable in a sample and its true value. The term "error" is used when the discrepancy between the measured and true values is expressed in the units of the measured variable. Relative error is when the error is expressed by the percentage deviation from the true value.

▮ ***Precision.*** The agreement among replicate laboratory measurements. Precision is measured by the standard deviation when using the units of the measured variable. Relative standard deviation is when the standard deviation is expressed as a percent of the mean of the replicate values.

Sample Container Cleaning

Avoiding sample contamination requires careful cleaning of sample bottles and laboratory equipment. Some general guidelines for cleaning are presented here. Additional requirements for certain individual variables are covered in the methods sections for those variables. The recommended procedures should be applied to sample containers and all laboratory glassware and implements that will come into direct contact with samples during collection, storage, or analysis.

Laboratory equipment should always be washed with detergent, rinsed with tap water, and rinsed an additional three times with ultrapure deionized water. Detergents must be selected considering the analyses to be performed (e.g., use phosphorus-free detergent when performing phosphorus analysis). An ultrasonic cleaner can minimize the need for hand scrubbing. Following the water rinses, perform acid washing with sulfuric acid on equipment involved with nutrient analyses. After acid washing, rinse equipment completely at least six times with ultrapure deionized water.

If QC criteria are not met, thoroughly review the cleaning operation to determine if inadequate cleaning procedures could be causing contamination.

Criteria for Acceptance of QC Results and Corrective Actions

While this chapter contains general guidelines for accepting QC results and corrective actions, more detailed information is available in U. S. EPA (1979). Control limits for accuracy and precision are established in every laboratory, and these limits may vary among laboratories.

Recommended Reading

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CHAPTER 5

Sediment Monitoring

Traditional point sources of pollution typically discharge effluents of uniform, known quality, at continuous design flow, making them relatively easy to assess, model, and control. Point source assessments have relied on water column chemistry monitoring. However, urban runoff and other nonpoint sources of pollution—because of their intermittent, diffuse, land-use-specific nature—are highly variable in effluent quality and environmental effects. Of greatest environmental concern is the cumulative impact of runoff and nonpoint sources (NPS) of pollution on a waterbody within a watershed.

This chapter discusses sediment monitoring and assessment—an area of monitoring that is typically ignored yet is especially important in the assessment and management of urban runoff and other nonpoint sources. This chapter also reviews and discusses the activities undertaken in Florida to develop and implement coastal sediment sampling, analysis, and environmental assessment techniques.

Water quality managers often do not understand or know how to cope with runoff and NPS pollution. Problems include

- Discriminating anthropogenic loadings from natural watershed loadings of metals and nutrients;
- Assessing intermittent, shock loadings of pollutants;
- Assessing cumulative impacts of multiple sources;
- Comparing waterbodies and establishing priorities for management actions;
- Distinguishing actual or potential problems from perceived problems; and
- Establishing cost-effective ways to assess pollution trends and understand overall watershed pollution.

Most runoff pollutants accumulate over time in sediments, not in the water column. Therefore, assessing cumulative effects of watershed runoff and NPS pollution sources on aquatic systems should include evaluation of sediments and the organisms that reside there. Alternative assessment methods are needed to determine the actual environmental effects of runoff and to assess the effectiveness of control measures. This manual presents two alternative methods. Sediment monitoring is reviewed in this chapter and biological monitoring in Chapter 6.

Assessing Sediments Contamination

Traditionally, concerns about managing aquatic resources have focused on water quality. However, recently we have become more aware of the importance of sediments in determining the fate and effects of numerous contaminants. While evaluations of sediment quality are often used to address site-specific management needs, sediment quality is also a sensitive indicator of overall environmental quality.

Sediments influence the environmental fate of many toxic and bioaccumulative substances in

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aquatic ecosystems. Specifically, sediment quality is important because many toxic contaminants found in only trace amounts in water can accumulate to elevated levels in sediments. As such, sediments serve both as reservoirs and as potential contaminant sources to the water column. Sediments tend to integrate contaminant concentrations over time and may represent long-term sources of contamination. Sediment-associated contaminants can also directly affect benthic and other organisms. In addition to the physical and chemical relationships between sediments and contaminants, sediments provide benthic communities with suitable habitats for essential biological processes (e.g., spawning, incubation, rearing).

Sediments provide an essential link between chemical and biological processes. By understanding this link, environmental scientists can develop assessment tools and conduct monitoring programs to more accurately evaluate the health of aquatic systems. Therefore, sediment quality data provide essential information for evaluating ambient environmental quality conditions in waters. Additionally, information about the amount and quality of sediments within runoff management systems, storm sewers, and other conveyances can help track pollution sources and prioritize areas for implementing control measures.

Assessment of sediments to determine whether urban runoff pollutants are causing or contributing to ecological problems within a waterbody is increasingly performed. Consequently, sediment monitoring and assessment procedures are being developed. Before sediments can be reliably used to assess the effects of contaminants on aquatic systems, three issues must be addressed:

- Accurate, reliable sediment sampling and laboratory analysis techniques;
- Interpretive techniques to determine whether contaminants (especially metals) found in sediments are natural or from human activity; and
- Sediment quality assessment guidelines correlating sediment contaminant concentrations with biological effects. These guidlines assess whether amounts of sediment likely to adversely affect water quality and living resources could recycle to the water column or through food chains.

The Florida Example

Natural versus Anthropogenically Enriched Sediments

Florida has an extensive coastline—approximately 11,000 mi (17,699 km)—and an unusual diversity of estuarine types.* Its many estuary conditions range from nearly pristine to localized severe degradation. Metals are of particular concern in protecting and rehabilitating estuaries because of their potential toxic effects and because high metal concentrations can signal the presence of other pollution. Natural metal concentrations vary widely among Florida estuaries, presenting special difficulties in comparing estuarine systems statewide and in making consistent, scientifically defensible management decisions.

In the past, determining whether estuarine and coastal sediments were anthropogenically enriched with metals was a difficult process requiring comprehensive site-specific assessments. However, a recently developed practical approach for assessing metals contamination in coastal sediments relies on normalization of metal concentrations to a reference element. In Florida, normalization of metal concentrations to aluminum concentrations in estuarine sediments provided the most promising method of comparing metal levels regionally. In Florida and Washington State, early research indicates that other elements (e.g., lithium) may be an appropriate reference element for assessing coastal sediments.

To understand this assessment tool, one must generally understand geochemical processes that govern the behavior and fate of metals in estuaries and marine waters. Natural estuarine sediments are predominantly composed of river-transported debris from continental weathering. Acids formed in the atmosphere or from the breakdown of organic matter (e.g., carbonic, humic, fulvic acids) mix with water and form leaching solutions. These leaching solutions break down rocks and carry away the products in solution or as solid debris. This debris is chiefly composed of chemically resistant minerals, such as quartz and clay minerals, which are the alteration products of other aluminosilicate minerals. The general formula M-$AlSiO_4$ represents the aluminosilicate clay minerals

** The material in this and the following two sections was adapted from Fla. Dep. Environ. Prot. 1988.*

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where: M = naturally occurring metal that can substitute for aluminum in the aluminosilicate structure
Al = aluminum
Si = silicon
O = oxygen

The metals are tightly bound within the aluminosilicate lattice.

The weathering solution also contains dissolved metals leached from the parent rock. Because of their low solubilities, however, the transporting solution (e.g., rivers) contains low amounts of metals. Most metals transported by rivers are tightly bound in the aluminosilicate solid phases. As a consequence, weathering causes little fractionation between the naturally occurring metals and aluminum.

In general, when dissolved metals from natural or anthropogenic sources come in contact with saline water, they quickly adsorb to particulate matter and go from the water column to bottom sediments. Thus, metals from both natural and anthropogenic sources are ultimately concentrated in estuarine sediments, not the water column. Since much of the natural component of metals in estuarine sediments is chemically bound in the aluminosilicate structure, the metals are generally immobile; however, the adsorbed anthropogenic or pollutant component is more loosely bound. Metals in the anthropogenic fraction, therefore, may be more available to estuarine biota and may be released to the water column in altered forms when sediments are disturbed (e.g., by dredging or storms).

The tool for interpreting metal concentrations in estuarine sediments is based on demonstrated, naturally occurring relationships between metals and aluminum. Specifically, natural metal/aluminum concentration relationships were used to develop guidelines to distinguish natural from contaminated sediments for several metals commonly released to the environment from anthropogenic activities. Aluminum was chosen as a reference element to normalize sediment metals concentrations for several reasons:

- After silicon, aluminum is the most abundant naturally occurring metal;
- Aluminum is highly refractory;
- The proportions of metals and aluminum in crustal materials are relatively constant; and
- Aluminum concentration is rarely influenced by anthropogenic sources.

So that the information used to develop the interpretive tool represented diverse Florida sediments, uncontaminated sediments from around the state were examined for their metal content, and the natural variability of metal/aluminum relationships was statistically assessed (Fla. Dep. Environ. Prot. 1988). Sediment samples from 103 stations in uncontaminated estuarine/coastal areas were collected and analyzed for aluminum and other environmentally and geochemically important metals. The areas sampled encompassed various sediment types ranging from terrigenous, aluminosilicate-rich sediments in northern Florida to biogenic, carbonate-rich sediments in southern Florida. These "clean" sites were selected subjectively, based on their remoteness from known or suspected anthropogenic metal sources.

To ensure that divers retrieved undisturbed sediment samples at each station, they collected sediments in cellulose-acetate-butyrate cores. Sediment for metals analyses was taken from the upper 5 cm (nearly 2 in) of each core. Duplicate samples taken at each station were analyzed for nine metals—aluminum, arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc. Particular care was taken to ensure total digestion of sediment samples as required by the project quality assurance plan.

Simple linear regressions for each metal on aluminum were performed on log-transformed data and 95 percent prediction limits were calculated. Significant correlations were obtained for arsenic, cadmium, copper, lead, nickel, and zinc. The plotted regression lines and prediction limits (Figures 5.1 to 5.7) form the basis for interpreting metal concentrations in sediments. The results indicate that aluminosilicate minerals have a major influence on metal concentrations in Florida's natural sediments. Furthermore, sediment metal/aluminum relationships provide a basis for interpreting metals data from Florida coastal sediments. The effectiveness and utility of this sediment assessment tool has been tested in a variety of regional studies (Hanson and Evans, 1991; Schropp et. al. 1989; Pardue et al. 1992).

To determine whether estuarine sediments are enriched with metals, we calculate a mean value of each metal (derived from replicate or triplicate samples) and plot points representing corresponding metal and aluminum values. The sediment is judged to be natural or metal enriched, depending on where the points lie relative to the regression lines and prediction limits. If a point falls within the prediction limits, then the sediment metal concentration is within the expected natural

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range. If a point falls above the upper prediction limit, then the sediment is considered to be metal-enriched. Before we determine enrichment, we should confirm the accuracy of the analytical results, since an unusual point can indicate procedural errors. Since the results are interpreted with respect to the 95 percent prediction limit, some points from clean stations will lie outside the prediction limit. The farther from the prediction limit, the greater the likelihood that the sample does indeed come from a metal-enriched sediment. The greater the distance above the prediction limit, the greater the degree of enrichment.

Figures 5.1 through 5.7 show the blank metal/aluminum figures derived from the statistical analyses of sediment samples from 103 stations in Florida's uncontaminated estuarine/coastal areas. Extrapolated portions of the lines are represented by dashed lines. Metals data can be plotted on these figures to assess metals enrichment of estuarine sediments (Fla. Dep. Environ. Prot. 1988).

Figure 5.1.—Arsenic/aluminum regression line with 95 percent prediction limits.

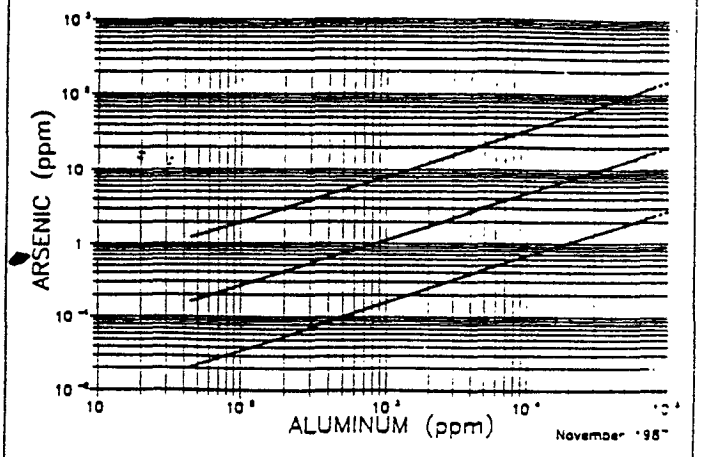
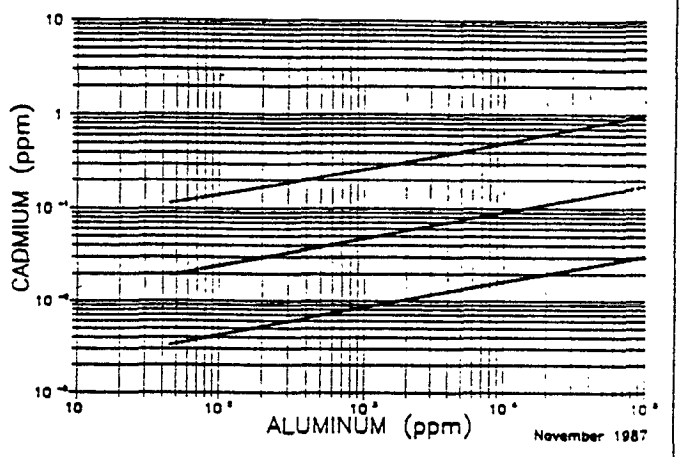


Figure 5.2—Cadmium/aluminum regression line with 95 percent prediction limits.



Source: Figures 5.1 – 5.7 from Fla. Dep. Environ. Prot. 1988.

Applying the Interpretive Tool

The interpretive tool, using metal and aluminum relationships, allows results of sediment chemical analyses to be used for a variety of environmental information needs, including

- **Distinguishing natural versus enriched metals concentrations in coastal sediments.** The degree of enrichment can also be estimated by the deviation from the expected natural range.

- **Comparing metal concentrations within an estuary.** Absolute metal concentrations in coastal sediments will vary depending on many factors, including sediment grain size, mineralogy, and anthropogenic metal sources. Normalizing metals to the reference element—aluminum—allows comparisons of metal concentrations among sites within an estuary.

- **Comparing investigative results from different estuaries.** By normalizing metal concentrations to aluminum, we can assess relative metal enrichment levels and rank estuaries according to specific metal enrichment problems.

- **Tracking the influence of a pollution source.** In some cases, we can determine the extent of metal-enriched sediments. This delineation focuses attention on real, rather than perceived, problems.

- **Monitoring trends in metal concentrations.** By periodically examining sediments at permanent sampling stations or along known pollution gradients, the technique may provide a much-needed device for cost-effective monitoring of the overall estuary pollution climate and the effectiveness of watershed control measures.

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Figure 5.3—Chromium/aluminum regression line with 95 percent prediction limits.

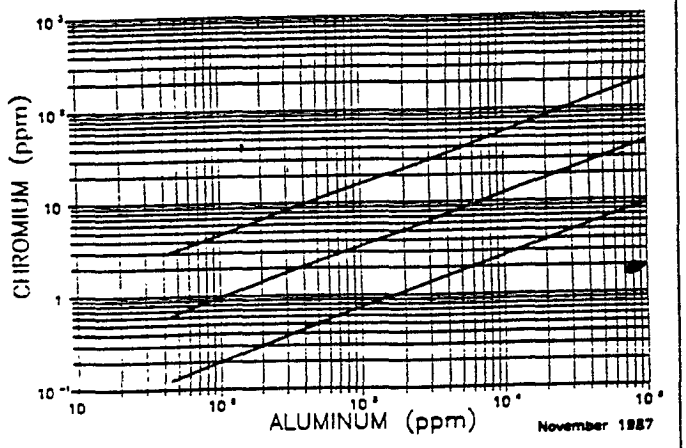
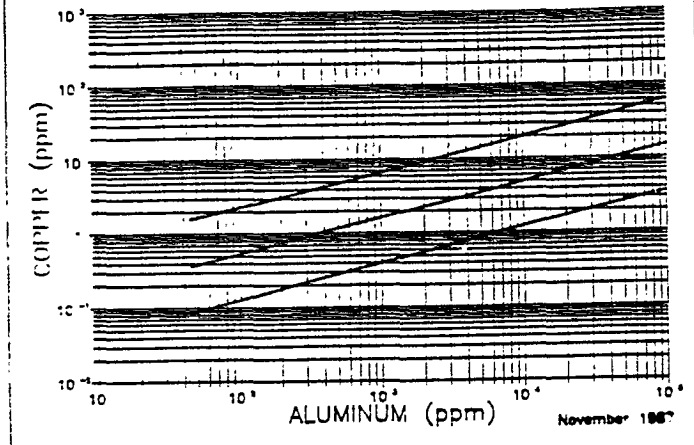


Figure 5.4—Copper/aluminum regression line with 95 percent prediction limits.



■ **Determining procedural or laboratory errors.** The location of points on the metal/aluminum figures can signal possible errors, including sample contamination in the field or laboratory and analytical or reporting errors.

■ ***Screening* tool to promote cost-effective use of tests.** A variety of tests (e.g., elutriate, bioassay) demonstrate potential release to the water column or toxicity of metals in sediments. This interpretive tool can reduce the time and cost of testing by screening sediments and selecting for further testing only those whose metal concentrations exceed expected natural ranges.

Interpretive Tool Limitations

This approach provides an interpretive tool to evaluate metals concentrations in estuarine sediments. Funding limitations in Florida have prevented collecting and analyzing sediment samples from freshwater systems to see if the tool can be used in those aquatic systems. However, such sampling is now being done in Washington State and was completed in Illinois. Tool use requires knowing local conditions and applying professional judgment and common sense. Consider the following points when using this tool:

1. The interpretive tool is useless without reliable data; results from single, nonreplicated samples should never be used. Ideally, collect sediment samples in triplicate. If budget constraints dictate analysis of only duplicate samples, archive the third sample. If a disparity in the results of the replicate analyses occurs, retrieve and analyze the archived sample to resolve the problem.

2. Carefully analyze sediment metals using techniques appropriate for saline conditions and capable of providing adequate detection limits. Because naturally occurring aluminum and other metals are tightly bound within the sediment's crystalline structure, the metals analyses methods must include complete sediment digestion. If aluminum is not completely released by a thorough digestion, metal-to-aluminum ratios may appear to be unusually high. Complete digestion requires the use of hydrofluoric (HF) acid during the digestion process.

3. Mercury presents special problems, both in the laboratory and in interpretating the results. Since mercury is more volatile than the other metals, use a different digestion procedure employing a lower temperature. Natural mercury concentrations are very near routine analytical detection limits, reducing precision and accuracy. Furthermore, mercury's apparent weak inverse relationship with aluminum precludes using aluminum as a reference element.

   To analyze mercury, the Florida Department of Environmental Protection (DEP) assumed that the maximum mercury value in the clean sedi-

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ment data set (0.21 ppm mercury) represents the maximum mercury concentration found in Florida's natural sediments. To evaluate sediment samples, consider those containing less than 0.21 ppm mercury as typical of clean sediments. Samples with greater than 0.21 ppm mercury should be suspected as being enriched and should be interpreted similarly to other metals that fall outside the 95 percent prediction limits.

4. Aluminum concentrations in the data set from which these guidelines were prepared ranged from 47 to 79,000 ppm. The data set, to the extent possible, represents various natural clean sediments found in Florida estuaries. The majority of samples recovered from Florida estuarine sediments will have aluminum concentrations within this range. Some clay-rich sediments, especially in northwest Florida, may contain aluminum concentrations exceeding 79,000 ppm. Kaolinite, illite (muscovite), montmorillonite, and chlorite—four commonly occurring marine clays—contain aluminum concentrations of approximately 21 percent, 20 percent, 15 percent, and 10 percent, respectively.

   Theoretically, the maximum aluminum concentration in a natural marine sediment is about 210,000 ppm (21 percent) if the sediment is composed of pure kaolinite. Since sediments are not pure clay, the aluminum concentration in estuarine sediment samples should be considerably less than this theoretical maximum; in only a few instances should aluminum concentrations exceed 100,000 ppm (10 percent aluminum). Carefully examine any samples containing greater than 100,000 ppm aluminum for evidence of contamination or analytical error.

5. During the construction of the "trimmed clean" data set, some points containing low aluminum values were removed from the cadmium, lead, nickel, and zinc data. Since the lowest overall aluminum value was 47 ppm, the regression lines and prediction limits for these four metals have been extrapolated down to an aluminum value of 47 ppm.

6. At stations where a metal concentration exceeds the 95 percent prediction limit, the metal must be considered enriched. We cannot immediately assume, however, that a finding of enrichment indicates a problem. Some samples from natural clean sediments may contain metal concentrations that exceed the 95 percent prediction limit. Interpretation of metal concentrations, using these metal-to-aluminum relationships, must also consider sediment grain size, mineralogy, coastal hydrography, and proximity to sources of metals.

Figure 5.5—Nickel/aluminum regression line with 95 percent prediction limits.

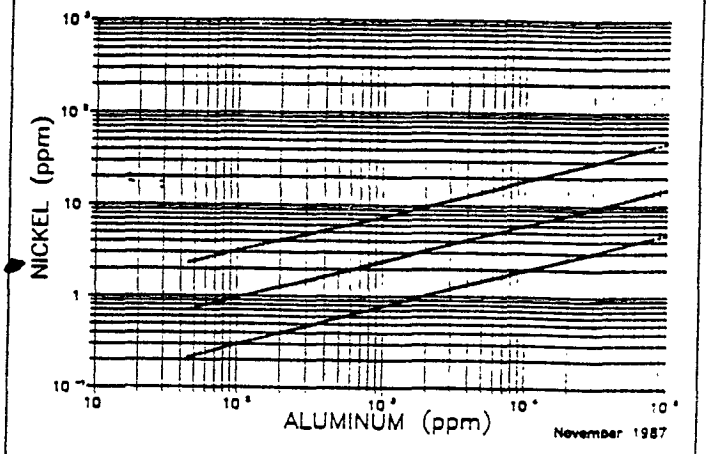
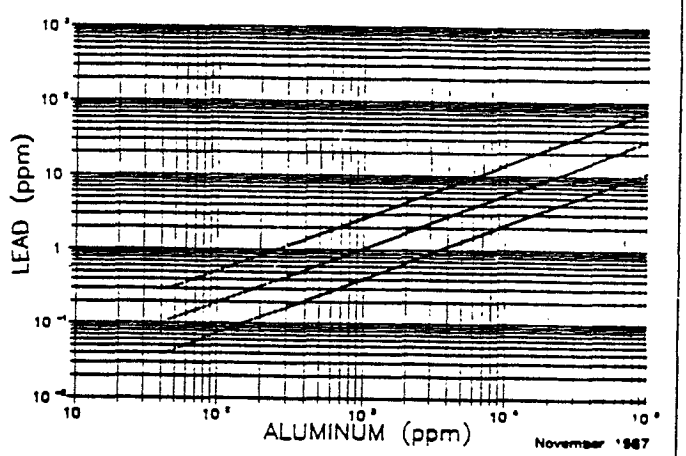


Figure 5.6—Lead/aluminum regression line with 95 percent prediction limits.



Determining the Ecological Significance of Enriched Sediments

Sediment chemistry data alone do not provide an adequate basis to identify or manage potential sediment quality problems. After determining that

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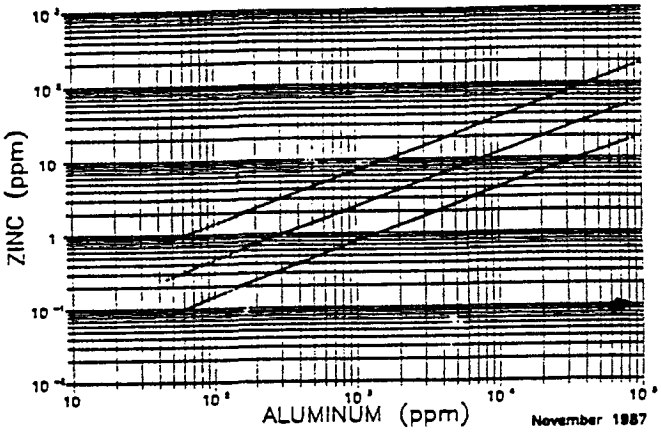
Figure 5.7—Zinc/aluminum regression line with 95 percent prediction limits.



sediments are anthropogenically enriched with pollutants, we must next determine whether these sediment-bound pollutants are harmful to the environment. Biologically-based sediment quality assessment guidelines (SQAGs) also are required to interpret the ecological significance of sediment chemistry data. Numerical SQAGs support assessing the potential effects of sediment-associated contaminants.

Various approaches help formulate sediment quality guidelines (SQGs) (Chapman, 1989; Persaud et al. 1989; Beak, 1987 and 1988; U.S. Environ. Prot. Agency, 1989a,b; Sediment Criteria Subcommittee, 1989 and 1990; and MacDonald et al. 1991). The major approaches by which SQGs are developed are

- Sediment background approach (SBA);
- Spiked sediment bioassay approach (SSBA);
- Equilibrium partitioning approach (EqPA);
- Tissue residue approach (TRA);
- Screening level concentration approach (SLCA);
- Sediment quality triad approach (SQTA);
- Apparent effects threshold approach (AETA); and
- National status and trends program approach (NSTPA).

To date, no effects-based SQAGs apply directly to Florida conditions. While effects-based SQAGs have been developed specifically for a few regions of the country (i.e., Puget Sound is using an apparent effects threshold approach), the EPA Science Advisory Board (SAB) cautions against using these guidelines outside the areas for which they were developed (Sediment Criteria Subcommittee, 1989). The SAB has also questioned the validity of the sediment quality criteria that EPA is currently developing (i.e., using the equilibrium partitioning approach). These SAB evaluations suggest that SQAGs under development in other jurisdictions will not likely address Florida's immediate requirement for sediment assessment tools.

Ideally, SQAGs should be developed from dose-response data that describe acute and chronic toxicity of individual contaminants to sensitive life stages of resident aquatic organisms. These data should be generated in controlled laboratory studies, where the influences of important environmental variables—such as total organic carbon (TOC), acid volatile sulfide (AVS), salinity, and others—are identified, quantified, and compared to the values predicted by appropriate models (e.g., EqP models). Finally, the results of these studies should be validated in field trials to ensure that guidelines derived from these data will apply to a broad range of locations. Understanding the factors that influence toxicity also supports site-specific sediment quality assessments by evaluating and modifying the preliminary guidelines.

Unfortunately, data are insufficient to derive numerical SQAGs using the ideal approach. Currently, only a limited number of controlled laboratory studies (i.e., spiked-sediment bioassays) have been conducted to assess the effects of sediment-associated contaminants on estuarine and marine organisms. In spite of this limitation, other data are routinely collected that clarify the toxic effects of these contaminants. Specifically, a variety of whole sediment toxicity tests have assessed the biological significance of contaminant concentrations in sediments from specific geographic locations. Toxicity tests were performed on benthic organisms (e.g., bivalve mollusks, shrimp, amphipods, polychaetes, nematodes, chironomids and other arthropods) and on pelagic organisms (e.g., *Daphnia*, oyster larvae, luminescent bacteria [Microtox]). Numerous field studies also assessed the diversity and abundance of benthic infaunal species (e.g., bivalve mollusks, arthropods, amphipods) and epibenthic organisms (e.g., echinoderms, crustaceans). Many of these studies collected matching data on the contaminant concentrations in sediments. Studies that report matching sediment chemistry and biological

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effects data provide highly relevant information to the SQAGs derivation process.

A suitable strategy for deriving SQAGs for Florida recognizes the limitations of the existing database to evaluate the potential biological effects of sediment-associated contaminants. In addition, the strategy must address the immediate requirement for defensible SQAGs and the long-term requirement for increased reliability and applicability of these guidelines (i.e., guidelines that account for the environmental characteristics influencing the bioavailability of sediment-associated contaminants).

To provide Florida with a sediment assessment tool, the Florida DEP Contaminated Sediment Management Unit, in association with MacDonald Environmental Sciences, reviewed the preceding approaches to identify those applicable to Florida's coastal conditions. Selecting an appropriate procedure to derive guidelines for Florida's coastal waters necessitates evaluating each approach in light of the state's specific needs. As such, criteria were established to objectively evaluate the approaches and select a relevant strategy to derive these guidelines. The primary considerations in selecting a strategy were practicality, cost-effectiveness, scientific defensibility, and broad applicability to sediment quality assessment. These include the following considerations:

1. Practicality is a central consideration in developing SQAGs. Numerical SQAGs must be easy to use and understandable. The immediate need for these assessment tools necessitates selecting an approach that can be quickly implemented.

2. As in most states, Florida has limited resources to support SQAG development and implementation. Financial and personnel limitations make collecting significant quantities of additional data improbable. Therefore, the approach must develop numerical SQAGs with the current data, and it must be amenable to reevaluation as new data become available.

3. For SQAGs to be effective in Florida, they must be effects-based (i.e., consider biological effects) and scientifically defensible. Key evaluation criteria to assess various approaches include their potential to consider factors that control the bioavailability of sediment-associated contaminants, to establish cause-and-effect relationships, and to apply to all classes of chemicals and mixtures of contaminants that can occur in Florida. In addition, they must be compatible with other tools, such as the metals tools discussed previously. Potential approaches should explicitly consider data from Florida and elsewhere in the southeastern United States and provide a way to account for site-specific environmental conditions.

4. The inherent uncertainty associated with each approach requires guidelines to support identifying ranges of contaminant concentrations that may have high, moderate, and low probabilities of adverse biological effects.

5. SQAGs must address the specific needs of the agencies that manage environmental quality. For example, SQAGs should be relevant to the design, implementation, and evaluation of environmental quality monitoring programs by identifying contaminants and sites likely to cause adverse biological effects. This information would help identify the need for further investigations at sites with specific contaminant concentrations that exceed the SQAGs. Guidelines should also help identify areas that need remediation; however, they would not necessarily be used to establish clean-up levels. Furthermore, guidelines should contribute to regulatory programs by evaluating source control measures and/or the need for further biological and chemical testing to support regulatory decisions.

Each approach has deficiencies that limit its direct application in Florida. For this reason, an integrated strategy for deriving numerical SQAGs was recommended for the state of Florida (MacDonald, 1993). This strategy provides relevant near-term assessment tools and a basis to refine these guidelines as the necessary data become available.

Using the recommended approach, numerical SQAGs were developed for 25 priority contaminants in Florida coastal waters (MacDonald, 1993) using a modification of the National Status and Trends Program approach (Long and Morgan, 1990). The guidelines, from numerous investigations of sediment quality conducted throughout North America, are based on a weight-of-evidence linking contaminant concentrations and adverse biological effects. The guidelines represent a cost-effective response to a practical need for assessment tools. However, these guidelines are preliminary and will likely be revised or refined with results from field validation and other related studies conducted in Florida and else-

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where in North America. The guidelines should be used with other interpretive tools to conduct comprehensive and reliable assessments.

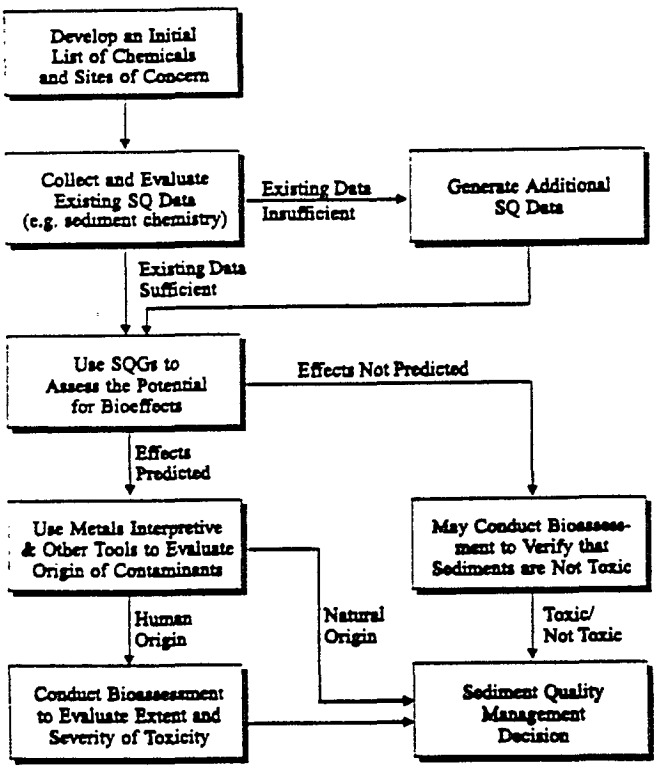
Effects-based SQAGs help assess the potential for biological effects associated with various contaminant concentrations. MacDonald (1993) derived no observed effects levels (NOELs) and probable effects levels (PELs) to define three ranges of contaminant concentrations: the probable effects range, the possible effects range, and the no effects range.

The probable effects range is the range of specific contaminant concentrations in sediment within which biological effects are usually or always observed (probable effects range ≥ PEL). Sediments with contaminant concentrations within the probable effects range *represent significant and immediate hazards to exposed organisms.* Sites with concentrations of one or more contaminants that fall within the probable effects range should be given the highest priority in implementing sediment quality management options. However, direct biological assessment is required to determine the nature and extent of effects that could be manifested.

The possible effects range is the concentration range of a specific sediment contaminant with uncertain adverse biological effects (NOEL < possible effects range < PEL). This range is likely to be dependent on factors, such as bioavailability, that may influence the toxicity of the substance. Sediment-associated contaminants *represent potential hazards to exposed organisms* when concentrations fall within this range. Sediments with contaminant concentrations within this range may require further assessment to determine the biological significance of the contamination. In general, further assessment would be supported by biological tests designed to evaluate the biological significance of sediment-associated contaminants to key species of aquatic biota.

The no effects range is the range of sediment contaminant concentrations where biological effects are rarely or never observed (no effects range ≤ NOEL). Sediments with concentrations of contaminants within the no effects range are *of acceptable quality* for those contaminants. In general, further investigations of sediment quality conditions within the no effects range are relatively lower priority. However, biological testing may be required to validate the results of the initial potential assessment for adverse biological effects, particularly in sediments with low levels of TOC, AVS, and/or other variables that could influence the bioavailability of sediment-associated contaminants.

Figure 5.8—Framework for conducting site-specific assessments of sediment quality.



Source: MacDonald, 1993.

Assessing Sediment Quality in Florida

MacDonald (1993) developed a framework (Figure 5.8) for the Florida DEP for future use of sediment quality assessment guidelines and related tools. This framework identifies essential considerations to address in conducting site-specific sediment quality assessment programs. The following elements comprise the framework:

- Collect historical land and water use information;
- Collect and evaluate existing sediment chemistry data;
- Collect supplemental sediment chemistry data;
- Conduct preliminary assessment of the potential for biological effects of sediment-associated contaminants;

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- Evaluate natural versus anthropogenic sources of sediment-associated contaminants;
- Conduct biological assessment of sediment quality; and
- Implement management of sediment quality.

This framework consistently assesses sediment quality in marine and estuarine areas. However, the framework is not intended to replace accepted sediment testing protocols, such as those developed for the ocean disposal of dredged material. Instead, it provides general guidance to support the sediment quality assessment process.

Step 1. Collect Historical Land and Water Use Information

The first phase of a site-specific sediment quality assessment involves collecting and reviewing the site's pertinent historical information. Information required includes the types of industries and businesses that operate or have operated in the area, the location of wastewater treatment plants, land use patterns in upland areas, runoff management systems, residential developments, and other historic, ongoing, and potential activities within the area. These data help to identify sources that could contaminate aquatic ecosystems. Information on the chemical composition of wastewater effluent discharges, contaminants likely to be associated with nonpoint sources, and physical/chemical properties of those substances helps to develop an initial list of chemical concerns.

Information should also be collected that helps define the site's environmental management goals. Environmental management goals in estuarine and marine systems may be based on protecting the whole ecosystem, maintaining viable populations of sport and commercial fish species, protecting human health (e.g., swimmable and fishable), or a variety of other considerations (e.g., seagrass restoration, reestablishment of shellfish, regional runoff management). As such, information on existing site uses helps make decisions on the level of investigations that should be conducted.

Step 2. Collect and Evaluate Existing Sediment Chemistry Data

Collecting and evaluating existing sediment chemistry data is critical to the site-specific sediment quality assessment process. Sediment chemistry data typically are generated under various environmental programs. Collect relevant data to support a preliminary assessment of sediment quality. These data should be fully evaluated to determine their applicability. This evaluation should cover the overall quality of the data set and the degree to which the data represent current site conditions.

Assessment of sediment quality also requires information that adequately represents the site's contemporary environmental conditions. Therefore, knowing the age of the chemistry data is essential to determine the data's applicability. Natural degradative processes in the environment can lead to reduced concentrations of sediment-associated organic contaminants. Major events, such as storms, can transport sediments between sites, and industrial developments and/or regulatory activities can alter the sources and composition of contaminants released into the environment. Thus, assessments of sediment quality should be undertaken with the most recent data available.

In addition to temporal variability, the chemistry of bed sediments varies spatially as well. Therefore, a single sample likely represents only a small proportion of the geographic area. For this reason, data from a number of stations are required to represent a site's sediment quality conditions. The actual number of stations required depends on the size of the area, the concentrations of sediment-associated contaminants, and the variability of contaminant concentrations.

Another important factor to consider in evaluating existing sediment quality data is the variables analyzed. The list of analyses must reflect potential contaminant sources from area land and water use activities. For example, in harbors, variables such as pentachlorophenol (used to preserve pilings), tributyltin (used in antifouling paints for ships), and copper (used in antifouling paints for pleasure crafts) should be measured. Similarly, highly elevated concentrations of polycyclic aromatic hydrocarbons and lead are often associated with urban runoff discharges. In agricultural areas, persistent pesticides and nutrients should be considered in sediment quality assessments.

If the results of the data evaluation indicate that sediment chemistry data are acceptable, we can proceed with the preliminary assessment of the potential for biological effects. However, if the sediment chemistry data are of unacceptable quality or do not adequately represent the site, additional data may be required to complete the assessment.

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Step 3. Collect Supplemental Sediment Chemistry Data

The third stage in assessing sediment quality involves generating supplemental sediment chemistry data. Additional testing may be required when data are insufficient to support the assessment of sediment quality at a site. The initial list of chemical concerns provides a defensible way to identify potential analyses for the sediment quality monitoring program.

Sampling programs should delineate temporal and spatial and vertical and horizontal variability in sediment contamination and explicitly identify quality assurance/quality control measures to implement. Collection, handling, and storage of sediment samples should follow established protocols, and analytical methods and detection limits should be appropriate. Total digestion of sediment samples with a strong acid (e.g., hydrofluoric) is required. A focused, well-designed monitoring program ensures that the resulting data will support a defensible sediment quality assessment.

Step 4. Conduct Preliminary Assessment of the Potential for Biological Effects of Sediment-Associated Contaminants

Sediment chemistry data alone are not adequate to assess the hazards posed by sediment-associated contaminants to aquatic organisms. Interpretive tools can determine if these contaminants are present at concentrations that could impair the designated uses of the aquatic environment. Effects-based guidelines to assess sediment quality provide a scientifically defensible way to evaluate the potential effects of sediment-associated contaminants on aquatic organisms. The three ranges of contaminant concentrations were discussed previously.

Step 5. Evaluate Natural Versus Anthropogenic Sources of Sediment-Associated Contaminants

Interpretation of environmental metals data is difficult because absolute metal concentrations in coastal sediments are influenced by various factors, including sediment mineralogy, grain size, organic content, and anthropogenic enrichment. These factors result in metals levels that can vary over several orders of magnitude at uncontaminated sites in Florida (Schropp et al. 1990). While numerical, effects-based sediment quality assessment guidelines provide essential information to evaluate sediment-associated metals, they should not be used alone to evaluate the quality of marine and estuarine sediments. Instead, assessments of sediment quality should evaluate the potential for adverse biological effects and the degree of anthropogenic enrichment. Using this approach, metals concentrations would be considered a serious concern when they exceed the biological effects-based guidelines and are anthropogenically enriched.

In the past, determining whether estuarine and coastal sediments were anthropogenically enriched with metals was difficult, requiring comprehensive, site-specific assessments. However, as discussed previously under "Assessing Sediments Contamination," Florida has developed a practical approach to assess metals contamination in coastal sediments. This procedure relies on normalization of metal concentrations to a reference element aluminum.

Step 6. Conduct Biological Assessment of Sediment Quality

Biological testing is essential in assessing sediment quality. The nature and extent of available information creates significant uncertainty in predicting the biological significance of sediment-associated contaminants (i.e., most of the data used do not support a cause-and-effect relationship). Therefore, biological testing—generally a suite of biological tests—is required to provide reliable information on the toxicity of bed sediments and to confirm the results of the preliminary sediment quality assessment.

In Florida, further biological testing supports three distinct aspects of sediment quality assessment. First, biological testing may assess sediment toxicity at sites where the concentrations of one or more contaminants fall within the probable and possible effects range. Second, biological testing may assess toxicity sediments likely to contain unmeasured substances. Third, biological data assess whether the recommended SQAGs are applicable to Florida coastal waters. Additional biological testing determines the systematic differences between the sensitivities of species represented in the Biological Effects Data System (BEDS) (MacDonald, 1993) compared to the sensitivities of species that reside in Florida coastal waters. In addition, ancillary biological testing determines the systematic differences between the toxicity—as affected by bioavailability and other factors—of a substance in sediments represented in BEDS compared to Florida sediments. In

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some cases, biological testing will require site-specific SQAGs to assess the potential effects of sediment-associated contaminants.

The biological testing program should address whole sediment toxicity, but it may also consider potential effects in the water column. Evaluation of whole sediment toxicity is a key component of the sediment quality assessment process in regulatory and management applications. Biological tests that assess potential water column effects are generally more applicable, for example, in programs concerned with regulating disposal of dredged materials.

A number of tests can evaluate the biological significance of sediment contamination. These tests may be as simple as short-term bioassays on a single contaminant using a single species or as complex as microcosm studies investigating the long-term effects of contaminant mixtures on ecosystem dynamics. In addition, tests may be designed to assess the toxicity of whole sediments (solid phase), suspended sediments, elutriates, sediment extracts, or pore water. Organisms routinely tested include microorganisms, algae, aquatic macrophytes, invertebrates, and fish.

Other biological information can assess sediment quality. For example, comparing biological indicators, such as the diversity and abundance of benthic invertebrate communities, at test sites and appropriate ecoregion reference sites provides a means of assessing the relative toxicity of test sediments. Various statistical procedures can help identify contaminants associated with observed biological effects using adequate sediment chemistry data. In addition, spiked-sediment bioassays can establish cause-and-effect relationships for specific substances or contaminant mixtures. Further, tests to evaluate pore water toxicity provide information that can identify the toxic elements of contaminated sediments. Information on contaminant level in aquatic biota and on bioaccumulation help determine contaminant levels in sediments to protect the health of humans and of wildlife that consume aquatic organisms.

Step 7. Implement Management of Sediment Quality

The objective of the sediment quality assessment process is to provide information that supports environmental quality management. Management decisions will depend on various factors, including the nature and severity of the contamination, the potential for exposure of aquatic organisms, management goals for the site, availability of remediation technology, costs associated with remediation, and public expectations. By integrating information on these factors, managers and others can make defensible decisions on remediating, preventing, and monitoring contamination.

We can make several sediment quality management decisions using information available from the environmental assessment. At some sites, no additional action is warranted. Other sites may require monitoring for trends in sediment quality. Seriously contaminated sites may require some remedial action to achieve environmental management goals. These remedial actions could include removing and treating toxic materials, isolating or capping contaminated sediments, implementing source control measures, or no action at all (i.e., permit natural degradation and sedimentation to mitigate contaminant effects).

MacDonald (1993) stresses the importance of combining the effects-based guidelines and the metals interpretive tool. MacDonald examines data on levels of sediment-associated lead from two geochemically distinct systems, Biscayne Bay and Apalachicola Bay, to illustrate the integrated sediment quality assessment framework. Figure 5.9 shows a summary of the available data (Fla. Dep. Environ. Prot. 1993) on the levels of sediment-associated lead in the Miami area. The data, sorted by increasing concentration, were assigned sample numbers from 1 to 108. Evaluation using the SQAGs suggests that approximately 15 percent of the samples fall within the probable effects concentration range (exceed the PEL of 160 mg/kg). Another 20 percent fall within the possible effects range (between NOEL and PEL). Therefore, comparing sediment chemistry data with numerical SQAGs suggests a relatively high probability of observing adverse biological effects. Further examination of the data using the metals interpretive tool (Figure 5.10) demonstrates that sediments from this area are clearly anthropogenically-enriched with lead. Roughly 90 percent of the samples exceed the 95 percent prediction limits established for clean sites. Concordance between the effects-based and the geochemically based tool suggests that the Miami area should have priority in further investigations to evaluate sediment toxicity.

In Apalachicola Bay, roughly 20 percent of the samples had levels of lead that exceeded the NOEL of 21 mg/kg (Figure 5.11). Comparison of the ambient lead levels in Apalachicola Bay with SQAGs suggests possible adverse biological effects at a significant number of sites. However, fur-

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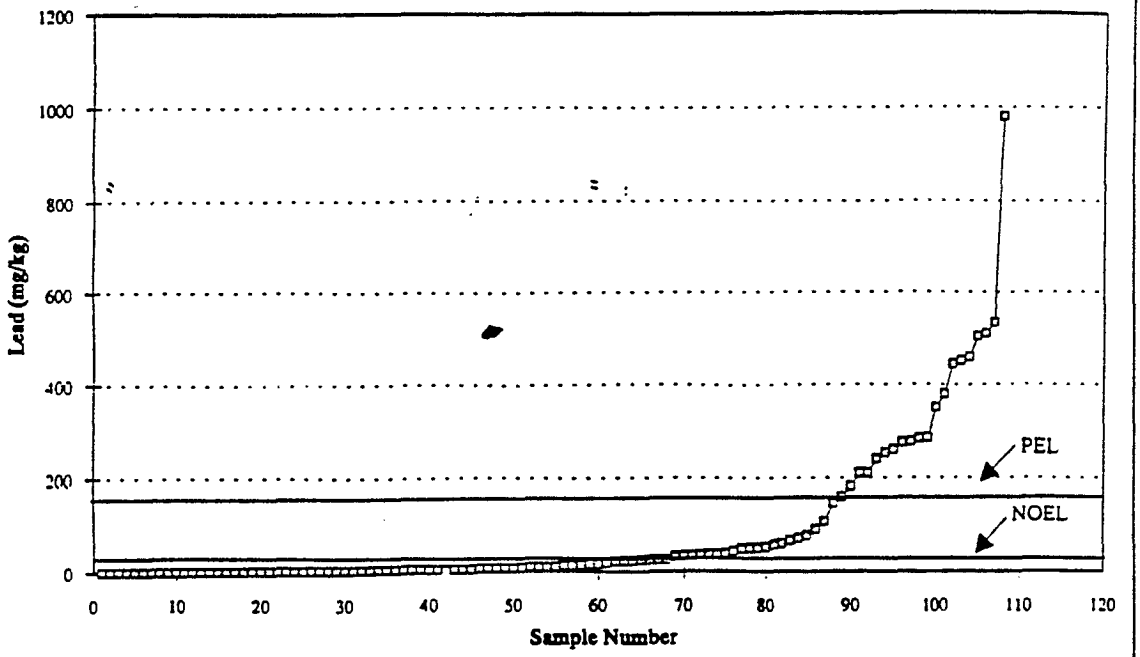
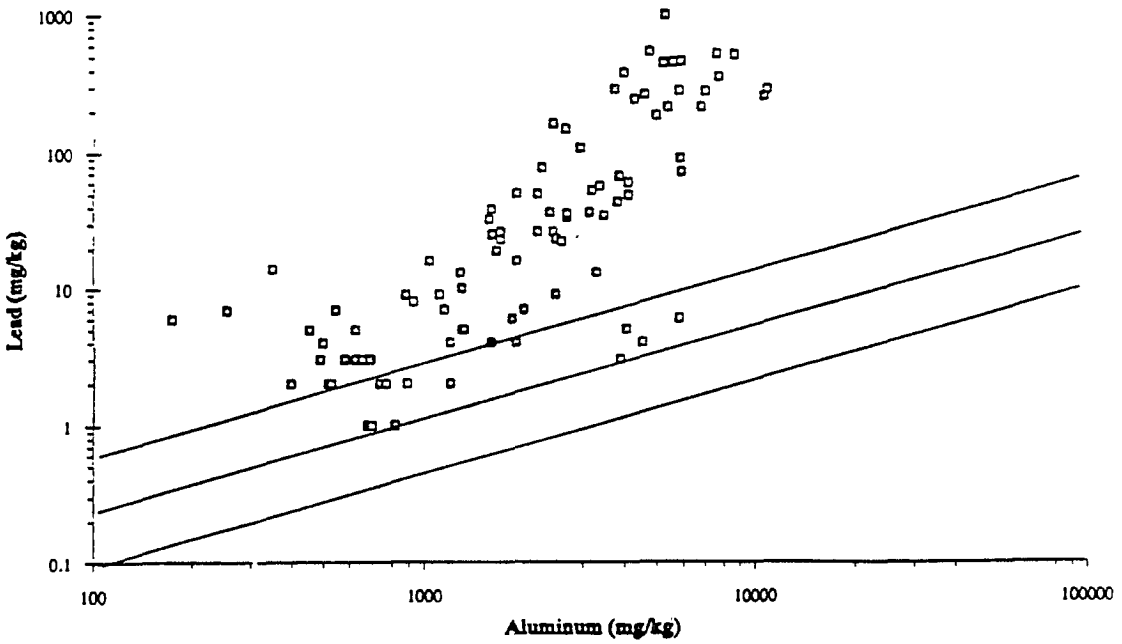
Figure 5.9—Lead concentrations in sediments in Biscayne Bay.



Source: Fla. Dept. Environ. Prot. 1993.

Figure 5.10—Aluminum normalized concentrations of lead in Biscayne Bay sediments.



Source: Fla. Dept. Environ. Prot. 1993.

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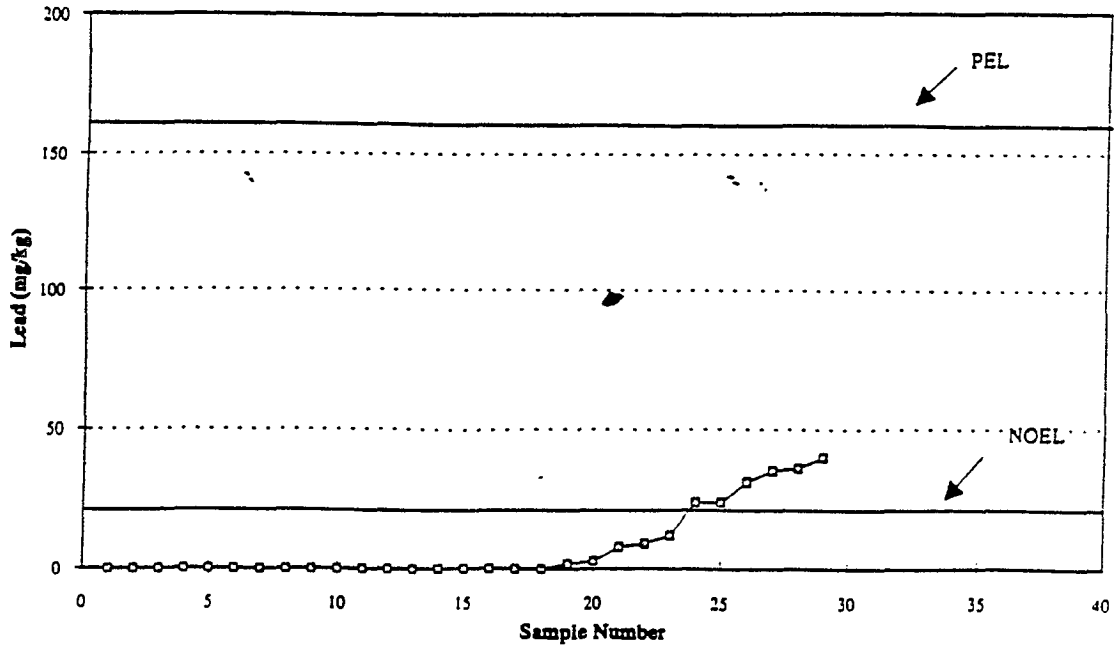
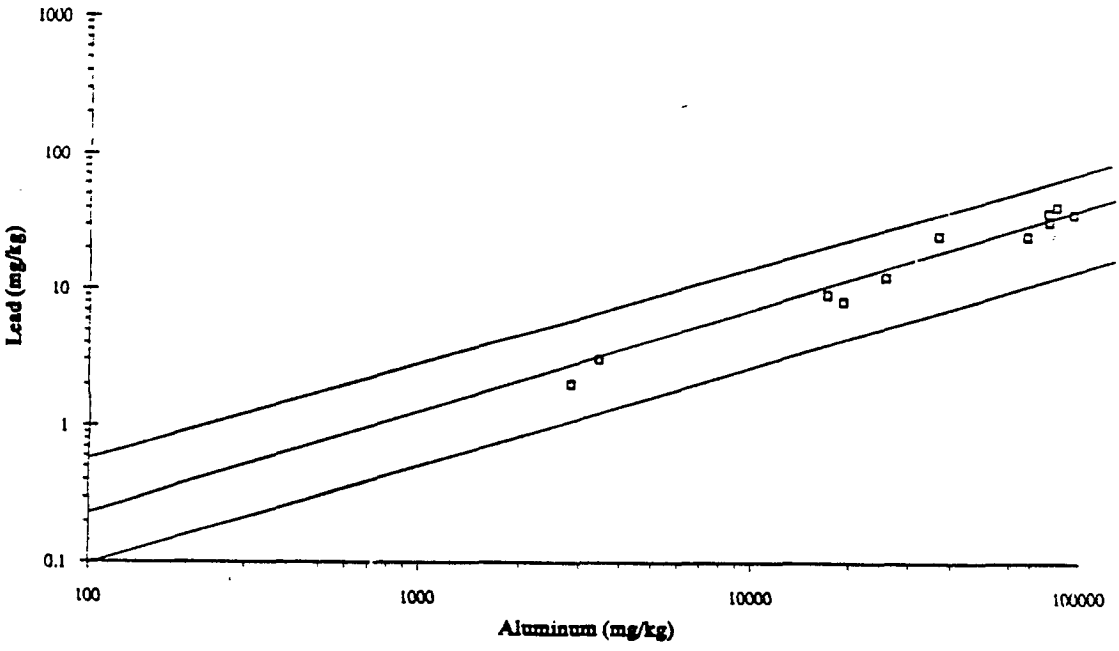
Figure 5.11—Lead concentrations in Apalachicola Bay sediments.



Source: Fla. Dept. Environ. Prot. 1993.

Figure 5.12—Aluminum normalized concentrations of lead in Apalachicola Bay sediments.



Source: Fla. Dept. Environ. Prot. 1993.

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ther evaluation using the metals interpretive tool indicates that aluminum-normalized lead level is indicative of those measured in clean sediments in Florida (Figure 5.12). While the effects-based tool predicts the possibility of adverse effects at some sites, the geochemical tool demonstrates that lead concentrations in Apalachicola Bay occur naturally and, as such, should not be considered hazardous to aquatic organisms. This system does not require further investigations to evaluate the extent of sediment toxicity.

Recommended Sediment Assessment Approach Limitations

Sediment quality assessment guidelines using the recommended approach are preliminary values and should be refined as new information becomes available. This approach has several limitations and considerations:

- The approach determines the potential for sediment-associated contaminants to induce biological effects. We cannot infer direct cause-and-effect relationships when comparing chemical data to the recommended guidelines.
- The SQAGs apply to marine and estuarine waters only, not to freshwater systems.
- The SQAGs are not expressed as factors thought to control the bioavailability of sediment-associated contaminants (i.e., total organic carbon for nonpolar organics and acid volatile sulfide for divalent metals).
- The data used to derive the SQAGs consist primarily of acute toxicity study results. Few data exist on the chronic responses of aquatic organisms to contaminants associated with sediments.
- The recommended guidelines should be used with other assessment tools and protocols, such as the Florida Department of Environmental Regulations metals interpretive tool and the Green Book (U.S. Environ. Prot. Agency and Army Corps Eng. 1991) to provide comprehensive evaluations of sediment quality.
- The recommended guidelines were developed using information from various North American locations. These data may not represent Florida's diverse sediment types. For this reason, exercise caution in using these guidelines, particularly in carbonate-dominated sediments.

Sediment Quality Assessment Guideline Applications

The recommended sediment quality assessment strategy should provide consistency in evaluating Florida's sediment quality. While the SQAGs represent an integral element of this strategy, they should be used with other assessment tools to efficiently and cost-effectively evaluate ambient sediment quality conditions. In this context, these SQAGs may be used to

- Interpret the results of sediment quality monitoring data. SQAGs may assess the potential adverse biological effects of specific concentrations of sediment-associated contaminants.
- Support the design of sediment quality monitoring programs. SQAGs may evaluate existing sediment chemistry data and rank areas and chemicals of concern according to their potential association with adverse biological effects. As such, monitoring priorities may be more clearly and effectively identified.
- Identify the need for site-specific investigations to support regulatory or watershed management decisions, including source controls and regional urban management sites. SQAGs can evaluate existing data to determine if additional testing (e.g., sediment toxicity bioassays) is needed.
- Evaluate the hazards associated with increased contaminant levels at specific sites. SQAGs may act as early-warning tools for watershed management or regulatory action before contaminant levels become problematic.
- Support a preliminary assessment of the applicability of EPA's developing sediment quality criteria. The SQAGs can assess the protection level these criteria afford to aquatic organisms.
- Facilitate multijurisdictional agreements on sediment quality issues and concerns. SQAGs can establish site-specific sediment quality objectives to help define governmental responsibilities in preventing and remediating sediment contamination.

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These guidelines provide a consistent way to evaluate sediment quality in Florida. However, they are preliminary and their application is limited. Therefore, SQAGs should not be used

- In lieu of water quality criteria. However, these guidelines may be used in regulatory programs to evaluate effectiveness and identify the need for more stringent regulations;
- To define uniform values for sediment quality statewide (i.e., they should not be used as sediment quality criteria). Ambient environmental conditions may influence the applicability of these guidelines at specific locations;
- As criteria to dispose of dredged material or to replace formal assessment protocols established to dispose of dredged material; or
- Directly as numerical clean-up levels at severely contaminated sites (e.g., Superfund sites).

Recommended Reading

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CHAPTER 6

Biological Community Assessments

Traditionally, monitoring surface waters to assess their health and the effects of pollution discharges has relied upon chemical and physical measurements of the water column. While this approach assesses the effects of continuous discharges—such as wastewater treatment plants and industrial sources—it cannot accurately determine environmental impairments from intermittent sources such as urban runoff. This chapter discusses the development and use of biological community assessments to detect the effect of nonpoint source pollution on aquatic life.

Intermittent discharges create shock loadings to a waterbody, and the ecological effects depend on many variables and complex interactions. Moreover, many runoff pollutants become attached to sediment particles or settle quickly, exerting detrimental effects over a long period. Furthermore, urban runoff degrades habitat (e.g., channel and bank erosion) and causes tremendous siltation, neither of which are detected by water chemistry sampling.

Monitoring biological communities is an additional approach that can enhance surface water quality assessment and management. While chemical data reflect short-term conditions that exist when a particular sample is collected, biological communities accurately indicate overall environmental health because they continuously inhabit receiving waters and react to various long-term chemical and physical influences. Aquatic organisms also integrate a variety of environmental influences—chemical, physical, and biological.

Biological assessment involves integrated analyses of functional and structural components of the aquatic communities. Bioassessments are best used to detect aquatic life impairments and assess their relative severity. Once an impairment is detected, additional chemical and biological toxicity testing can identify the causative agent and its source. Both biological and chemical methods are critical in successful pollution control and environmental management programs. They are complementary, not mutually exclusive, ways to enhance overall program effectiveness.

Some advantages of bioassessments are that

- Biological communities reflect overall ecological integrity (chemical, physical, and biological).
- Over time, biological communities integrate the effects of different stressors, providing a measure of fluctuating environmental conditions.
- By assessing the integrated response to highly variable pollutant inputs, biological communities provide a practical approach for monitoring runoff source impacts and the effectiveness of best management practices.
- Routine monitoring of biological communities can be relatively inexpensive, particularly when compared to the cost of assessing toxic substances.
- The public is highly interested in the status of biological communities as a measure of environmental health.
- Biological communities offer a practical way to evaluate habitat degradation typically associated with urban runoff discharges.

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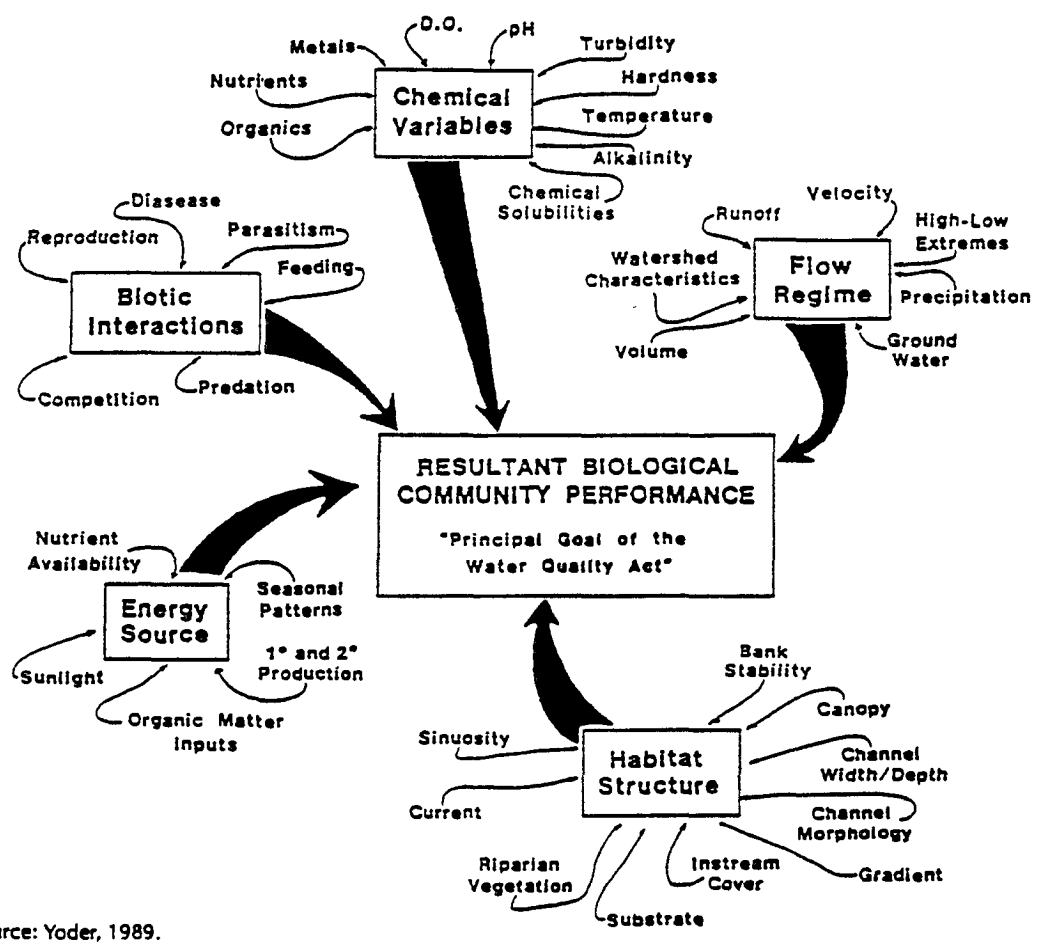
Biological Integrity

Karr et al. (1986) grouped environmental factors affecting most aquatic ecosystems into five major classes: chemical variables, biotic interactions, flow regime, habitat structure, and energy source. These factors interact to determine the integrity of water resources reflected by the resident aquatic life (Figure 6.1). Alterations to the physical, chemical, or biological processes can adversely affect the aquatic biota and, therefore, the biological integrity of the waterbody. Efforts to protect and restore waters by using only one or two of the five factors will likely fail if other factors are involved (Karr et al. 1986). Monitoring methods integrating all five classes are necessary to maintain and improve surface water quality and aquatic life resources.

Recent advances in computer technology and, more important, in biological assessment techniques make the current approach more practical. Advances include geographic information systems and available digitized databases, refined laboratory and field methods, standard assessment techniques, a practical and useful definition of biological integrity, and the regional reference site concept. These advances provide a framework to incorporate biological community assessments and "biocriteria" into surface water management programs.

Although the principal goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters, difficulties in defining an ecological approach to assessing biotic integrity has led regulatory agencies to rely primarily on chemical

Figure 6.1—Important chemical, physical, and biological factors that influence and determine biological community performance in surface waters.



Source: Yoder, 1989.

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measurements. However, Karr and Dudley (1981) define biotic integrity as "the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of the natural habitats within a region." This definition is based on measurable characteristics of aquatic communities and comparisons to a regional reference site.

Despite the many recent advances in bioassessment techniques, state-specific ecoregions, methods to delineate reference sites, and rapid bioassessment (RBA) methods are badly needed. These techniques offer the best means of accurately assessing the impacts of urban runoff and other nonpoint sources of pollution. Conducting this essential development work requires special expertise, adequate funding, and time.

To date, ecoregion reference sites have been selected and sampled, and RBA techniques have been developed and refined only for riverine systems. Work is just beginning to refine and test RBA methods for lakes, and little progress has been made on developing RBA methods for estuaries. These aquatic systems need standard assessment techniques and quantitative biocommunity evaluation criteria.

Ecoregions and Reference Sites

Spatial frameworks can profoundly influence the effectiveness of research, assessment, and management of many water resource problems, especially those caused by urban runoff and nonpoint sources. Traditionally, we have relied on spatial frameworks based on political boundaries, watersheds, hydrologic units, or physiographic regions. However, these areas do not correspond to patterns in vegetation, soils, land surface form, land use, climate, rainfall, or other characteristics that control or reflect spatial variations in surface water quality or aquatic organisms.

Water quality management is slowly moving beyond the technology-based, uniform national standards approach that is point source oriented. The new approach recognizes land/water interactions, nonpoint sources, and regional variations in attaining water quality. Water quality assessments need a regional framework to

- Compare regional land and water patterns;
- Compare ecological similarities and differences;
- Compare habitat similarities and differences;
- Establish realistic, achievable chemical and biological standards;
- Assess the effects of all pollution sources within a watershed, especially intermittent discharges;
- Predict the effectiveness of management practices;
- Prioritize assessment and management efforts;
- Locate monitoring and special study sites; and
- Extrapolate site-specific information to larger areas.

Omernik (1987) proposed using spatial frameworks based on ecological regions (ecoregions) to assess the health of aquatic systems. Ecoregions reflect similarities in the type, quality, and quantity of water resources and the conditions affecting them. Therefore, regional patterns of environmental factors reflect regional patterns in surface water quality.

Using an ecoregional framework, we can sort out spatial variability in the environmental characteristics that we wish to manage. Delineating ecoregions requires collecting and examining reference material to understand the area. This includes determining what the ecoregion looks like, its dominant environmental features, the kinds of natural and human impacts influencing resource quality, and the characteristics supporting the regional delineation. Different environmental features drive each ecoregion. In some parts of the country, land-surface form dominates vegetation, soil formation, and land use; annual precipitation more strongly affects these characteristics in other areas.

Defining, delineating, describing, and depicting ecoregions involves a systematic collection and analysis of diverse environmental information (Figure 6.2). This process is described completely in *Regionalization as a Tool for Managing Environmental Resources* (U.S. Environ. Prot. Agency, 1989a). Ecoregions are defined at hierarchical levels for the conterminous United States (Figure 6.3). More detailed subregions have been developed for Arkansas, Colorado, Minnesota, Ohio, and Oregon. Continued subregion

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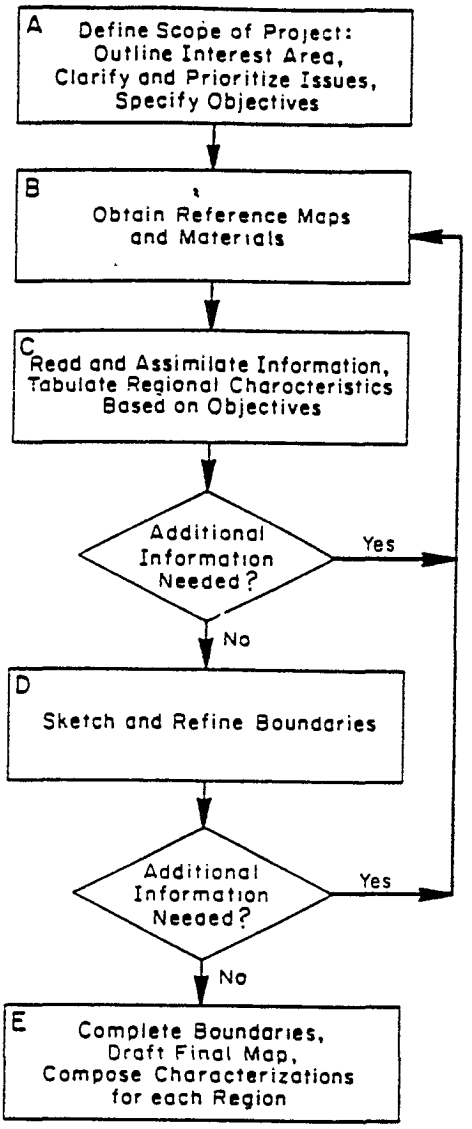
Figure 6.2—Steps to develop regionalization.



Source: U.S. Environ. Prot. Agency, 1989a.

development is underway in Alabama, Florida, and Appalachia. Additionally, subregions are being planned in other states, largely because of biological criteria development and enhanced assessment and management of nonpoint sources.

Once ecoregions are delineated and field verified, ecoregion reference sites should be selected. An essential component of the management framework, these sites allow us to evaluate the environmental health of a locale by comparing it to a known reference site. This is a key concept in Karr and Dudley's (1981) definition of biotic integrity, which compares site evaluations to the aquatic community of "natural habitats within a region." Ecoregion reference sites used in water resources management must have two essential components: They must represent the ecoregion and have ecological conditions reasonably attained, given current background conditions.

Selecting ecoregion reference sites allows us to approximate attainable quality by measuring the physical, chemical, and biological quality of streams draining watersheds that represent the region's natural environmental characteristics and have received the least amount of human influence. Select sites according to the following steps (U.S. Environ. Prot. Agency, 1989a):

1. Specify environmental characteristics affecting water quality such as soil type; vegetative cover; amount, intensity, and timing of annual or seasonal precipitation; topography and slope; and occurrence of natural geologic deposits.
2. Map areas that share similar characteristics.
3. Select watersheds from within those areas.
4. Eliminate watersheds where access is prohibited.
5. Eliminate watersheds affected by human influence. Since this will likely leave an insufficient number of watersheds, add those subject to the least anthropogenic influences. Unfortunately, in many parts of the country, pristine watersheds do not exist. However, given regional land use practices, the least affected watersheds should identify reasonable expectations in the region.
6. Verify the site's suitability to ensure the accuracy of mapped information and to eliminate inappropriate watersheds. Site visits are essential. Make use of local expert opinion.
7. Collect physical, chemical, and biological data to generate reference data that define the range of regionally achievable quality. Use this data to compare the quality of other sites. The next section discusses the type of and ways to collect biological data.

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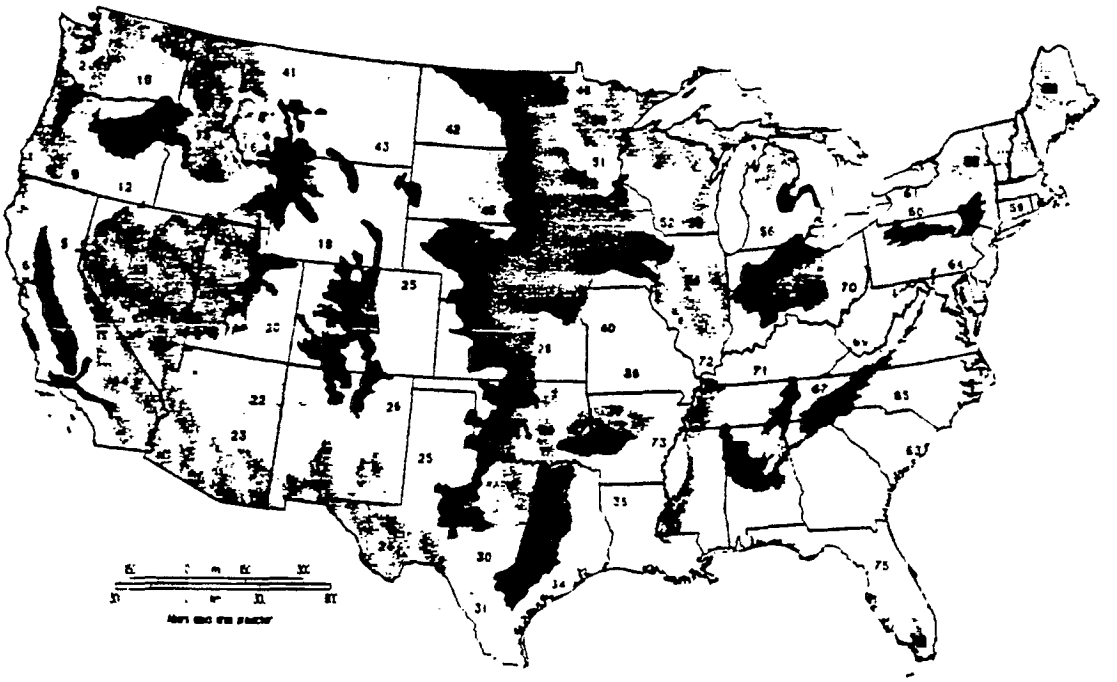
Figure 6.3—Ecoregions of the conterminous United States.



Source: U.S. Environ. Prot. Agency, 1989b.

Rapid Bioassessment Protocols

In 1985, U.S. EPA conducted a survey to identify states that routinely perform biological assessments and evaluate their field methods. A workgroup of state and EPA biologists reviewed existing methods and refined protocols for monitoring benthic macroinvertebrates. Incorporating comments from state and staff, EPA also developed a set of fish protocols. *Rapid Bioassessment Protocols for Use in Streams and Rivers* (U.S. Environ. Prot. Agency, 1989b) contains a more comprehensive discussion of this topic.

The rapid bioassessment protocols (RBPs)—also known as community bioassessment protocols—advocate an integrated assessment, comparing habitat (physical structure and flow regime) and biological measures with empirically defined reference conditions (Figure 6.4). Reference conditions are established through systematic monitoring of actual sites (ecoregion reference sites) that represent the natural range of variation in "least disturbed" water chemistry, habitat, and biological condition.

Of these three components of ecological integrity, ambient water quality may be the most difficult to characterize because of the complex array of chemical constituents that affect it. Therefore, the implementation framework presented in Figure 6.4 first describes the development of an empirical relationship between habitat quality and biological condition and then refines this relationship for a given region. As additional information is obtained from systematic monitoring of potentially impacted and site-specific control sites, the predictive power of the empirical relationship is enhanced. Once the relationship between habitat and biological potential is understood, water quality impacts can be objectively discriminated from habitat effects, and management efforts can focus on the most important source of impairment.

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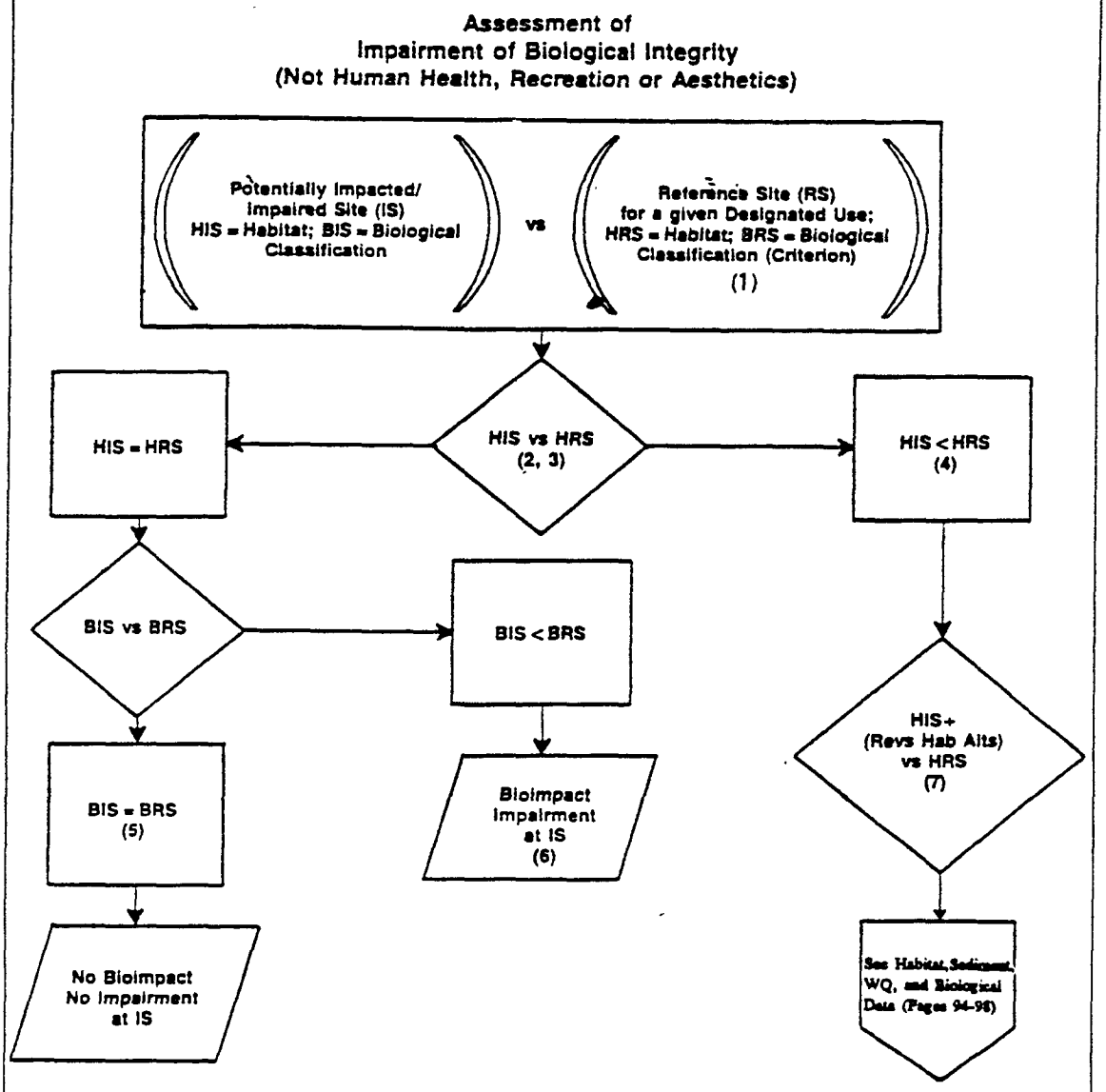
Figure 6.4—Bioassessment decision matrix (numbers in parenthesis refer to numbered Explanatory Notes).



Source: U.S. Environ. Prot. Agency, 1989b.

Figure 6.4—Explanatory Notes

1. The reference site (RS) should represent a database consisting of the best attainable physical habitat, water/sediment chemistry, and biological parameters for specific environmental conditions. Acceptable ranges for the habitat and biological parameters of concern are based on this reference database.

   In the RBP assessment scheme, selected parameters are integrated to define generic habitat categories and bioclassifications. The integrated characterizations describe important attributes of the designated use and represent criteria for attainment/non-attainment of the designated use. Figure 6.4 also illustrates how designated uses and criteria may be established or refined as ambient monitoring activities proceed and how new data are incorporated into the reference database.

   Considerable effort may be required initially to identify reference sites and the habitat and biological characteristics of a specified aquatic life use.

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Figure 6.4—Explanatory Notes continued

Alternatively, data required to define new or refined use characterizations and assessment criteria could be collected through implementation of an effective ambient monitoring program. However, when the *initial* reference database includes a spectrum of least disturbed habitats and concomitant biotic conditions, the need for site-specific controls may be greatly reduced. The value of a comprehensive reference database becomes more evident with progression through the implementation framework.

2. The purpose of the habitat assessment is to determine whether the impaired site (IS) has the potential to support a biological community comparable to that of the reference (see note 6).

3. Applicable ranges for several important habitat characteristics are generally incorporated into the habitat assessment field sheets, and the habitat evaluation can be made quickly onsite. However, preliminary reconnaissance is especially helpful when impaired site habitat (HIS) proves to be much lower in quality than reference habitat (HRS) and an evaluation of reversible habitat alterations (attainability) may also be necessary. Reconnaissance information allows planning for the additional work needed to characterize more appropriate reference sites.

4. In the early stages of developing assessment criteria for a given aquatic life use, HIS may often appear degraded relative to the HRS database. The likelihood of such an outcome is proportional to the richness of the initial HRS database. As more potentially impacted stations are assessed, however, certain stations will be shown to support

   - Biological communities equivalent to the reference sites despite apparent habitat deficiencies. Information from such sites will enrich the reference database and broaden the applicability of the use designation.

   - A relatively degraded community limited by intrinsic or irreversible habitat constraints. In this case, the original use is not attainable, and data collected from such a site should be used to revise the use designation.

5. The robustness of the comparison between the biological condition at the impaired site (BIS) and that at the reference (BRS) is limited by the rigor of the assessment procedure used (e.g., many versus few replicates) and the scope of the overall assessment (i.e., the number of biological community segments actually evaluated). The comparison of BIS and BRS is useful to detect or confirm *appreciable* impact to the biotic community and may be insensitive to certain subtle and/or threshold effects.

6. If BIS equals BRS, no detectable impairment occurs. This conclusion assumes no overriding limitations on the biological potential of IS relative to RS that are not accounted for by the previous habitat comparison (see note 2). Factors that could uniquely affect IS are discussed in station siting. For example, stations RS and IS may be located on a first order stream with primary organic inputs from a coniferous forest. In this situation, certain characteristics of the benthic community, such as taxa richness, may actually increase with organic enrichment from point source discharges rather than decrease as otherwise expected. This atypical situation should be assessed as if HIS plus reversible habitat alterations) is less than HRS (note 7).

7. The HIS plus reversible habitat alterations versus HRS comparison amounts to a simplistic use attainability analysis (UAA) that only considers habitat. The comparison involves scaling up the observed habitat parameter values to the extent that they might be feasibly improved. For example, bank stability, bank vegetation, and streamside cover could be greatly enhanced by fencing a pasture and planting trees, whereas other parameters may be unalterable. This mini-UAA can help to assess site-specific potential in the determination of actual impairment. If HIS and HRS are *potentially* equivalent, then use impairment can be appropriately assessed regarding resident biota. If HIS and HRS are not equivalent even when reversible habitat alterations are considered, biological effects may not be independent of habitat constraints. These potential scenarios are discussed in more detail in the section on integration of habitat, sediment, water quality, and biological data.

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The following are major steps in using EPA's rapid bioassessment protocols along with a brief discussion of some key considerations:

1. **Assessment of the structural/compositional and functional characteristics of the benthic macroinvertebrate community.**

   - **Seasonality for benthic collections.** Optimum biological sampling will correspond to invertebrates recruitment cycles, which vary with climate.

   - **Methods for benthic collections.** Considerations include natural versus artificial substrates; single versus multiple habitat sampling; and sampling coarse particulate organic material such as leaves, twigs, and bark.

   - **Benthic sample processing and enumeration.** Handling samples consistently is important because detailed comparisons are made among stations and sites.

   - **Benthic environmental tolerance characterizations.** Assessment of biological condition is based on the calculation of several metrics. Certain metrics rely on classifying benthic taxa according to their relative sensitivity to pollution. However, the meaning of pollution tolerance varies around the country, requiring each state to adapt established tolerance classification systems.

2. **Assessment of the structural/compositional and functional characteristics of the fish community.**

   - **Seasonality for fish collections.** The preferred sampling season is middle to late summer, when stream flows are less variable and more moderate.

   - **Methods for fish collections.** Electrofishing, seines, and rotenone are the most commonly used collection methods. Each has advantages and disadvantages.

   - **Sampling representative habitats.** The sampling station should represent the stream reach, incorporating at least one riffle, run, and pool if these habitats are typical. Sampling is most effective near shore and cover, such as macrophytes, boulders, snags, and brush.

   - **Fish sample processing and enumeration.** Standardized processing of fish samples should include identification of species, recording incidence of external abnormalities, and weighing (if biomass data are desired).

3. **Assessment of the structural/compositional and functional characteristics of the algal community.**

   - Note: See *Rapid Bioassessment Protocols* (U.S. Environ. Prot. Agency, 1989b) for a discussion of the advantages of using benthic macroinvertebrates, fish, and algae.

4. **Assessment of habitat type occurrence and quality.**

   - **Habitat, as affected by in-stream and surrounding topographical features.** This assessment largely determines aquatic community potential. Both the habitat's quality and quantity affect the structure and composition of its biological communities. Consider both physical characteristics and water quality parameters in assessing habitat.

   - **Physical characteristics.** These include estimating watershed land uses and their associated pollutant discharges/loadings; stream characteristics such as width, flow, and depth (in riffles, runs, and pools); substrate types; sediment odors, oils, and extent of deposits; extent of canopy cover; and human alterations such as dams, channelization, bottom scouring, channel stability/erosion, or modified shorelines.

   - **Water quality observations.** These should include recent and current weather conditions, temperature, dissolved oxygen, pH, conductivity, turbidity, and water odors or surface oils.

5. **Integration of benthic macroinvertebrate, fish, and habitat assessments using quantitative indices.**

   - **Species richness.** This figure should reflect the health of a community by measuring the variety of organisms present (total number of genera or species).

   - **Modified Hilsenhoff biotic index.** This index summarizes the overall pollution tolerance of the benthic arthropod community.

   - **Scraper and filtering collector functional group ratio.** This ratio provides

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insight into potential disturbance factors. Predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source.

- **EPT (Ephemeroptera, Plecoptera, Trichoptera) and Chironomidae abundance ratio.** The relative abundance of these four major invertebrate groups is used as a measure of community balance.

- **Percent contribution of the numerically dominant taxon to the total number of organisms.** This indicates community balance at the lowest positive taxonomic level.

- **EPT index.** This summarizes taxa richness within the insect orders that are generally pollution sensitive.

- **Community similarity indices.** These are used to compare biological communities at impacted sites and reference sites.

- **Ratio of shredder functional feeding group and total number of individuals collected.** This compares the shredder community at an impacted site and at a reference site.

- **Index of Biotic Integrity (IBI).** This broad index is grounded in fisheries community ecology that incorporates zoogeography, ecosystem, community, population, and individual perspectives.

6. **Careful choice of sampling locations to ensure that generally comparable habitats exist at each station.**

   - **Consider community differences.** Otherwise, differences attributable to a degraded habitat will be difficult to separate from those attributable to water quality degradation.

   - **Avoid locally modified sites.** These include small impoundments and bridge areas.

   - **Consider entering waters.** Avoid sampling near the mouths of tributaries entering large waterbodies, since these areas will have habitats more indicative of larger waterbodies.

7. **Use effective quality assurance and quality control procedures to ensure the usefulness of environmental monitoring data.**

   - **Develop a QA project plan.** It should describe the specific objectives, procedures, and methods for all staff working on the project.

   - **Training.** Train staff conducting the assessments consistently to ensure complete and standardized assessments.

   - **Achieve consistency.** Each agency must define its specific sampling methods, laboratory procedures, and analytical and validation techniques (e.g., replicate samples).

   - **Consider subjective habitat characterization.** Take special care in conducting the evaluation. Appropriate training and periodic cross-checks are essential.

   - **Routinely calibrate all field instruments.**

EPA (U.S. Environ. Prot. Agency, 1989b) presents five rapid bioassessment protocols—three for benthic invertebrates and two for fish. The appropriate bioassessment approach depends on the study objectives. RBPs I and IV are screening tools to help determine if biological impairment exists. Benthic RBP I and fish RBP V are more rigorous and provide more objective and reproducible evaluations than RBPs I and IV. RBPs II, III, and V are semiquantitative and use an integrated analysis technique to provide continuity in evaluating impairment among sites and seasons. Each of the RBPs is summarized briefly.

- **Rapid Bioassessment Protocol I—Benthic Macroinvertebrates and Rapid Bioassessment Protocol IV—Fish.** These RBPs provide a screening mechanism to identify biological impairment. They are not intended to quantify the degree of impairment nor provide definitive data to establish cause-and-effect relationships. They allow a cursory assessment, using cost and time efficiencies to evaluate a large number of sites, identify major water quality problems, and help plan and develop management strategies.

- **Rapid Bioassessment Protocol II—Benthic Macroinvertebrates.** This RBP provides information to rank sites as severely or moderately impaired so that additional study or regulatory/management action can be planned. Like RBP I, this protocol can be used as a screening tool and allows agencies to evaluate a large number of sites with relatively little time and effort. The more documented procedures and integrated metrics of

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RBP II promotes better consistency and allows better comparison among sites.

■ **Rapid Bioassessment Protocol III—Benthic Macroinvertebrates and Rapid Bioassessment Protocol V—Fish.** These two RBPs provide a consistent, well-documented biological assessment. Like RBP II, they provide information for ranking site impairment and a way to compare repeatable results over time (trend monitoring). These RBPs include taxonomic identifications to the lowest practical level, thereby providing information on population as well as community level effects. They include an integrated assessment of metrics and can be used to develop biocriteria.

Habitat, Sediment, Water Quality, and Biological Data

Relationship between Habitat Quality and Biological Condition

An overall assessment of ecological condition first evaluates habitat quality, then analyzes the biological components in light of these data.* If adverse effects are likely, then sediment and water chemistry sampling and evaluating potential pollution sources within the watershed should be undertaken. As the principal determinant of biological potential, habitat sets the context for interpreting biosurvey results. Along with sediment quality, habitat can be used as a general predictor of biological condition. Routine water chemistry can also help to characterize certain impacts.

In RBPs I and IV, which involve minimal biological sampling, habitat evaluation carries considerable weight in the final assessment. However, in RBPs II, III, and V, the biological evaluations are more rigorous and take precedence. The habitat assessment plays a supporting role within these protocols. It identifies obvious constraints on the site's attainable potential, helps select appropriate sampling stations, and provides basic information for interpreting biosurvey results. Sediment assessment, as discussed in Chapter 5, should be added to this methodology.

A site's attainable biological potential is determined primarily by habitat quality. The relationship between habitat quality and biological condition can be seen as a sigmoid curve (Figure 6.5), with community response varying with habitat quality. In the upper segment of the curve, good quality habitat (supporting or comparable) will often support high quality communities. Responses to minor alterations in habitat will be subtle and inconsequential. However, as habitat quality declines, discernible biological impairment results. In the absence of confounding water quality effects, this relationship is roughly linear.

In areas of severe habitat degradation, predicting the degree of biological impairment is more difficult. Community structure depends less on habitat diversity, which is usually simplified by degradation, and more on the opportunistic colonization strategies of a relatively few tolerant species. These opportunists have adapted to environmental conditions unfavorable to most other species. In the absence of competition, they thrive—or at least survive—in these marginal conditions. Therefore, biological measures, particularly those used in the RBPs, are relatively insensitive to habitat variations in this range. A nonsupporting characterization may correspond to either a moderately or severely impaired biological condition, depending on the specific site.

When habitat, sediment, and biological data are systematically collected together, empirical relationships can be quantified and subsequently used for screening impact sites, scoping field activities, and discriminating water quality impacts from habitat degradation. By acquiring a multiple-site database, confidence bounds can be established for the habitat/indigenous community relationship.

A theoretical relationship of habitat quality and biological condition as affected by water quality problems (organic or toxic loadings) can also be hypothesized (Figure 6.6). Curve II indicates the general relationship of biological condition to habitat quality in the absence of water quality/sediment effects. Curve II may resemble a sigmoid curve as illustrated in Figure 6.6. Curve III represents a situation where organic pollution or toxicants will adversely affect biological condition regardless of the habitat quality.

In areas of good or excellent habitat, biological communities reflect degraded conditions when water quality/sediment effects are present. However, as habitat degrades to a poor condition from water quality/sediment problems, community response may be less dramatic because of the presence of tolerant and generally opportunistic species. Curve I represents a situation indicative of nutrient enrichment, which will artificially sus-

* *Material in this section was adapted from U.S. Environ. Prot. Agency, 1989b.*

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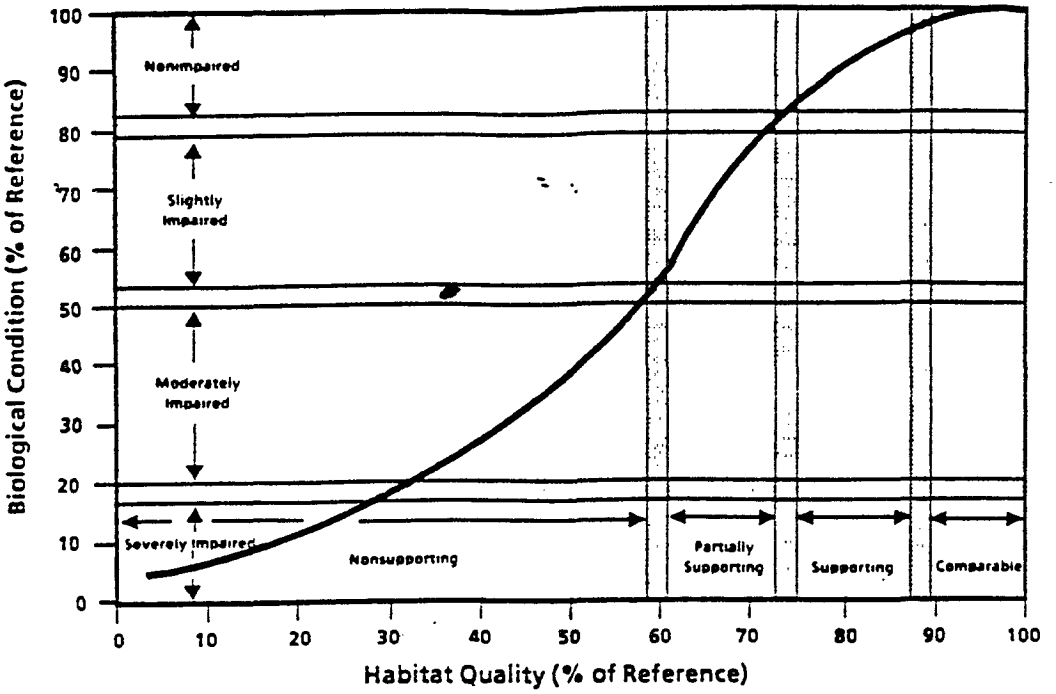
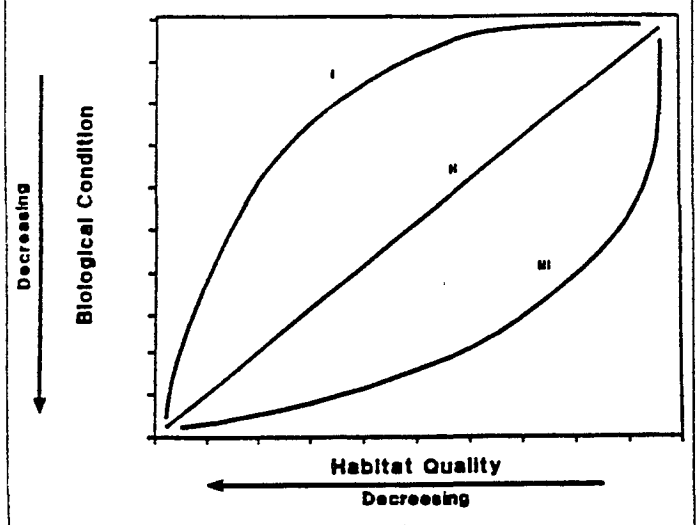
Figure 6.5—Relationship between habitat and biological condition.



Source: U.S. Environ. Prot. Agency, 1989b.

tain a more diverse fauna than dictated by the habitat quality. However, at some point along the curve as habitat degradation proceeds, nutrient enrichment will no longer support a diverse community, resulting in a drastic decrease in biological condition.

Figure 6.6—Relationship of habitat quality and biological condition in the context of water quality.



Source: U.S. Environ. Prot. Agency, 1989b.

Bioassessment Technique

Biological assessment components are evaluated using eight metrics (measurements) for benthic RBPs II and III and 12 metrics for fish RBP V. The pollution sensitivity range exhibited by each metric differs among metrics (Figures 6.7 and 6.8). Some are sensitive to a broad range of biological conditions; others only to some conditions. Sensitivity of metrics may also vary depending on whether organic or toxic impacts are being evaluated (Figure 6.7). The considerable overlap in the sensitivity ranges helps reinforce final conclusions regarding biological condition, while metrics that can better differentiate responses at the impairment range extremes enable a more complete bioassessment. This integrated analysis approach thus allows a broader assessment of condition than an analysis using any single metric. However, information from individual metrics enhances overall data interpretation.

Certain metrics are designed to be better estimators of either organic or toxic effects. For exam-

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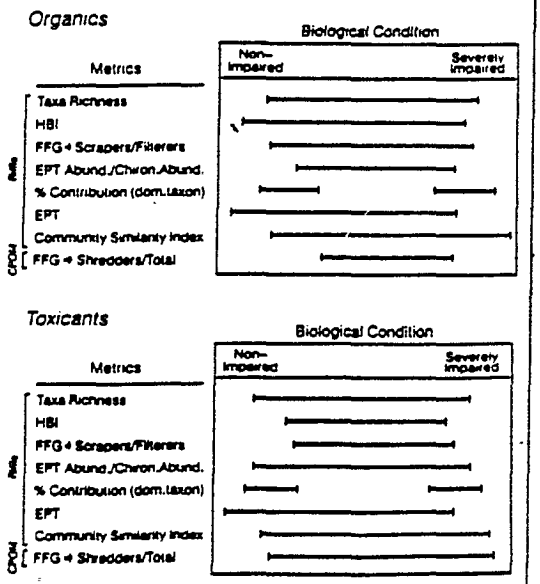
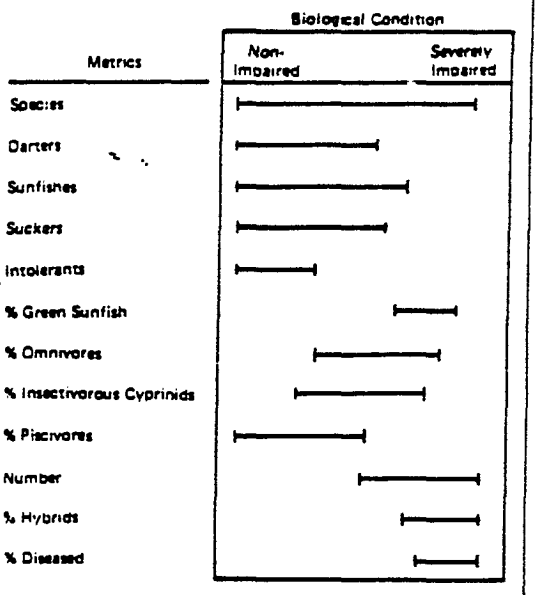
Figure 6.7—Range of sensitivities of RBP II and III benthic metrics in assessing biological condition in response to organics and toxicants.



Source: U.S. Environ. Prot. Agency, 1989b.

Figure 6.8—Range of sensitivities of RBP V fish metrics in assessing biological condition.



Source: U.S. Environ. Prot. Agency, 1989b.

ple, the Hilsenhoff Biotic Index—a macroinvertebrate index—uses a tolerance classification scheme based on organic pollution effects. Functional group representation can be altered by either organics or toxicants (Figure 6.7). Although toxicants somewhat affect scrapers and filter/feeders, their ratio can best be used to assess organic enrichment. A reduction in the value obtained for scrapers and filter feeders can indicate a reduction in the quality of the periphyton as a food source and/or an increase in the suspended fine particulate organic matter (FPOM). Filter feeders are also affected by FPOM contaminated by toxicants.

The relative abundance of shredders in the benthic community is a good indicator of toxic problems. Vegetation sprayed with pesticides eventually becomes a coarse particulate organic matter (CPOM) food source for shredders. Therefore, depending on toxicant concentrations, CPOM may affect shredders. The ratio of the abundances of EPT taxa and chironomids may also function as a toxicant indicator.

The 12 IBI metrics, used in fish protocol V, also represent differing sensitivities (Figure 6.8). For example, municipal wastewater discharges typically affect total abundance and trophic structure (Karr et al. 1986), while unusually low total abundance generally indicates a toxic effect. However, some nutrient deficient environments support a limited number of individuals, and an increase in abundance may indicate organic enrichment. Bottom dwelling species that depend on benthic habitats for feeding and reproduction are particularly sensitive to the effects of siltation and benthic oxygen depletion and are good indicators of habitat degradation.

For the benthic and fish biosurveys and habitat assessment, scores are assigned to each metric or parameter based on a decision matrix. For habitat assessment, parameter quality is evaluated through visual observation. The score assigned to each habitat parameter is a function of a range of scores and is weighted by its contribution to the total habitat quality. The scores assigned to the benthic and fish metrics are based on computed values of the metrics and a station comparison, where the regional or stream reference station serves as the highest attainment criterion. Comparing the total score computed for the metrics or parameters with the reference station score provides a judgment about impairment of biological condition.

Effects indicated by the aquatic community need to be evaluated in a habitat quality context.

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A poor habitat for riparian vegetation, bank stability, or stream substrate would not favorably support a well-balanced community structure. Habitat quality constraints may prohibit attaining a higher quality biological condition.

An Integrated Assessment Approach

Assessing sediment, characterizing watersheds, and mapping pollution sources can be used to determine potential hot spots in watersheds and subbasins. Bioassessment and water chemistry sampling can then assess the aquatic system's actual health in these locations. A bioassessment should initially focus on habitat quality. Based on a regional reference, the habitat at an impacted site may be equal to or less than the desired quality for that particular system. If the habitat and reference are equal, then we can make a direct comparison of biological conditions as discussed in Figure 6.4. If the habitat is lower in quality than the reference, the first step is to evaluate the habitat potential. A site-specific control may be more appropriate than a regional reference for assessing an impact site. If so, select an appropriate site-specific reference site to ensure that its habitat and sediment characteristics represent the area. Once the appropriate reference site type is determined, possible outcomes of the bioassessment are

- No biological effects;
- Effects due to habitat degradation;
- Effects due to sediment or water quality; or
- Effects due to a combination of sediment, water quality, and habitat degradation.

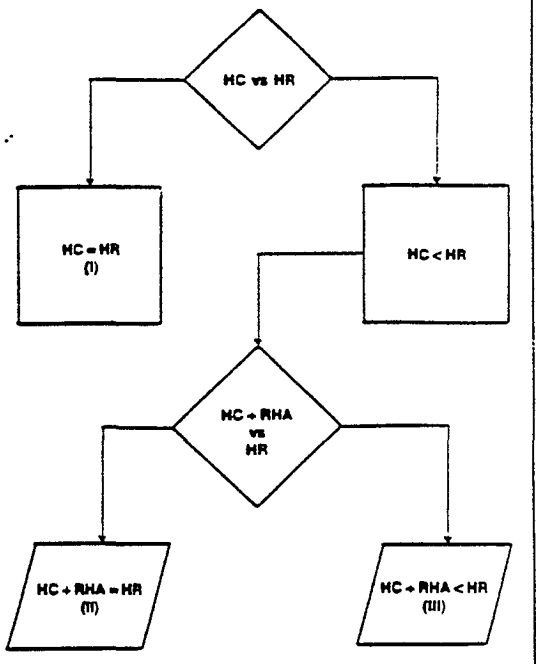
After habitat problems are identified, separating the impairment cause from sediment or water quality problems is usually difficult. Figure 6.9 illustrates the approach to assessing biological effects. Selecting an appropriate station of comparison to evaluate biological impact begins with an evaluation of habitat at the potential control station. This comparison assumes that a regional reference database is available for the site being studied. Reference data used for comparison may be obtained from a single reference site. However, a reference database derived from numerous sites is much preferred and strongly recommended.

Scenario I depicts the situation where the habitat quality at the control station (HC) is equivalent to that at the regional reference (HR). If the control station habitat is degraded relative to that at the reference site, it becomes necessary to consider the effect that reversible habitat alterations (RHA) may have on habitat quality (Scenarios II and III). Reversible habitat alterations are those habitat parameters that can potentially be altered by remedial action (i.e., bank stabilization, bank vegetation, streamside cover).

If habitat quality at the control station (HC) is equivalent to that at the regional reference station (HR) as in Scenario I, then a biological assessment can be used to evaluate the potential water quality effects at the control site (Figure 6.10).

1. If impairment is not detected in a comparison of biological condition at the control station (BC) to biological condition at the reference station (BR), then C should be included in the R database; either C or R may be used as a reference for biological assessment at the impact

Figure 6.9—Evaluation of habitat at a site-specific control relative to that at a regional reference.



Key:
HC = Habitat quality at control station
HR = Regional reference
RHA = Reversible habitat alterations

Source: U.S. Environ. Prot. Agency, 1989b.

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site (I). C would be the best indicator of a site-specific situation and would be more appropriate for use in determining water quality effects of point source pollutants, since it would be located on the same waterbody and would integrate all other background sources of impairment, other than the point source being evaluated. The reference would be more appropriate in an assessment of intermittent or nonpoint sources, since finding a nearby site-specific control that would not be impacted by the impact sources being assessed is virtually impossible. If R is based on an extensive database, then using R as a reference would provide a better estimate of acceptable variation in a data set.

2. If biological impairment is detected at C relative to R, the impairment may be attributed to water quality or sediment effects. The use designation at C is probably appropriate, but R should be used as the bioassessment reference site because of the impairment at C.

Specific approaches to evaluate environmental health for differing combinations of habitat conditions, biological condition, water quality, and sediment quality are discussed in section 8.3 of *Rapid Bioassessment Protocols for Use in Streams and Rivers* (U.S. Environ. Prot. Agency, 1989b).

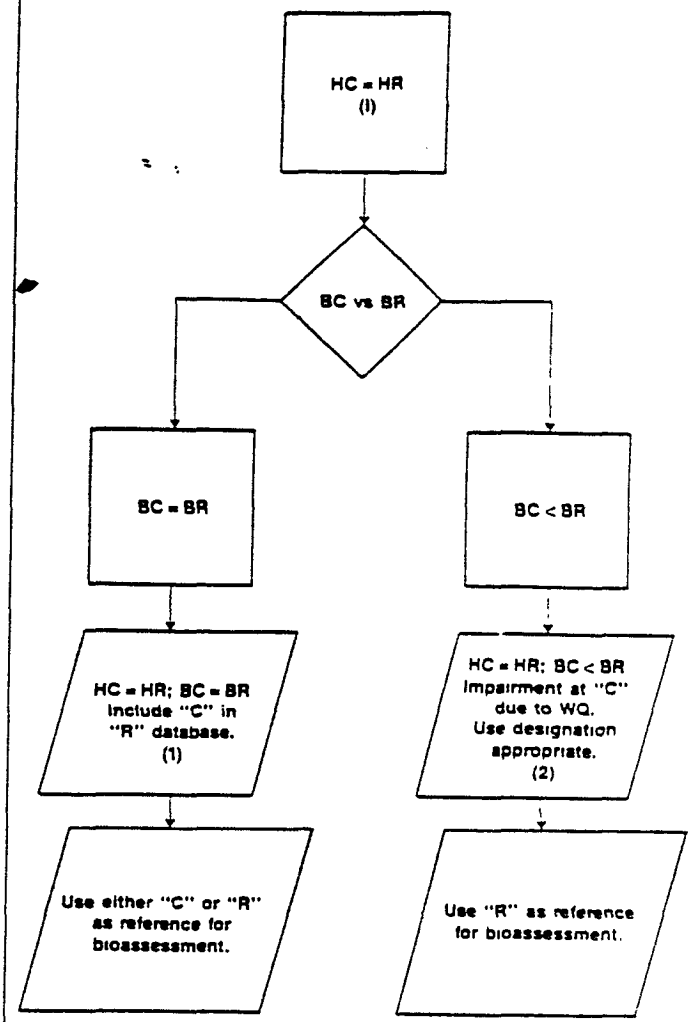
Biocriteria

To implement water quality standards under the Clean Water Act, EPA requires states to include biological criteria in addition to water chemistry criteria. However, for various reasons, states have relied primarily on surrogate chemical criteria and narrative biological criteria (e.g., concentrations shall not cause imbalances of flora and fauna) to measure the health of biological communities. This situation is changing as EPA places increased emphasis on more quantitative biological criteria and as states begin assessing and managing urban runoff and nonpoint sources.

Yoder (1991) emphasizes five major needs to derive and establish scientifically defensible numeric biological criteria (biocriteria):

1. An operational definition of biological integrity. Karr and Dudley (1981) provide a workable, practical definition: "The ability of an aquatic community to support and maintain a structural and functional performance comparable to the natural habitat of a region."
2. The establishment of ecoregions and ecoregion reference sites.
3. The development and refinement of multimetric community measures such as the Index of Biotic Integrity, the Index of Well-Being (I_{WB}), and the Invertebrate Community Index (ICI).
4. Standardized, thorough, and cost-effective biological assessment techniques such as the RBPs discussed previously.

Figure 6.10—Evaluation of water quality effects. (numbers in parenthesis refer to points of discussion in text).



U.S. Environ. Prot. Agency, 1989b.

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5. Trained, experienced, and knowledgeable staff.

In recent years, the Ohio Environmental Protection Agency (EPA) incorporated biocriteria into its water quality standards regulations. These biocriteria are based on a system of tiered aquatic life uses. The five classes include coldwater habitat, warmwater habitat, exceptional warmwater habitat, modified warmwater habitat, and limited resource waters. Ohio has defined these designations qualitatively in ecological terms and established quantitative or narrative chemical criteria for each.

Ohio derived numerical biocriteria for rivers and streams for three classes of waters—warmwater habitat, modified warmwater habitat, and exceptional warmwater habitat—based on in-stream fish and macroinvertebrate communities. Sampling conducted at more than 300 "least impacted" reference sites provided the ecoregional framework and established attainable, baseline expectations for each region and for the individual use classes.

Ohio EPA used three biological indices—IBI, I_{wb}, and ICI—to establish its biocriteria. Criteria for each index are defined by organism group, biological index, site type (fish), ecoregion, and aquatic life use designation. Modified I_{wb} and IBI criteria were defined for each of the five Ohio ecoregions for three site types: headwaters (drainage areas – 20 mi^2 [51.8 km^2]), wading sites (streams sampled with wading methods, usually 20-300 mi^2 [51.8-777 km^2]) and boat sites (streams sampled with boat methods, usually 200-6,000 mi^2 [518-15,540 km^2]). The calibration of the indices and the resultant biocriteria consider the effect of stream size and sampling gear selectivity.

Ohio established ecoregional biocriteria for the warmwater habitat class at the 25th percentile value of the reference site data for each ecoregion index. It set criteria for the exceptional warmwater habitat class at the 75th percentile, based on a statewide—not ecoregion—assessment of data from reference streams. In addition, Ohio established modified warmwater habitat criteria for some streams with physical habitat so altered that the expected warmwater habitat use could not be realistically attained but could support some semblance of a warmwater habitat community. The two biocriteria (25th percentile values) established for this class were for sites in the Huron/Erie Plain and for sites in the rest of the habitat.

Ohio EPA also established a process to determine the use attainment of Ohio's lotic surface waters. Attainment is assessed primarily based on biological monitoring and the ability to achieve the use class biocriteria. Nonattainment depends on the magnitude of departure from the ecoregional biocriteria (e.g., within four IBI units of the ecoregion criteria) and the distance downstream over which the departure is sustained. Generally, attainment is achieved by meeting all three numeric indices. Attainment is considered partial if at least one organism group index does not meet expectations but is no lower than a fair narrative rating, and the other organism group exhibits attainment. Nonattainment occurs if none of the indices meet ecoregional biocriteria or if one organism group gets a poor or very poor narrative rating, even if the other group exhibits attainment.

EPA (U.S. Environ. Prot. Agency, 1989a) presents an example of how Ohio EPA uses these biocriteria to assess waterbody impairment. A warmwater habitat stream, located in the Erie/Ontario Lake Plain ecoregion, receives point source discharges. Each graph in Figure 6.11 indicates various levels of attainment of each index, with the lines tracing the longitudinal profile of the index values along the stream. In this case, above the pollution sources, the stream attains its regional warmwater habitat biocriteria—40 for the IBI, 8.0 for the I_{wb}, and 36 for the ICI). Each index shows impairment below the discharges, followed by movement toward recovery. Each index responds somewhat differently.

This biological assessment framework accurately assesses the environmental health of surface waters as seen by a comparison of Ohio's use attainment conclusions (Table 6.1).

Table 6.1—Comparison of percent of stream segments attaining aquatic life uses, based on biosurvey and in-stream chemical data.

CHEMICAL ATTAINMENT	BIOSURVEY ATTAINMENT			
	FULL	PARTIAL	NON	TOTAL
Full	17	18	17	52
Partial	2	1	6	9
Non	4	6	28	39
Total	23	25	52	

Note: Rows indicate full attainment, partial attainment, or nonattainment based on in-stream water chemistry; columns indicate attainment based on biosurveys.

Source: U.S. Environ. Prot. Agency, 1989a.

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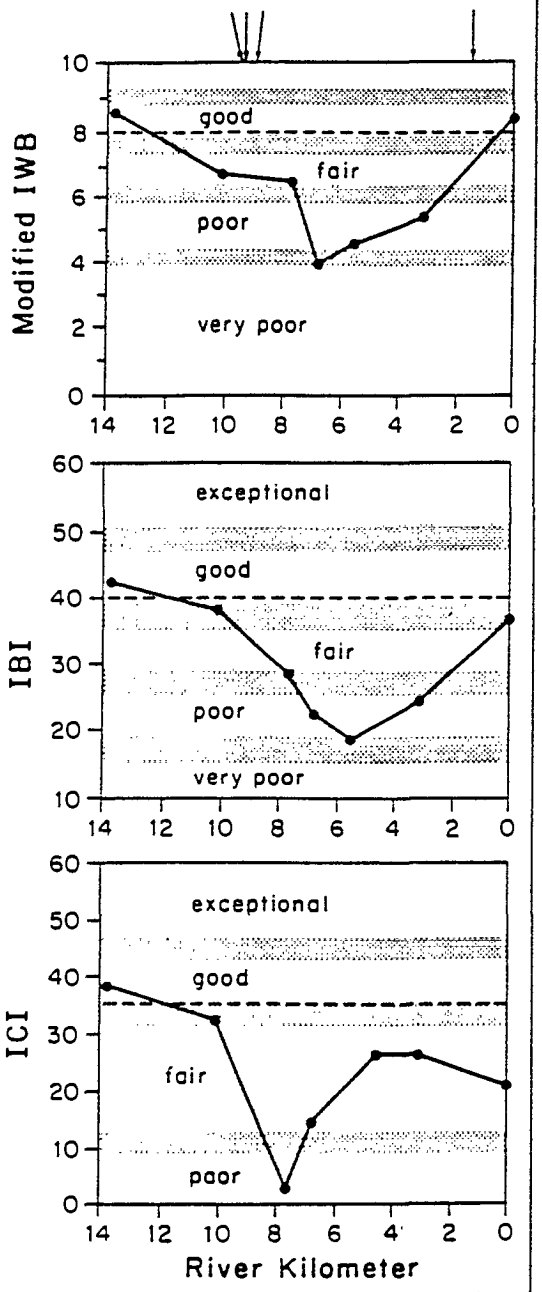
Figure 6.11—The Ohio Environmental Protection Agency uses biocriteria to interpret the significance of environmental impacts. Pollution discharges are indicated by the arrows at the top of the figure; applicable biocriteria are indicated by the dashed lines.



Source: U.S. Environ. Prot. Agency, 1989a.

Conclusions drawn from Table 6.1 include

- Based on chemical data, 52 percent of the segments fully attained aquatic life uses;
- Based on biosurvey data, only 23 percent achieved full attainment;
- Both assessments agreed on full attainment in 17 percent of the cases, with overall agreement on 46 percent; and
- In 35 percent of the cases, chemical data indicated full attainment, but biosurvey data indicated partial or nonattainment. In nearly half of these cases, impairments were due to habitat, flow modifications, or siltation.

Recommended Reading

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CHAPTER 7

Erosion Prevention and Sediment Control

In considering urban runoff control during construction, erosion prevention and sediment control must be considered individually. However, for effective site control, these efforts are linked. Erosion prevention reduces the amount of sediment generated from the land. Once erosion occurs, sediment control practices are necessary to limit the downstream movement of the sediment. This chapter examines erosion prevention and sediment control and offers specific recommendations for management.

For many years, erosion and sediment control during construction has been recognized as a major component of an urban runoff management program. Local sediment control programs generally date back to the early 1970s. The USDA SCS published an excellent pamphlet entitled "Conquest of the Land through 7,000 Years" (U.S. Dep. Agric. 1978). This document discusses the fall of several civilizations as a result of poor soil stewardship.

The economic impacts of off-site sedimentation are defined by several barometers, including dredging costs for local reservoirs or shipping channels, drainage channel maintenance by local departments of public works, cost of water treatment, and the cost to remove sediments from water intake structures. Not only is the removal of sediments expensive, but the transport and final disposition may be the single most costly item of the entire maintenance operation. Depending on the land use of the watershed draining to the area where sediment is being removed, the sediments may need testing for toxicity. Consideration must be given to where the spoil material can be safely placed.

Visibility makes sediment more easily identified than other pollutants. Visually inspecting streams after a storm can easily document the problem—water, by nature, is not brown. Sediments in streams, rivers, reservoirs, and estuaries mostly result from accelerated erosion because of societal impacts. Geologic erosion does occur, but mostly in arid areas where vegetation struggles to establish itself and survive. In areas with rainfall adequate to maintain dense stands of vegetation, sediment in streams generally comes from accelerated erosion resulting from lack of effective ground cover.

Design Considerations

Erosion Prevention

Erosion prevention requires reducing the amount of land that is disturbed to decrease sediment detachment and mobilization. Urban runoff management considerations reflect a similar philosophy to that contained in the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) and National Pollutant Discharge Elimination System (NPDES) stormwater guidances. The first consideration should be pollution prevention and source reduction.

Soil should not be considered a waste product but rather a resource to be protected. Minimizing areas subject to disturbance reduces the amount of work that the more traditional structural erosion and sediment controls must accomplish. Unless the land was actively engaged in another use, the site's native vegetation prior to development probably provided more effective ground cover than any proposed vegetation.

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When land is disturbed, phasing of construction projects and rapid revegetation and stabilization of exposed areas must be considered. Phasing of a project limits the area exposed at any one time. It also assists the land developer in determining how to develop the site. Too often, an entire site is disturbed and left unstabilized for a long period.

Once an area has been disturbed, the single most important erosion control practice is stabilization with the intended ground cover. When the intended ground cover cannot be immediately provided, apply a temporary ground cover such as seed and straw mulch.

Sediment Control

Even with effective, timely site stabilization, a construction site generates sediments. Sediment control functions primarily as perimeter control, although interior site controls could also reduce the work (trapping need) that perimeter controls must perform. The type of runoff that is intercepted prior to sheet or concentrated flow dictates the type of sediment controls.

In sheet flow, the initial form that overland flow takes, runoff travels at a uniform depth over the ground. Generally, sheet flow will exit from a maximum slope length of about 100 ft (30.48 m). Once flow exceeds that length, areas of concentrated flow form small rivulets and channels. Sediment control practices designed for areas of sheet flow construct barriers so that water ponds or accumulates and filters through the barriers. Straw bale dikes and silt fences, the two most commonly used sheet flow practices, are effective only when sheet flow transports sediment.

Once flow is concentrated, sediment trapping practices are the only effective way to control sediment. These controls consist of two elements: a means to convey or divert runoff such as diversion berms or swales, and the actual trapping practice. Diversion dikes or swales travel across slopes and direct sediment laden runoff into trapping devices. Designs are cited in most state and local sediment control handbooks. Trapping devices include sediment traps and basins. The two practices function identically—their main difference being the size of drainage area—relying exclusively on settling. Sediment traps are used for smaller drainage areas. Sediment basins are used for larger drainage areas and, as such, must be designed and constructed to prevent overtopping or failure. This could pose downstream safety hazards. Retention time is determined by the practice's holding capacity. Around the country, most jurisdictions use .5 in (1.27 cm) of runoff storage per acre draining to the practice. These practices hold the sediment-laden water long enough for the sediment to drop to the bottom and then discharge the runoff. The amount of holding time depends on the discharge volume (.5 in per acre) and sediment particle composition.

Sediment traps function for smaller drainage areas, generally under 5 acres (2.02 ha). Traps are simpler to design and construct, even through their storage volumes are identical to sediment basins. A failed trap generally has a minor impact.

Historical Problem Areas

While most states have sediment control laws, most laws are ineffective, weak, or for the most part ignored. An effective program requires laws that are equitable and consistently applied throughout a jurisdiction. Programs not having well-defined criteria and review and inspection procedures will not be successful. A major problem, unique to erosion and sediment control, is that control practices are temporary. Therefore, a land developer may perceive that not implementing and maintaining needed practices saves money.

That perception is not totally accurate. Accelerated soil erosion also incurs costs. Topsoil loss requires fertilizers to stabilize the final site; the loss of fill material on elevated sites, such as highway embankments, requires replacement for final site elevation—all at a cost.

Despite the economic tradeoffs, many land developers fear that implementing good site sediment control practices are an economic burden when they must compete with others who do not implement such controls. Erosion and sediment controls, uniformly mandated and enforced, would place all developers on a equal footing.

Therefore, the driving mechanism for an effective erosion and sediment control program is a clearly defined uniform law defining responsibilities and enforcement options. The law should mandate the review and approval requirements before site clearing and enforcement options if control measures are inadequate. These requirements must have a solid legal basis, as they will surely be tested.

Another problem involves public construction. Public works agencies, highway agencies,

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and other public construction programs are generally not required to meet the same restrictions as private construction. When included, public construction frequently does not meet acceptable levels of performance. Enforcement mechanisms such as stop work and civil or criminal penalties are not considered viable options because they lead to cost overruns financed by the public. To achieve an effective control program, all agencies must comply with the laws and regulations.

Utility construction can also cause significant problems. A sewer, electric, cable, gas, or other utility contractor may cut through diversion dikes or other controls put in place by the general contractor. In these situations, responsibility for repair can be difficult to determine.

Plan Review

Local agencies should require a plan review before construction begins. Plans must define criteria and standards before receiving final approval. On small sites, normally reviewed as a general permit, the land developer might agree to implement needed practices such as straw bales or silt fences. Larger sites, where concentrated runoff flow exists or is expected, need detailed individual reviews to ensure that adequate practices are included. Requiring a developer to have only a pollution prevention plan on site, without a detailed plan review and approval procedure, will not provide downstream resource protection.

From a staffing standpoint, the number of plans estimated per year will determine how many individuals are required for plan review. The average plan reviewer can review two to six plans a day, depending on the plan's complexity. The larger a site and the more movement of earth, the greater is the degree of review and the time required. In addition, the reviewer can expect over 50 percent of the original submissions to be incomplete or contain errors in the site control approach. This will require modifications and another review. However, this number will decrease as the program grows and developers gain experience. Each subsequent review takes time and reduces the staff's ability to tackle new projects.

The review and approval time frame is another area of confusion and controversy that limits program success. In many areas, local jurisdictions have approved development plans without requiring erosion and sediment controls—often years before projects are built. Time limits should be set for previously approved projects to be resubmitted for approval.

Inspection

Inspectors are the backbone of any erosion and sediment control program; regular inspection of construction activities is the mark of a successful program. A site review program ensures that controls are implemented and maintained. An inspector, who can normally inspect from three to five sites a day, should visit each site frequently enough to ensure adequate site control throughout construction. To ensure proper site control, Maryland and Delaware *require that active construction sites be inspected about once every two weeks.* Rarely, however, does a local program have adequate inspection staff even in states with aggressive program implementation.

Inspectors should complete and provide to the owner/developer a site inspection form that discusses site conditions, details areas requiring improvement, and establishes a time frame for corrective actions. Consistency and follow-up inspections are critical to good site control and maintenance. Failure to inspect the site for corrections at the appropriate time may cause the contractor to reduce efforts to control sediment or prevent erosion.

Implementation

The effectiveness of the initial implementation of erosion and sediment control depends on the contractor's experience and the thoroughness of the approved plans. Plans should include adequate legal authorization to stop work and apply penalties if necessary. Site conditions often call for control modifications. In highway construction, for example, controls are often based on final site conditions rather than initial runoff patterns. Since these controls may not function until the final stages of the project, interim plans and measures are needed.

Maintenance

Proper maintenance of erosion and sediment controls is often difficult. While many contractors may meet requirements to implement erosion and sediment controls, they often do not include the costs of maintaining those controls in their initial bids. Because maintenance costs reduce a contractor's profit, compliance after erosion and sediment control facilities are installed requires more aggressive enforcement.

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Another problem occurs when a contractor clears an entire site for grading and development, leaving the site bare throughout construction. A better practice is to phase clearing to maintain existing ground cover until disturbance is necessary.

Filled sediment traps or basins present another maintenance problem. Material removed from periodic cleaning is often placed in an area that lacks sediment control. Inspections determine when sediment trapping devices should be cleaned and where the spoil material should be placed—generally upstream of the sediment traps.

Measuring Success

Measuring the success of any preventive program is difficult since programs are based on preventing resource degradation rather than on measurable improvements. This is particularly true in erosion and sediment control, where no practice is 100 percent effective in totally preventing adverse impacts to downstream resources. Documented case studies have shown that miles of stream reaches can be affected for years. Therefore, resource degradation should be limited to the shortest possible time frame and the shortest possible distance downstream.

Science

Many practices—such as temporary stabilization and phasing of controls—are beneficial, but actual performance data are lacking. Other practices, such as sediment trapping devices, are documented but more information is needed to adequately predict expected performance. Other controls recognized as being needed—phasing of development, vegetative practices and temporary stabilization—are qualitative in their design and performance.

Controlling erosion and sediment in arid areas is different from control in "water rich" areas, and additional research on this subject is needed. Once erosion and sediment control practices are installed, the character of sediment discharges changes dramatically. The offsite impact of these practices has not been documented.

Recommended Approach

Inadequate site control during construction can devastate downstream resources more than any action other than a release of chemicals. The extent of the devastation depends on the rainfall characteristics of a given area. Therefore, implementing a site control program is essential for an overall program to succeed.

While the adverse impacts from land developing activities is well documented, our implementation of control programs is lacking. More control programs must be developed to ensure that all construction activities, private and public, are required to implement control practices.

Erosion Control

A number of items could be established as erosion control criteria:

1. Site phasing could be used to limit the total area of bare soil that is exposed at any one time. For example, Delaware sediment and stormwater regulations permit no more than 20 acres (8 ha) of land to be cleared at a time. Once land grading is initiated on that parcel, a developer may remove stumps, roots, brush, and organic material from a second 20-acre parcel. Actual clearing or grading of that second parcel may not proceed, however, until the first parcel has been either temporarily or permanently stabilized.

   Certain types of activities require flexibility to clear land in excess of 20 acres. These activities include highway interchanges, shopping malls, and other large projects. However, the land developer should make a written request stating why the 20-acre limit causes an undue hardship.

   The selection of 20 acres as a clearing limit is arbitrary. Any reasonable limit can be used as long as the land developer considers the site's development and limits soil exposure.

2. Revegetation must be required and its time frame specified. In arid regions, revegetation requirements should be related to predevelopment geologic erosion rates or seasons.

   Since rainfall patterns vary seasonably in many areas, these variations should be considered in setting a revegetation timetable. For example, seeding could be deferred until seasonal conditions allow for vegetative growth, but mulching for temporary stabilization would be required. Mulches can include organic materials such as straw or wood fiber, stone, matting, or chemical stabilizers.

   Policies for timing revegetation also vary. Delaware selected a 14-day time frame based on its ability to inspect sites approximately every

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two weeks and the frequency of expected rainfall. This policy requires the land developer to pay prompt attention to stabilization once a grading operation has been completed. Also, a number of states, such as Maryland and Delaware, require temporary or permanent stabilization if an area remains exposed and no site work is planned for a period of time.

Sediment Control

Several items could be considered for sediment control:

1. While sediment control is less effective than erosion control, it still must be considered to deal with overland flow. Two common mechanisms used to remove a particle in suspension are filtration and sedimentation. Practices effective for sheet flow include filtration controls such as straw bale dikes and silt fences. Effective lengths of slope prior to the onset of concentrated flow is approximately 100 ft (30.5 m). In general, flow lengths greater than 100 ft should have sedimentation practices such as sediment traps or basins.

2. Interior and perimeter controls are important considerations for sediment controls. A number of jurisdictions will allow a reduction in sizing of perimeter controls if interior controls, such as temporary stabilization of selected areas, traps, or filtration practices, are used. However, since the effectiveness of sedimentation practices rely on detention time, undersizing perimeter sediment controls can prevent adequate functioning of the perimeter trap or basin. These practices must be designed to handle the total expected flow. One effective way to reduce their size is to divert clean water away from the disturbed areas, thereby reducing the expected flow to the control.

3. The size of control practices depends somewhat on a region's rainfall. However, most states use a simple method to compute trap or basin size—they are sized equally—based on a set amount of storage per acre of drainage entering the trap or basin. Since the early 1970s, Maryland's Soil Conservation Service has recommended a volume of 1,806 ft^3 (51.2 m^3) of storage per acre, based on a silt loam soil and a desire to reduce suspended solids by 70 percent.

   Delaware uses a size criterion of 3,600 ft^3 (102 m^3) per acre draining to a control practice. This figure provides peak control of a two-year storm for a disturbed site condition, using predevelopment considerations. It also improves the sediment trapping ability of the control practice. The 3,600 ft^3 per acre size is not considered excessive for urban runoff management regulations and has not proven controversial. Other jurisdictions, like South Carolina, use an individual approach requiring hydrological analysis of each site to achieve a specified treatment level.

   Choosing one approach over another depends on monitoring results and ease of implementation. In general, control strategies and practices should be kept simple—the more complex a program, the more potential for error.

4. When implementing erosion and sediment control, consolidate efforts to reduce total costs. Permanent runoff basins, for example, can easily function to control sediment during construction with several modifications to the outlet structure. When the construction phase is complete, follow these guidelines to ensure an appropriate transition:

   - The sediment basin should be dewatered and the accumulated material spread, stabilized, or otherwise removed from site.
   - The pond bottom should be regraded to design requirements and the outlet structure altered to meet the approved design.
   - The pond area should be stabilized with vegetation runoff. If the runoff pond is a constructed wetland, the plants should be placed after the entire construction site and pond area are stabilized to reduce turbidity and prevent excessive sedimentation within the basin or on the plant community.

Programmatic Considerations

Education

Education may be the single most important program component, especially in light of limited resources. Education should be targeted to specific audiences and prioritized, with initial efforts directed toward the regulated community such as developers and contractors.

Delaware and Maryland require contractors to send a representative to a certification program. The three-and-a-half hour program educates contractors on the need for runoff

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management and their responsibilities under the program. As of 1987, Maryland has certified over 10,000 individuals. Since Delaware's program began in 1991, over 2,000 individuals have been certified. These programs continue to be popular with contractors.

Educational efforts also should be directed at plan designers and plan reviewers, inspectors, and the general public. Educational programs increase the visibility of the sediment control program which, in turn, increases its acceptance by the regulated community and the general public. In a time of diminishing resources, public acceptance often translates into political support to minimize funding reductions.

Staffing

The erosion and sediment control plan should be implemented by a defined program staff. Relying on building plan reviewers and building inspectors to implement the program reduces the program's effectiveness, with the inspection and enforcement component suffering most. Delaware has implemented an innovative approach to inspection and enforcement through its Certified Construction Reviewer (CCR) program.

The state or local plan approval agency may require that the developer provide a CCR to inspect the site weekly and submit an inspection form to the developer, contractor, and the responsible inspection agency. To qualify, the CCR attends a 32-hour training course that covers such topics as water quantity and quality, soils, vegetation, site inspection procedures, and laws and regulations. Upon passing a final examination, the individual receives certification. The CCR must submit accurate, weekly reports but is not required to initiate enforcement action. The public agency must still conduct periodic inspections and initiate enforcement, but the CCR program represents a means to reduce public inspection requirements.

Consistency

A regulatory program requires consistency to be successful. Submission requirements should be based on site conditions, with basic standard items required in every case. Inspection and enforcement requirements should mandate site control implementation and maintenance. Erosion and sediment control requirements should be supported through an effective and consistent enforcement mechanism. Helpful documentation can include check lists for plan review and inspection forms for site review. Above all, a coherent policy of progressive enforcement is essential.

Consistent policy is also necessary for public agency compliance. Expect governmental agencies to resist additional regulatory requirements. A common response is compliance with the intent of the law but not with submission and approval requirements. Field implementation and maintenance of controls will be poor unless all parties agree to accept authority and commitment to implementation.

Recommended Reading

The following resources contain excellent information on erosion and sediment control processes and strategies. They will also provide assistance to jurisdictions considering establishing a design or construction handbook. Most of these documents must be purchased.

Erosion and Sediment Control Planning and Design Manual

North Carolina Department of Natural Resources and Community Development of Land Resources
Land Quality Section
P.O. Box 27687
Raleigh, NC 27611

State of Delaware, Delaware Erosion and Sediment Control Handbook, 1989

Delaware Department of Natural Resources and Environmental Control
Division of Soil and Water Conservation
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

Soil Erosion and Sediment Control Handbook

Rhode Island Resource Conservation and Development Area
5586 Post Road, Box 6
East Greenwich, RI 02818

Erosion and Sediment Control Handbook, 3rd Ed., 1992

Virginia Department of Conservation and Recreation
Division of Soil and Water Conservation
203 Governor Street, Suite 206
Richmond, VA 23219-2094

Stormwater Management Manual for the Puget Sound Basin (Technical Manual)

Department of Ecology
State of Washington
Mail Stop PV-11
Olympia, WA 98504-8711

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CHAPTER 8

Urban Runoff Treatment Practices

Urban runoff management in its broadest and most comprehensive form involves controlling both the quantity and quality of runoff. Control options are commonly called best management practices (BMPs).

Quantity control practices regulate the peak flow rate and sometimes the total volume from precipitation. Water quality control practices prevent the initial release of pollutants into urban runoff, or once they are released, reduce the quantities that enter surface or groundwaters. Completely recapturing released pollutants is impossible, and the expense increases for higher and higher levels of recapture. Prevention is more efficient and cost-effective. This chapter examines the principles of runoff quantity and quality control and details a number of treatment practices.

Control practices are categorized in a number of ways. One system is as follows:

- **Quantity control practices.** Methods of detaining runoff to regulate its rate of release to receiving waters or to infiltrate runoff into the ground so that it does not become surface flow.
- **Management practices.** Ways of doing business to prevent pollutant releases.
- **Source control practices.** Specific actions taken at potential sources to prevent pollutants from contacting precipitation or runoff.
- **Erosion and sediment control practices.** A variety of techniques used to control areas that have been bared from construction in progress or have not been revegetated after construction or other activities.
- **Treatment practices.** Facilities that remove pollutants already in runoff.

These practices are often divided into structural and nonstructural groups. Nonstructural practices mainly embrace preventive actions that do not require building anything, such as management and source control practices. Many erosion and sediment control practices are also preventive, although some—like filter fabric fences and sedimentation ponds—treat runoff containing eroded sediments and involve construction or hardware installation. While quantity control can be nonstructural (e.g., policies to retain natural soil and vegetation cover), it generally involves building a facility such as a detention pond or an infiltration device. Treatment practices are usually structural.

This chapter covers permanent structural quantity control and treatment practices. Chapter 14 provides specific criteria for inspecting these facilities after construction and periodically thereafter to determine maintenance needs. Chapter 12 covers management and source control practices. Erosion and sediment control practices are covered in Chapter 7 and their inspection in Chapter 14.

Structural quantity control and treatment practices can also be grouped in various ways, one of which is the following:

- **Storage practices**
  - Ponds—wet ponds, extended-detention dry ponds, and dry ponds
  - Vaults and tanks
  - Oil separators
- **Vegetative practices**
  - Swales
  - Filter strips
  - Wetlands—natural and constructed
  - Landscape management (i.e., urban forestry)

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- **Infiltration practices**
  - Basins
  - Trenches
  - Perforated pipes
  - French drains
  - Porous pavements
- **Filtration practices**
  - Sand filters
  - Leaf compost filters
  - Catch basin filters (various media)

The ponds, vaults, and tanks under storage practices can benefit quantity control, quality control, or both. However, dry ponds drain too quickly to provide any substantial runoff treatment. Enclosed vaults and tanks are limited in biological activity and are usually too small to function well in water quality control. Therefore, these devices are only effective for quantity control. Wetlands and all infiltration options can also supply quantity and quality control. The remaining practices are largely treatment devices.

In a number of instances, one mode of operation (storage, vegetative treatment, or infiltration) predominates but the practice incorporates other modes. For example, wetlands involve both storage of water and vegetative action. Also, most ponds infiltrate some water unless they are lined.

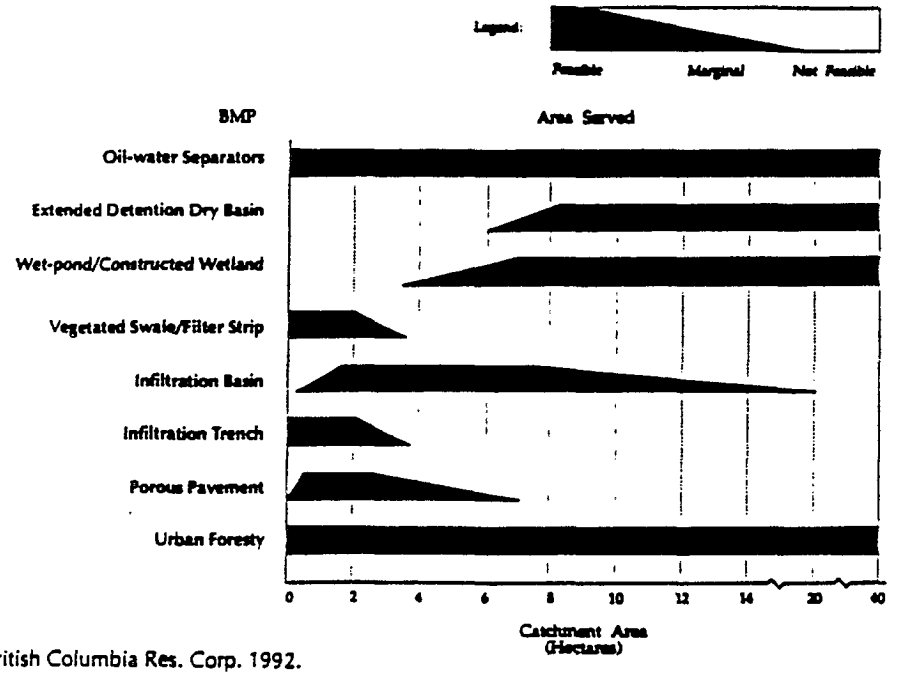
The trend is to combine the capabilities of two or more options by establishing "treatment trains" arranged in series, a strategy discussed at the end of this chapter.

Practice Selection

Success in applying any management practice initially depends on selecting the appropriate option for the site's control objectives and conditions. The objectives must be clearly delineated at the outset and conditions investigated in enough detail to match the practice to the site. Objectives might include whether quantity control, quality control, or both are to be provided; what pollutants are to be treated; and what, if any, side benefits are to be produced. Conditions that determine a practice's relevance include service area, soils, hydrogeologic conditions, and circumstances of the receiving water and nearby properties.

The British Columbia Research Corporation (1992) developed charts that incorporate these considerations, adapting and extending earlier work by Schueler (1987) and the Washington Department of Ecology (1992). Figures 8.1 and 8.2 and Tables 8.1 through 8.4 present these charts as aids in practice screening.

Figure 8.1—Applicability of treatment practices relative to catchment area.



Source: British Columbia Res. Corp. 1992.

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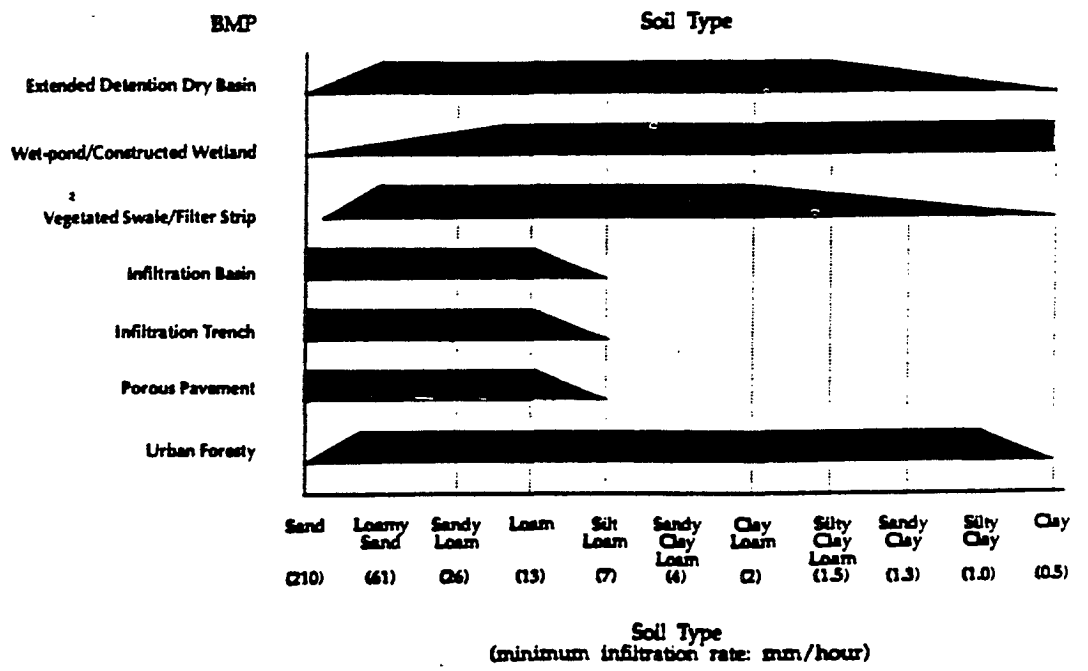
Figure 8.2—Applicability of treatment practices relative to soil type.



Source: British Columbia Res. Corp. 1992.

Table 8.1—Constraints on treatment practices.

BMP	SLOPE	HIGH WATER TABLE	CLOSE TO BEDROCK	PROXIMITY TO FOUNDATIONS	SPACE CONSUMPTION	MAXIMUM DEPTH LIMITATION	HIGH SEDIMENT INPUT	THERMAL IMPACTS
Oil-water separator	●	●	■	■	●	○	○	●
Extended detention dry basin	●	●	■	●	○	●	■	●
Wet pond / Constructed wetland	●	●	■	●	○	○	■	○
Vegetated swale	■	○	■	■	●	●	○	●
Vegetated filter strip	■	■	■	■	●	●	○	●
Infiltration basin	■	○	○	■	■	○	○	●
Infiltration trench	○	○	○	○	●	○	○	●
Porous pavement	○	○	○	○	○	○	○	●
Urban forestry	●	■	●	■	●	●	●	●

● Generally not a restriction.
■ Can be overcome with careful site design.
○ May preclude the use of a BMP.

Source: British Columbia Res. Corp. 1992.

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Table 8.2—Comparative quantity control benefits provided by water quality control practices.

BMP	PEAK DISCHARGE CONTROL			VOLUME CONTROL	GROUNDWATER RECHARGE/LOW FLOW MAINTENANCE	STREAMBANK EROSION CONTROL
	2-YEAR STORM	10-YEAR STORM	100-YEAR STORM			
Oil-water separator	○	○	○	○	○	○
Extended detention dry basin	●	●	●	○	○	●
Wet pond	●	●	●	○	○	●
Constructed wetland	●	●	●	■	■	●
Vegetated swale / Filter strip / Urban forestry	■	○	○	■	■	○
Full infiltration basin	●	■	○	●	●	●
Combined infiltration-detention basin	●	●	●	●	●	●
Off-line infiltration basin	○	○	○	●	●	●
Full infiltration trench / Porous pavement	●	■	○	●	●	●

● Usually provided.
■ Sometimes provided with careful design.
○ Seldom or never provided.

Source: British Columbia Res. Corp. 1992.

Table 8.3—Potential pollutant removal effectiveness of treatment practices.

BMP	CONTAMINANT						
	SUSPENDED SOLIDS	OXYGEN DEMAND	TOTAL LEAD	TOTAL ZINC	TOTAL PHOSPHORUS	TOTAL NITROGEN	BACTERIA
Oil-water separator	○	◆	◆	◆	◆	◆	◆
Extended detention dry basin	●	■	●	■	■	○	◆
Wet pond	●	■*	●	■	■*	○*	◆
Constructed wetland	●	●*	●	●	●*	●*	◆
Vegetated swale	●	○	●	■	○	○	◆
6 meter-wide turf filter strip	○	○	○	○	○	○	◆
30 meter-wide forested filter strip	●	●	●	●	■	■	◆
Infiltration practices	●	●	●	●	●	■	●

● High potential for removal.
■ Moderate potential for removal.
○ Low potential for removal.
◆ Insufficient knowledge.
* May be subject to exports of nutrient-enriched and deoxygenated water.

Source: British Columbia Res. Corp. 1992.

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Table 8.4—Potential auxiliary benefits of treatment practices.

BMP	AQUATIC HABITAT CREATION	WILDLIFE HABITAT CREATION	NO TEMPERATURE INCREASE	LANDSCAPE ENHANCEMENT & AESTHETICS	RECREATIONAL BENEFITS	PUBLIC SAFETY	COMMUNITY ACCEPTANCE
Oil-water separator	O	O	●	O	O	●	●
Extended detention dry basin	O	●	●	■	■	■	■
Wet pond	●	●	O	●	●	■	●
Constructed wetland	●	●	O	■	■	■	■
Vegetated swale	■	■	■	■	O	●	●
Vegetated filter strip	O	●	●	■	■	●	●
Infiltration basin	O	●	●	■	■	●	■
Infiltration trench	O	O	●	O	O	●	●
Porous pavement	O	O	●	O	O	●	●
Urban forestry	O	●	●	●	■	●	●

● Usually provided.
■ Sometimes provided with design modifications.
O Seldom provided.

Source: British Columbia Res. Corp. 1992.

The recently issued California Storm Water Best Management Practice Handbooks (Camp, Dresser, McKee et al. 1993) refined the process of practice selection further with several recommendations (Municipal Handbook, Section 3), one of which was the following evaluation criteria:

- Ability to meet regulatory requirements;
- Effectiveness in pollutant reduction;
- Public acceptance;
- Ability to be implemented;
- Institutional constraints; and
- Cost.

The handbook recommends assigning a rank of 1 to 5 to each practice for each criterion. Each criterion can be weighted differently by assigning a weighting multiplier.

Principles of Runoff Quantity Control

Purpose and Goals

Controlling runoff quantities is important because, as discussed in Chapter 3, hydrologic change can produce extensive ecological impacts in small-scale aquatic systems where much valuable habitat for fish and other biota is located. The possible role of hydrologic changes in degrading valued salmon resources and recent flooding have stimulated efforts to improve quantity control programs and facilities, especially in the Pacific Northwest.

This chapter does not fully discuss design for quantity control, but it does present the key principles that should be applied. These principles are currently being integrated into some of the older runoff management manuals developed in the Northwest. New versions of manuals by Washington Department of Ecology (1992) and King County Surface Water Management Division (1990) will likely integrate these principles. Several texts present the current state of the art in some detail, including Bedient and Huber (1988), Urbonas and Stahre (1993), Wanielista (1990), and Wanielista and Yousef (1993).

The goal of quantity control in runoff system design is to maintain the predevelopment hydrograph—the maximum runoff rate, dynamics, and total volume—after a change in the watershed. This means replacing the depression and below-ground storage removed or bypassed in development. Maintaining the predevelopment hydrograph requires replacing all of the lost depression and soil storage. This is done only through extensive new infiltration opportunities or with large

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detention volumes that hold water while the slow processes of evaporation and infiltration operate. Matching predevelopment peak rate alone means recovering one-third to two-thirds of the lost storage. Even this less restrictive criterion generally requires much larger detention volumes than customarily demanded in existing regulations.

Analysis and Control

Effective runoff quantity control depends on substantial hydrologic analysis, only now being established. The analysis depends on

- Obtaining and properly using precipitation records for the place and time to be controlled;
- Good estimates of peak runoff flow rates and volumes of critical conditions;
- Relating water movement through and beyond the quantity control device with the effect of temporary storage in the device ("routing"); and
- Using this information to set the size of the storage volume and design the outlet structure, which controls the release rate.

The first two steps pose difficult problems. Precipitation records generally lack geographic coverage, length, frequency of recording, and accuracy. Two options to estimate peak runoff are to use models based on selected precipitation events (e.g., the 25-year frequency, 12-hour duration rainfall) or a computerized continuous simulation model.

Excluding the rational method—which is completely inadequate for this purpose—the most common event-based models are the USDA SCS' curve number method and its derivatives. These models have several liabilities, such as the arbitrariness of the selected events. Because they have no way to represent depression and soil storage of runoff, they tend to overpredict the peak runoff rate before development occurs, when the storage potential is significant. Consequently, while the objective is to match the predevelopment rate, the target is set too high. To compensate for this shortcoming, base the design on a selection of events or apply a safety factor to flow rate or storage volume size and discharge rate estimates.

Another problem with event-based models is their inability to deal with unpredictable storm dynamics. If a second storm arrives before the first one drains, the facility could overflow. To compensate for this fault, select as the basis events of longer duration and some of the less frequent, larger events. In the Pacific Northwest where winter rains are frequent and prolonged, the solution is to use a seven-day event duration, which produces larger storage facilities.

Continuous simulation models—EPA's Storm Water Management Model (SWMM) or Hydrologic Simulation Program-Fortran (HSPF)—have some important advantages over event-based models. These computer models consider such complexities as soil storage and infiltration. Given sufficient input data and proper use, they can simulate a range of conditions spanning many years—critical conditions like rain-on-snow and closely spaced storms that could cause a basin to overflow. On the other hand, these models require more and better precipitation data than are often available; additional data to represent soils, topography, and vegetation; and considerable expertise.

The Pacific Northwest is also developing "runoff files" for the HSPF model. Runoff files are unit area hydrographs for limiting precipitation conditions and site characteristics. The user merely specifies those characteristics and the location. A routing routine provides pond size and release rate.

Another Northwest strategy deals with the potential impacts of greater total volumes caused by development, even if peak rates do not increase. As pointed out previously, real volume control can result only from replacing lost depression and soil storage. However, limiting peak flow to a rate lower than before development can at least partially compensate for the additional stress on stream channels from extra volume. One possibility is to limit the two-year peak release rate after development to half of the predevelopment peak release rate associated with the two-year, 24-hour event.

Treatment Practices

Pollution Removal Mechanisms

To properly specify, design, and operate treatment practices, one needs to understand the mechanisms that can operate to prevent pollutants from entering receiving waters. Table 8.5 lists all the principal mechanisms that can capture, hold, and transform various classes of contaminants in

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urban runoff and the factors that promote the operation of each mechanism to improve water quality.

A factor to consider in the functioning of all mechanisms is time. The effectiveness of settling a solid particle is directly related to the time provided to complete sedimentation at the particle's characteristic settling velocity. Time is also a crucial variable to determine the degree that chemical and biological mechanisms operate. Characteristic rates of chemical reactions and biologically mediated processes must be recognized to obtain treatment benefits. For all of these reasons, water residence time is the most basic variable to apply effective treatment practice technology.

The information in Table 8.5 can also be arranged by features that promote specific pollutant control objectives. The following features fulfill the most common objectives:

- **Features that help achieve any objective**
  - Increasing hydraulic residence time
  - Low turbulence
  - Fine, dense herbaceous plants
  - Medium-fine textured soil
- **Features that help achieve specific objectives**
  - Phosphorus control
    - High soil exchangeable aluminum and/or iron content
    - Addition of precipitating agents
  - Nitrogen control
    - Alternating aerobic and anaerobic conditions
    - Low toxicants
    - Circumneutral pH
- **Metals control**
  - High soil organic content

Table 8.5—Summary of pollutant removal mechanisms.

MECHANISM	POLLUTANTS AFFECTED	PROMOTED BY
Physical sedimentation	Solids, BOD, pathogens; particulate COD, P, N, metals, synthetic organics	Low turbulence
Filtration	Same as sedimentation	Fine, dense herbaceous plants; constructed filters
Soil incorporation	All	Medium-fine texture
Chemical precipitation	Dissolved P, metals	High alkalinity
Adsorption	Dissolved P, metals, synthetic organics	High soil Al, Fe high soil organics (met.); circumneutral pH
Ion exchange	Dissolved metals	High soil cation exchange capacity
Oxidation	COD, petroleum hydrocarbons, synthetic organics	Aerobic conditions
Photolysis	Same as oxidation	High light
Volatilization	Volatile petroleum hydrocarbons and synthetic organics	High temperature and air movement
Biological microbial decomposition	BOD, COD, petroleum hydrocarbons, synthetic organics	High plant surface area and soil organics
Plant uptake and metabolism	P, N, metals	High plant activity and surface area
Natural die-off	Pathogens	Plant excretions
Nitrification	NH_3-N	Dissolved oxygen > 2 mg/L, low toxicants, temperature > 5-7°C, circumneutral pH
Denitrification	NO_3+NO_2-N	Anaerobic, low toxicants, temperature > 15°C

Source: R.R. Horner.

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High soil cation exchange capacity
Circumneutral pH

- **Organics control**
  - Aerobic conditions
  - High light
  - High soil organic content
  - Low toxicants
  - Circumneutral pH

These features differ in what degree of control the treatment system designer and operator have over the operation. Fortunately, several features that promote all favorable mechanisms (possibly excluding the soil) are under a high degree of control. Features that promote more specific objectives require more intervention, such as developing some desired soil condition.

Sources of Detailed Information

The main treatment practices, the principles that govern their operation, and the primary design considerations are featured in a number of government manuals and other texts. These sources are valuable in planning, design, plan review, construction, and operational activities. The primary reference, however, should be the manual of the jurisdiction where the site is located. In addition to the material presented in this chapter and the listed sources, Chapter 14 includes inspection checklists and diagrams that provide details on design configurations and operations.

Storage Practices

Wet Ponds

Ponds reduce runoff pollutants by settling solids and allowing a variety of physical, chemical, and biological mechanisms to capture or transform dissolved pollutants. Settlement of fine solids and the soluble pollutant removal mechanisms all require time in quiescent or pool storage—from several days to as many as three weeks for maximum performance. Therefore, wet ponds, which have a permanent storage pool, offer substantially greater treatment advantages than ponds that dry out between storms. Unless they are lined, most ponds infiltrate some water to the soil and are often referred to as retention/detention ponds.

Figure 14.9 illustrates a typical wet pond, showing a number of the design recommendations discussed in the following paragraphs.

Sizing Calculations and Expected Performance. Unlike in the design of wastewater treatment plants, knowledge is insufficient as yet to design runoff ponds to obtain a specific level of treatment. However, EPA's Nationwide Urban Runoff Program (NURP) included a comprehensive investigation of pond design and associated performance at 13 locations. The investigation concluded that performance could best be related statistically to the "volume ratio." This is the ratio of pool storage volume to "mean storm volume," a statistical measure expressing the runoff volume associated with the long-term average rain storm quantity (U.S. Environ. Prot. Agency, 1986).

EPA produced total suspended solids removal curves for different climatological regions. Figure 8.3, for example, shows the curve for all of the United States east of the 96th meridian, approximately along the western Minnesota border. Reductions of other pollutants were related to total suspended solids (TSS), as illustrated in Figure 8.4. Generally, a volume ratio of about 2.5 is necessary to achieve 75 percent TSS reduction, where corresponding phosphorus removal is approximately 50 percent. Each incremental increase of the ratio above 2.5 yields decreasing benefits, reflecting the fact that the pollutants easiest to capture are removed first. The results indicate that pollutants with significant amounts in dissolved forms cannot be reduced by more than 50 to 60 percent in a wet pond.

In the phosphorus example, reduction of 60 percent is approached only as the volume ratio grows toward 5. Ponds of this size generally provide two to three weeks of pool storage hydraulic residence time and consume 3 to 7 percent of the contributing catchment, depending on impervious area, slopes, rainfall characteristics, and other factors (Walker, 1987; Hartigan, 1989; Kulzer, 1989). Further improvement in phosphorus removal can be achieved in several ways, although all have practical limitations (Walker, 1987). They include

- Deepening the pond, although a practical limit of perhaps 2.5 m (about 8 ft) is imposed by the possibility that the bottom waters may become anaerobic;
- Infiltrating more water;
- Enhancing the plug-flow characteristics by design features;
- Installing certain aquatic plants, perhaps coupled with regular harvesting; or
- Chemical treatment.

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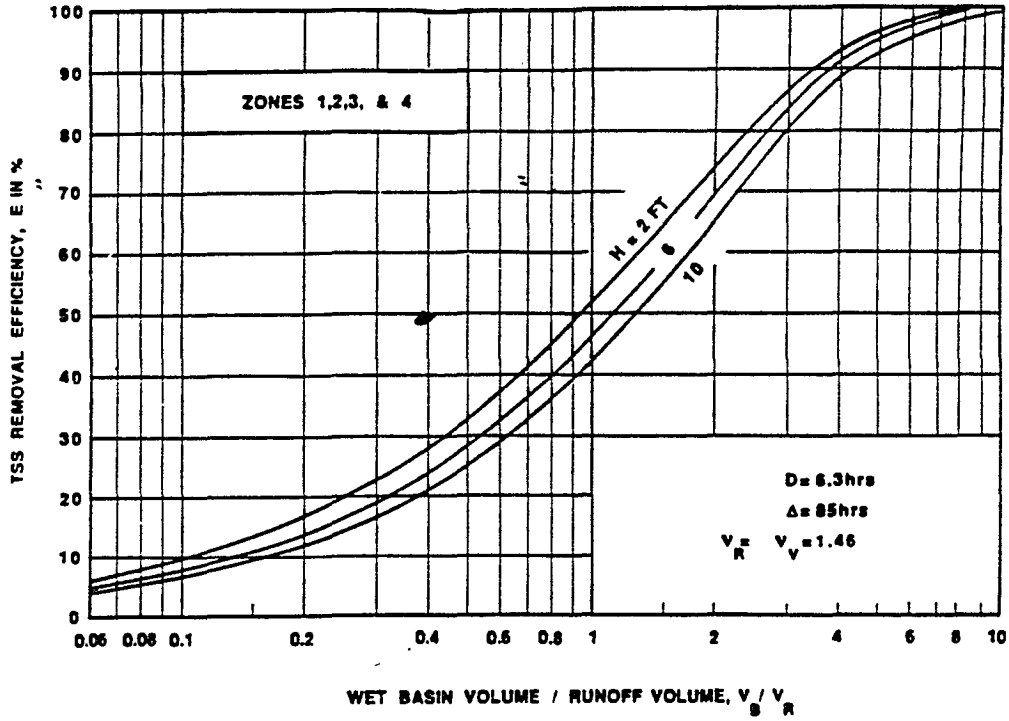
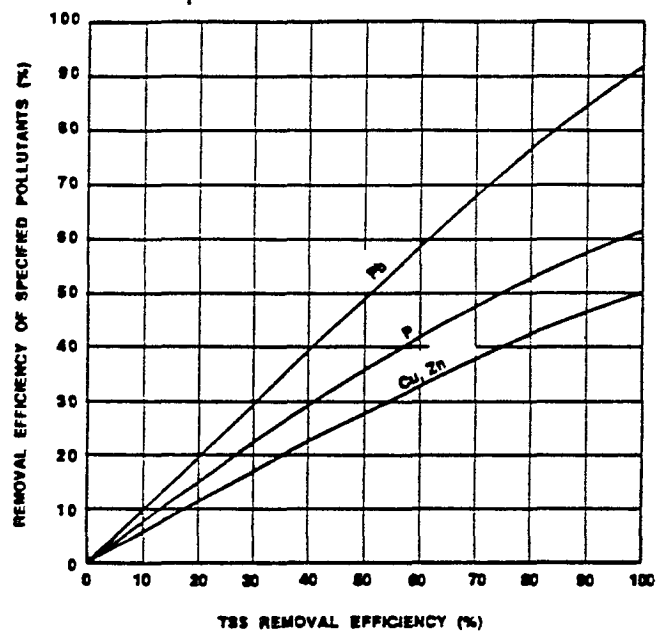
Figure 8.3—Total suspended solids (TSS) reduction curves for wet ponds in the United States east of the 96th meridian.



Source: Dorman et al. 1988.

Figure 8.4—Reductions of lead (Pb), phosphorus (P), copper (Cu), and zinc (Zn) in relation to total suspended solids (TSS) reduction in wet pond.



Source: Dorman et al. 1988.

A number of agencies have adopted the NURP pond guidelines as a design basis, including the Metropolitan Washington Council of Governments (Schueler, 1987), the Federal Highway Administration (Dorman et al. 1988), and the state of California (Camp, Dresser, McKee et al. 1993). The guidelines help set performance objectives for pollutants of interest and calculate the pool storage volume from the graph and climatological statistics for the region to reach those objectives.

Other agencies have specified either a certain runoff quantity or a precipitation event as the design basis. For example, treating the first 1 in (2.5 cm) of runoff provides treatment to most storms and total runoff volume in an average year. The Washington Department of Ecology (1992) selected the six-month, 24-hour rainfall event as the "water quality design storm." The treatment system (the pool storage in a wet pond) should provide sufficient volume to hold runoff from this storm. In Seattle, this event produces about 1.2 in (3.05 cm) of rain. With a mean rain storm of 0.48 in (1.22 cm) at this location, the NURP volume ratio is thus approximately 2.5 for any runoff coefficient.

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Design Recommendations. Better performance can be expected by enlarging the surface area to gain volume as opposed to deepening the pond. A large surface area-to-volume ratio shortens the solids' settling distance and allows better aeration and light penetration to promote biological pollutant removal mechanisms.

Other design features are also important to performance. Features that reduce the tendency of water to short circuit, which raises actual hydraulic residence times toward the theoretical values, include the following (Schueler, 1987; Horner et al. 1989; Kulzer, 1989):

- Two or more distinct cells to promote plug flow;
- Effective length-to-width ratio of at least 5:1, preferably, and at least 3:1 at a minimum;
- Inlet and outlet remote from each other or shielded by baffling;
- Low inlet velocity;
- Uniform flow distribution across the inlet pond; and
- Discharging water with minimum turbulence from mid-depth rather than near the bed or surface.

Other safety features that should be incorporated in wet pond designs include the following:

- Side slopes of at least three horizontal to one vertical;
- An emergency overflow weir stabilized to avoid erosion and possible failure during high flow;
- A shallow "safety bench" at least 10 ft (3 m) wide at the toe of the slope surrounding the perimeter;
- A buffer planted to discourage young children from approaching the pond;
- An outlet structure placed out of reach to children; and
- Fencing to protect children from any remaining dangerous areas.

Extended-Detention Dry Ponds

With insufficient time to operate dissolved pollutant removal mechanisms, sedimentation is the main means to reduce pollutants in extended-detention basins. This method is especially good for capturing solids or other contaminants connected with particulates. In fact, Kuo et al. (1988) showed that extended detention was more cost-effective compared to dry or wet ponds or infiltration. This practice can also be the best choice where water is insufficient or too unreliable to sustain a wet pond or constructed wetland.

Sizing Calculations and Expected Performance. Like wet ponds, extended-detention dry ponds are usually sized to capture a particular fraction of the runoff. In addition, this type of pond drains within a set period when filled with the design runoff volume, typically 24 to 40 hours.

Four NURP extended-detention ponds in Washington, D.C., with detention times of four to 18 hours offered at least 70 percent TSS removals with at least six hours of detention, and long-term total phosphorus reductions ranging from 13 to 56 percent (Schueler and Helfrich, 1989). Based on these somewhat conflicting results, Schueler (1987) estimated the upper limit of possible phosphorus reduction at 40 to 50 percent after 48 hours. Others, however, view the reliable efficiency to be much lower, perhaps 20 to 33 percent (Gibb et al. 1991). Schueler et al. (1992) now appear to agree with that assessment, quoting 10 to 30 percent. Stahre and Urbonas (1990) analyzed the available estimates of long-term efficiencies for various pollutants with a 40-hour detention time, as follows:

TSS	50 to 70%
chemical oxygen demand	20 to 40%
total phosphorus and total nitrogen	10 to 20%
lead	75 to 90%
zinc	30 to 60%
hydrocarbons	50 to 70%
bacteria	50 to 90%

Design Recommendations. Extended-detention pond performance generally benefits from the same design features as wet ponds to prevent short circuiting. Schueler (1987) recommends incorporating the removal capabilities of plants by managing part of the basin as a shallow wetland. Schueler and Helfrich (1989) suggest an extended-detention wet pond, with a relatively small permanent pool that expands temporarily.

Oil Separators

Oil separators, devices that separate dispersed oil and water, are limited to capturing free or unemulsified oil. The two basic types are the Ameri-

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can Petroleum Institute (API) separator and the coalescing plate (CP) separator. The API separator is a baffled tank that separates large volumes of free oil. The CP device separates free oil in much smaller volumes because it provides a large surface area for oil collected by the corrugated plate pack. Various spill-control devices are sometimes included in this type of treatment practice. The unit is used to catch small spills—it is not capable of separating dispersed oil. Figure 8.14 illustrates three oil separators.

API and CP separators were developed for industrial wastewater treatment. This wastewater is generally much higher in oil than most urban runoff, flow rates are more uniform, and the unit can get more operator attention. The separators are best used when discharge concentrations of oil and grease are higher than usually measured in general urban runoff. These concentrations are usually below 20 mg/L—often far below, unless an oil spill has occurred. Even the best CP separators cannot reduce concentrations below 10 mg/L, however. Therefore, these devices should be used mainly where petroleum products are handled, where vehicle traffic is heavy (e.g., trucking bases), and possibly where automobiles frequently come and go (expanding and contracting engine seals leak more oil than when engines run continuously). Otherwise, vegetated treatments can handle the usual relatively low concentrations. Spill control units should be installed anywhere slugs of oil could enter runoff, including residential areas where individual automotive maintenance is common.

▮ ***Sizing Calculations and Expected Performance.*** Following are procedures to size the two basic types of separators:

API SEPARATOR

1. Find oil drop rising velocity (V_p, cm/s):

$$V_p = (G/18 \cdot \mu) \cdot (d_p - d_c)D^2 \qquad [1]$$

where: μ = Dynamic viscosity of oil at coldest service temperature (use 0.015 poise at 5°C if no other information is available);

$d_p - d_c$ = Density difference between oil and water (use 0.1 g/cc if no other information is available);

D = Oil drop diameter (use 0.006 cm if no other information is available).

Convert V_p to ft/s by dividing by 30.48 cm/ft.

2. Find depth (d, ft):

$$d = (60 \cdot Q/2 \cdot V_h)^{0.5} \qquad [2]$$

where: Q = Design flow rate (cfs);

V_h = Horizontal velocity (3 ft/min or 15 times V_p, whichever is smaller; 0.5 ft/min is recommended if no other information is available).

Recommended range = 2 to 8 ft.

3. Set width in the range 2 to 3.33 times the depth.

Recommended range = 4 to 16 ft.

4. Find length (L, ft):

$$L = (d/V_p) \cdot V_h \qquad [3]$$

where: V_p = 0.033 ft/min is recommended if no other information is available.

5. Set baffle height-to-depth ratios at 0.85 for top baffles and 0.2 for bottom baffles.

CP SEPARATOR

1. Find V_p as above.
2. Find effective separation area = Q/V_p.
3. Select a unit from a manufacturer's catalog that provides at least the needed effective separation area.

A CP separator is theoretically capable of capturing free oil droplets down to 5 μm in diameter, although that performance requires a large unit. In contrast, the API type is practically limited to removing drops with diameters no smaller than 150 μm. How each reduces concentration depends on oil characteristics. CP separators can generally produce an effluent in runoff having no more than 10 mg/L oil and grease.

▮ ***Design Recommendations.*** A CP separator is marketed both with plates horizontal and at an angle. Angled plates are less prone to clogging by solids. The normal placement is 45 to 60 degrees from horizontal. Plates should be closely spaced to minimize oil rise distance without confining the flow so much as to raise velocity to a high level and create excessive turbulence; 3/4 in (1.90 cm) is a common spacing. Specific recommendations to improve success with API and CP units are the following:

- Exclude runoff from roofs and other areas not likely to contain oil;
- Place any pump being used downstream so as to prevent mechanical emulsification;

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- Avoid detergent use upstream to prevent chemical emulsification;
- Provide a forebay sized at 20 ft^2 (1.86 m^2) of surface area per 10,000 ft^2 (929.0 m^2) of drainage area; and
- Provide an afterbay in which to place absorbents.

Vegetative Practices

Swales and Filter Strips

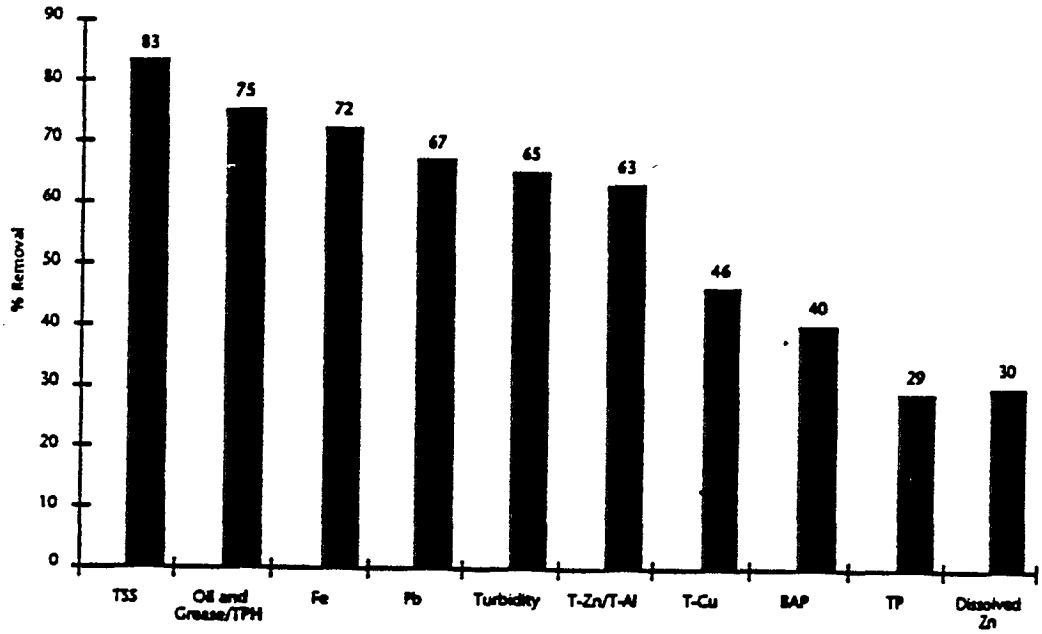
Treatment practices that use terrestrial grasses and other fine herbaceous plants are sometimes called biofiltration. These plants can be installed in a channel in which water flows at some depth—a swale—or on a broad surface area that has sheet flow—a filter strip. Biofilters can also have wetland plants in areas with the hydrology to sustain them.

A vegetated treatment strives for a plant stand that serves as a good filter. Ideal characteristics are dense, uniform growth of fine-stemmed plants tolerant of the area's water and climatological, soil, and pest conditions. Native plants generally combine the best properties. Plants serve mainly as filters; pollutant uptake is not a very important removal mechanism. Therefore, a number of species and mixes appropriate to the area will work equally well.

Sizing Calculations and Expected Performance. The results of a performance investigation of a grass swale, recently completed in the Puget Sound area of Washington (Municipality Metro. Seattle, 1992), refined a previously developed design procedure and recommended design features consistent with good performance. The report details the full design procedure, criteria, and guidelines that are excerpted here.

Figure 8.5, which summarizes the performance results, shows that the swale was relatively effective in capturing solids, oils, and the least soluble metals. The swale was less effective for more soluble metals, especially their dissolved fractions, and less yet for phosphorus. Nitrogen (not shown) exhibited little if any removal; fecal coliform's capture was inconsistent. Therefore, biofilters should generally be considered the sole

Figure 8.5—Average pollutant removal over six storms in a grass swale with an average hydraulic residence time of nine minutes.



TPH = total petroleum hydrocarbons
T = total
BAP = biologically available phosphorus

Source: Municipality of Metro. Seattle, 1992.

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treatment only to reduce solids and oil. In fact, they are a better choice than oil separators to remove low concentrations of oil and grease from urban runoff. Vegetation can reduce concentrations to even lower levels, while no feasible separator can decrease them below 10 mg/L. The vegetation option is also much cheaper. One theory suggests that biofilters reduce nutrients considerably better if growth is carefully mowed and removed before it dies and releases phosphorus and nitrogen; however, that hypothesis is unproven.

The design procedure uses Manning's equation of open channel flow to obtain a swale width for a given flow and slope and selected water depth. The velocity resulting in this size channel is then compared to a criterion, and the length is calculated using a hydraulic residence time criterion. A key study result is that a residence time of nine minutes is needed to achieve the highest and most reliable performance. Performance began to deteriorate noticeably when residence time fell below five minutes, recommended as the absolute minimum. A filter strip design is handled in the same general way but with a more shallow flow depth. Steps are as follows:

1. Determine the design flow rate (Q, cfs) by appropriate hydrologic analysis. Use as a basis continuous simulation with a computer model, a design rainfall event (e.g., six-month, 24-hour storm), or a set fraction of total runoff (e.g., first inch).

2. Determine slope (s, ft/ft) and select vegetation, design vegetation height, and shape if a swale. Normally, swales are parabolic or trapezoidal to avoid erosion in sharp corners of rectangular or V shapes. The trapezoidal shape is easier to construct and will tend to assume a parabolic shape over time.

3. Set design flow depth (y, ft). A grass swale's depth should not exceed one-third of the grass height in infrequently mowed swales, or one-half of the grass height in regularly mowed swales, up to a maximum of 3 in (7.62 cm). In swales with wetlands vegetation, the depth should be at least 2 in (5.08 cm) below the height of the shortest species. A filter strip's depth should be no more than 0.5 in (1.27 cm).

4. Solve Manning's equation for the width, using the conditions established in steps 1 through 3.

$$Q = 1.49 \cdot A \cdot R^{0.67} \cdot s^{0.5}/n \qquad [4]$$

where: A = cross-sectional area (ft^2);
R = Hydraulic radius (ft) = A/wetted perimeter;
n = Manning's roughness coefficient.

The Puget Sound study used experiments to determine a value of n for flow below the full height of a local common grass mix. The recommended values are, unless other information is available, 0.20 in (0.5 cm) for grass biofilters to be mowed regularly and those with herbaceous wetland plants and 0.24 in (0.6 cm) for infrequently mowed swales.

Solutions of Manning's equation for two configurations follow:

TRAPEZOIDAL SWALE

$$b = Q \cdot (n/1.49) \cdot y^{1.67} \cdot s^{0.5} - Z \cdot y \qquad [5]$$

$$T = b + 2 \cdot y \cdot Z \qquad [6]$$

FILTER STRIP

$$T = Q \cdot (n/1.49) \cdot y^{1.67} \cdot s^{0.5} \qquad [7]$$

where: T = Top width (ft);
b = Bottom width (ft);
Z = Side slope (ft/ft; should be no steeper than 3 horizontal to 1 vertical).

The bottom width of a swale should be no less than 2 ft (0.61 m) if it will be mowed and no more than 8 ft (2.44 m), unless it will be hand finished to get a completely level bottom. If b does not fit into this range, investigate how Q can be reduced by splitting flow, or set b = 8 ft (2.44 m) and proceed with the analysis, or specify hand finishing.

5. Compute A for the configuration:

TRAPEZOIDAL SWALE

$$A = b \cdot y + Z \cdot y^2 \qquad [8]$$

FILTER STRIP

$$A = T \cdot y \qquad [9]$$

6. Find flow velocity (V, ft/s): V = Q/A. If V is greater than 0.9 ft/s, which will knock over most grass and reduce settling of finer particles, investigate how Q can be reduced, or change the width and/or depth.

7. Compute length (L, ft):

$$L = V \cdot t \cdot 60 \text{ s/min} \qquad [10]$$

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where: t = Hydraulic residence time (min); t should be at least nine min, preferably, and no less than five min.

For swales, L should be at least 100 ft (30.38 m), a length below which flow short circuiting is more likely. If the length in a straight configuration cannot be fit to the site, investigate using a wide-radius curved path, reducing Q or changing the width and/or depth.

8. If flows larger than Q can enter the biofilter, the grass probably will be knocked over and provide no treatment until it becomes upright again. Therefore, flow regulation upstream or a bypass are recommended. If one of these measures is not provided, the velocity and depth with the largest flow rate must be calculated. If the velocity is above a level known to be erosive, the facility must be enlarged to accommodate it (use 3 ft/s maximum, if other information is lacking). The calculation procedure is standard and covered in open channel discussions in fluid mechanics texts, as well as in the previously cited report.

9. If the biofilter is a swale, once the maximum possible depth of flow is established, specify the swale's final depth. It should be at least 6 in (15.24 cm) deeper than the maximum possible flow depth.

▮ *Design Recommendations.* The following features maximize the success in establishing biofilters and in their performance:

- Locate the biofilter away from building and tree shadows to avoid poor plant growth from lack of sunlight.
- If the longitudinal slope is less than 2 percent or the water table can reach the root zone of vegetation, plant water-resistant vegetation to survive standing water or install an underdrain system to assist drainage. However, underdrains may not be practical with a large filter strip.
- If the longitudinal slope is in the 4 to 6 percent range, provide check dams approximately every 50 to 100 ft (15.24 to 30.48 m) to reduce velocity. However, check dams may not be practical on a larger filter strip.
- If the slope on which a swale is installed exceeds 6 percent, place swale to traverse the slope so that no slopes reach more than 4 percent, or 6 percent with check dams.
- Make the lateral slope entirely uniform to avoid any tendency for the flow to channelize.
- Introduce the flow so that entrance velocity is dissipated quickly, flow is distributed uniformly, and erosion is avoided (e.g., by using a riprap pad or some means of level spreading).

Natural Wetlands

Wetlands naturally regulate both water quality and quantity. In recent years, natural wetlands have been used for both purposes, sometimes with engineering changes such as modified inflow and outlet structures. This practice has been legally uncertain, since wetlands are classified as "waters of the United States" under the Clean Water Act (CWA). Using such waters to transport and treat waste is generally prohibited. However, some interpretations of the CWA allow the practice under limited circumstances. EPA's policy is not to use natural wetlands to treat urban runoff. Of course, wetlands treat water by default when they happen to receive runoff from an urbanized watershed.

Therefore, some attention has been paid to managing wetlands receiving urban runoff to learn how negative impacts can be avoided or minimized. The Puget Sound Wetlands and Stormwater Management Research Program is a long-term (1986-1996) comprehensive effort to follow ecological developments in wetlands through the urbanization process and learn what causes degradation and how it might be avoided. The program has produced preliminary management guidelines (King County Resour. Plann. Sec. 1993), with continued refinement as more information becomes available. The following summary excerpts key guideline provisions. Specifics pertain to freshwater-palustrine wetlands in the Pacific Northwest, but these limits would likely be appropriate in similar communities.

▮ *Management Guidelines.* Hallmarks are to

- Manage on a watershed or subbasin scale and context, so that the values of all water resources are considered and all alternatives for solving water quality and quantity problems are evaluated.
- Emphasize practices, such as source controls, that prevent the development of problems. Back up those approaches with measures that reduce the effects of problems before wetlands or other water

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resources are involved, such as pretreatments.

The guidelines are presented here as an example of a state strategy for managing wetlands. The guidelines, consistent with legal interpretations made by EPA Region 10 and the Washington Department of Ecology, state the conditions under which natural wetlands can be used for improving runoff quality:

- Situations must be analyzed case by case;
- Restoration or enhancement of a previously degraded wetland is warranted, and other wetland functions can be upgraded along with benefiting runoff water quality;
- Source control and treatment practices are applied in accordance with specific guideline recommendations, and any prevailing water quality standards are met; and
- The wetland is not one of certain rare or otherwise valuable types—estuarine, forested, peatland, or otherwise designated by recognized heritage and preservation programs—and does not provide habitat for rare, threatened, or endangered species.

The law is even less clear about the status of wetlands proposed for use only for runoff storage or incidentally affected by urban runoff. Of course, since all runoff contains contaminants, any distinction is artificial. Still, potential hydrologic effects are distinct from water quality impacts. In fact, the Puget Sound research has found that hydrologic change has more implications than water quality for wetland ecosystems where runoff is relatively low in pollutants. This program has devoted considerable effort to quantifying these hydrologic impacts—keying especially on plant and amphibian communities—and devising guidelines to overcome them. The following hydrologic guidelines specify limits on the wetland's hydroperiod—the depth (stage), frequency, duration, and pattern of inundation.

1. Depth limits—all wetlands, all year

Limit postdevelopment increase in annual maximum depth to 11.81 in (30 cm) (for 1.01-to-100-year return interval rainfall events).

Limit postdevelopment average monthly water level fluctuation (WLF) to

- An increase of 1.97 in (5 cm) if predevelopment WLF is greater than or equal to 5.9 in (15 cm);
- A maximum of 7.9 in (20 cm) if predevelopment WLF is less than 5.9 in (15 cm).

Note: WLF = Maximum depth – average depth in a time period.

2. Frequency and duration limits

These guidelines envision a fluctuating stage over time before development that could fluctuate more, both higher and lower; after development, these greater fluctuations are called "excursions." The guidelines set limits on the amount of the excursions and the total time, over one or more episodes, that can occur in a given period.

All wetlands—February 1 – May 31

- Limit postdevelopment stage excursions of up to 3.14 in (8 cm) above the predevelopment stage to a total duration of 24 hours in any 30-day period.

All wetlands—June 1 – September 30

- Limit postdevelopment stage excursions above or below the predevelopment stage to no more than 11.81 in (30 cm).
- Limit postdevelopment stage excursions of up to 5.9 in (15 cm) above or below the predevelopment stage to a total duration of 72 hours in any 30-day period.
- Limit postdevelopment increase or decrease in dry period—when pools dry down to the soil surface everywhere in the wetland—to two weeks.

Peat wetlands—bogs and fens (as more specifically defined by the Washington Department of Ecology)

- Limit postdevelopment stage excursions above the predevelopment stage of any amount to no more than once a year.
- Limit postdevelopment stage excursions of up to 5.9 in (15 cm) above or below the predevelopment stage to a total duration of 24 hours.

Forested wetlands and zones—wetlands or zones with at least 30 percent cover of trees at least 20 ft (6.1 m) tall

- Limit postdevelopment stage excursions of up to 7.9 in (20 cm) above the predevelopment stage to a total duration of 48 hours in any seven-day

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period during March 1 to May 31 and to 96 hours over the full growing season, March 1 to August 31.

- Avoid sediment accumulation of more than 7.9 in (20 cm) in any year.

Sedge meadows—wetlands or zones with at least 20 percent cover by *Carex, Eleocharis, Scirpus,* and/or *Dilichium*

- Avoid sediment accumulation of more than 5.9 in (15 cm) in any year.

These guidelines are fairly complex to apply. Establishing predevelopment conditions requires either monitoring water levels or accurate hydrologic modeling. Postdevelopment conditions can only be established by predictive modeling. Monitoring need not be done with continuously recording instruments; simple crest-stage and staff gages are adequate. However, a continuous simulation by computer model is almost necessary for postdevelopment analysis.

The guidelines are also difficult to observe; peak runoff rate control alone is not enough, and total runoff volumes must also be controlled to prevent hydroperiod changes in a storage basin like a wetland. As pointed out in the previous discussion of quantity control, volume control is accomplished only through infiltrating excess runoff produced by urban landscapes.

Constructed Wetlands

Wetlands specifically constructed to capture pollutants from runoff draining urban and agricultural areas are gaining attention as versatile treatment options. Several major works have recently covered constructed wetland treatment, including Hammer (1989), Strecker et al. (1992), Olson (1992), and Schueler (1992). Horner (1992a) assembled a short course manual incorporating findings and recommendations from these various sources. This discussion draws on these resources and should provide a concise summary of the current state of urban runoff treatment by constructed wetlands and how to proceed in developing projects.

From a legal and regulatory standpoint, constructed wetlands are designed, built, and continuously maintained to treat waste. Thus, under the CWA they are not regarded as "waters of the United States." While no regulations control water quality within, discharge is regulated in the same way as any treatment system.

This designation contrasts with wetlands built for such purposes as mitigation of wetland losses under CWA section 404 or to develop waterfowl habitat, known as "created wetlands." These systems have the same legal protections as natural wetlands, including prohibition against conveying or treating waste. They usually have multiple functions, with water quality improvement only incidental; entering water must be managed to prevent damage to intended functions. A constructed wetland also differs in purpose and legal status from a wetland restoration, which returns a degraded system with reduced acreage or functional ability to the condition preceding its degradation. If the wetland is not completely restored but one or more functions are increased, it is termed an enhanced wetland. Restored and enhanced wetlands also have the same legal protections as natural wetlands.

The principal advantages of constructed wetlands over other treatments are

- More diversity in structure, which offers potential for relatively effective control of most pollutants;
- Wider range of potential side benefits;
- Relatively low maintenance costs; and
- Wider applicability and more reliable service than infiltration.

The disadvantages of constructed wetlands include

- Larger land requirements for equivalent service than wet ponds and other systems, especially if intended to serve quantity as well as quality control purposes;
- Relatively high construction costs;
- Delayed efficiency until plants are well established;
- Uncertainty in design, construction, and operating criteria is a drawback actually plaguing competitive methods as well; and
- Public concern about nuisances that can develop with runoff constructed wetlands if care is not taken in siting, design, construction, and operation.

Sizing Calculations and Expected Performance. Strecker et al. (1992), in a full literature review of both natural and constructed wetlands to control runoff pollution, considered more than 140 papers and reports and assembled detailed information on 18 U.S. locations. Median pollu-

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tant removals in constructed wetlands were 80.5 percent for total suspended solids (TSS), 44.5 percent for ammonia-nitrogen (NH_3-N), 58.0 percent for total phosphorus (TP), 83.0 percent for lead (Pb), and 42.0 percent for zinc (Zn). Coefficients of variation (ratio of the standard deviation to the mean) for these contaminants ranged from 27.7 to 56.1 percent, showing both substantially higher and lower performance than the median levels. Pollutant reductions in constructed wetlands overall were higher than in natural ones, attributed to the specific design features and more intensive management.

Schueler (1992) recommends wetlands designs based on the overall literature. He estimates the performance of wetlands designed as he recommends as shown in Table 8.6. He considers these efficiencies to be provisional pending monitoring of the new systems.

Table 8.6—Projected long-term pollutant removal rates for wetlands constructed.

POLLUTANT	REMOVAL RATE (%)[a]
TSS	75
TP	45[b]
TN	25[c]
BOD, COD, TOC	15
Pb	75
Zn	50
FC	2 orders of magnitude

[a] Lower by an unknown amount for pocket wetlands.
[b] 65 percent in pond/marsh system.
[c] 40 percent in pond/marsh system.
Source: Schueler, 1992.

Several ways to arrange constructed wetlands, based on runoff quality and quantity control requirements, are to

- Place a runoff quantity control device on-line and a constructed wetland off-line to treat all runoff up to a certain volume;
- Construct a wetland with a permanent pool zone for treatment and a fluctuating storage zone and discharge control sized for peak runoff rate control; and
- Construct a wetland only for treatment in situations where quantity control is not required.

The first arrangement benefits from the fact that most pollutant mass loading over time is transported by runoff from the more frequent, smaller storms, and the first flush from the less frequent, larger storms. This arrangement is recommended where runoff quantity control is required because (1) the relatively shallow depths needed to maintain wetlands are somewhat inconsistent with the large storage volume needed for quantity control, and (2) large surges of water can damage the wetland.

Basic sizing decisions involve the pool storage volume (V_P), surface area, depth contouring (plus fluctuating storage volume, if runoff quantity control will be provided)—the same dimensions required in sizing a wet pond. At this point, constructed wetland technology has established no procedures to determine volume based on desired performance efficiencies and pollutant removal mechanisms. Accordingly, pool storage volume should be sized the same for wet ponds (see previous explanation).

Schueler (1992) illustrates four design concepts to configure constructed wetlands in the Mid-Atlantic area. To establish the wetland surface area (A_W), start by selecting a trial mean depth (D) from the following approximate ranges (after Schueler, 1992):

Shallow marsh	0.30-0.45 m
Pond/marsh	0.60-0.85 m
Extended-detention wetland	
permanent pool	0.25-0.30 m
extended-detention zone	1.0 m
Pocket wetland	0.15-0.40 m

Using the trial mean depth, calculate surface area by $A_W = V_P/D$.

After determining satisfactory basic dimensions, allocate depths to the different wetland zones according to the design concept. Schueler (1992) recommends the following zones to obtain diversity in structure and treatment capabilities:

Deep areas —30-180 cm deep, no emergent vegetation—forebay, micropools, deep water pools and channels
Low marsh—15-30 cm below normal pool
High marsh—0-15 cm below normal pool
Irregularly inundated zone—above normal pool

Schueler also supplies approximate depth allocations for the various zones and design concepts.

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■ ***Design Recommendations.*** Identify and adopt a natural wetland that performs water quality control well and use it as a reference model. Natural wetlands control water quality because of their structure. Therefore, the elements of this natural structure must be recreated in a wetlands. Natural wetlands tend to have a more complex structure than do most runoff treatment systems. This complexity allows a range of mechanisms to operate and diverse pollutants to be treated. The result is relatively high efficiencies, compared to competing alternatives. Structural complexity can be created with high marsh peninsulas and islands.

A structurally complex system is more expensive and difficult to construct than a simple one. In some cases, we may need to dispense with a few features of an ideal system. In addition, a complex design may not be faithfully constructed. Therefore, design personnel should be in the field to interpret the design and guide construction.

A constructed wetland must have enough time to develop before it is put in full service. Attempts to short-circuit ecological processes by over-management will probably fail.

1. Site Selection

Evaluate a prospective site carefully before making a selection. Table 8.7 summarizes the major considerations that should be analyzed. While an analysis requires gathering significant data, it is essential.

A viable constructed wetlands depends on an adequate and steady water supply. A water budget should be carefully constructed to ensure that water is available and inputs at least balance outputs throughout the year:

$$I + P + D + S > O + E + R \qquad [11]$$

where: I = Surface inflow;
P = Precipitation;
D = Groundwater discharge;
S = Wetland storage at beginning of calculation period;
O = Surface outflow;
E = Evapotranspiration; and
R = Groundwater recharge.

(All units are in terms of volume or water depth over the wetland surface.)

Table 8.7—Considerations in selecting constructed wetlands sites.

CATEGORY	CONSIDERATIONS
Land use and general	Land availability Existing site use and value Site problems (e.g., previous dumping, utility lines) Adjacent land use and value Connection to wildlife corridors and potential for adjacent areas to be biological donors Public opinion Accessibility for construction and maintenance Ability to control public access according to project objectives
Environmental and regulatory	Federal, state, and local laws and regulations Avoidance of archaeological and cultural resources Avoidance of critical wildlife habitat areas
Hydrology and water quality	Water supply reliability Low potential for disruptive flooding Water supply of adequate quality to sustain biota Low potential for adverse effects on downstream waterbodies and adjacent properties and their water supplies Need for lining to retain water or avoid groundwater contamination
Geology	Flat or gently sloped topography Adequate soil development Sufficient depth to bedrock Soil characteristics consistent with pollution control objectives Suitability of site materials for construction

Source: R.R. Horner.

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Estimate the water budget during site selection and check it after the preliminary design. In areas with pronounced seasonal drought (e.g., most of the western United States), calculate the balance for the dry period. Groundwater terms are difficult to establish, but a hydrogeologist familiar with the location should estimate them as closely as possible. Since natural wetlands often dry below the soil surface, permanent standing water is not necessarily needed to have a viable wetland. Washington State research has found that plant community richness declines substantially when drying extends longer than two months, compared to wetlands with shorter dry periods (Azous, 1991). Hence, the water balance should at least confirm that drying will not exceed two months.

2. Vegetation

Experience with wetlands creation, restoration, and construction projects shows that the plant community develops best when the soils harbor substantial vegetative roots, rhizomes, and seed banks. Development is enhanced when volunteer vegetation can enter from nearby donor sites. However, volunteers cannot be relied upon completely and should be supplemented by transplanting. While vigorous resident and volunteer stock may provide most of the vegetation, transplanting is still a wise strategy, as confirmed by most of the literature.

Hydric soils that contain vegetative plant material used to establish new wetlands are called wetland mulch. Ample use of this mulch enhances diversity and speeds plant establishment, but its content is somewhat unpredictable and donor sites are limited. Also, guidelines for extracting, handling, and storing the material are limited. In addition, exotic, opportunistic species might overtake more desirable natives—watch for this problem when obtaining material.

Potential donor sites include wetland soils removed during maintenance of highway ditches, swales, sedimentation ponds, retention/detention ponds, and clogged infiltration basins; during dredging; or from natural wetlands scheduled to be filled under permit—although these soils are best used for mitigating the loss. The upper 5.9 in (15 cm) of donor soils are best obtained at the end of the growing season and should be kept moist until installation. Establishing repositories for mulch reclaimed in maintenance operations is being explored. Despite the potential of wetland mulch and volunteer recruitment, transplanting is still the most reliable method and provides instant partial cover.

Wetland plant nurseries have sprung up recently in many places in the nation to provide material. The following list of general selection principles was compiled from Garbisch's (1986) recommendations for creating wetlands and from the comprehensive constructed wetlands literature:

- Base selections more on the prospects for success than on specific pollutant uptake capabilities. Plant uptake is an important mechanism only for nutrients, much of which are released upon the plants' death; nutrient removal is more the result of chemical and microbial processes than of plant uptake.
- Select native species; avoid natives that invade vigorously.
- Use a minimum of species adaptable to the various elevation zones; diversification will occur naturally.
- Select mostly perennial species; give priority to those that establish rapidly.
- Select species that are adaptable to the broadest ranges of depth, frequency, and duration of inundation (hydroperiod).
- Match the environmental requirements of plant selections to site conditions. Consider especially hydroperiod and light requirements.
- Give priority to species used successfully in constructed wetlands and commercially available species.
- Avoid specifying only species foraged by wildlife expected to use the site.
- Establish woody species to follow herbaceous species.
- Plant to achieve objectives other than pollution control.

Although selection based on pollution control capabilities is not recommended, considerable information on pollution control has been compiled. Kulzer's (1990) summary of plant capabilities for pollutant removal suggests that the most versatile genera, with species throughout the country, are *Carex*, *Scirpus*, *Juncus*, *Lemna*, and *Typha*.

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Specific guidance for constructing wetlands is contained in Schueler (1992) and for creating wetlands in Garbisch (1986). The course manual by Horner (1992a) also incorporates this guidance on constructed wetlands.

3. Design Features

While size alone does not guarantee good performance, adequate size is necessary. If the layout permits water to traverse the wetland too fast, the theoretical hydraulic residence provided by the volume will not be achieved. The following features will help keep the flow from short circuiting the wetland.

Shape and configuration

- Create at least two distinct cells by restricting the flow to a narrow passageway between high marsh features.
- Make the wetland relatively wide at the inlet to help distribute the flow.
- Maximize the distance between the inlet and outlet.
- The effective length-to-width ratio should preferably be 5:1, and 3:1 at a minimum.
- The longitudinal slope—parallel to the flow path—should be less than 1 percent.
- The wetland should be carefully constructed to have no lateral slope—perpendicular to the flow path—to avoid concentrating the flow in preferred channels, which reduces actual residence time and risks erosion.
- Side slopes should be gradual (e.g., 5:1 to 12:1, horizontal to vertical) as in natural wetlands. In no place should the side slope be greater than 3:1.

Forebay

- Specify a relatively deep (3.93 to 5.9 ft/ 1.2 to 1.8 m) zone placed where influent water discharges. This forebay traps coarse sediments, reduces incoming velocity, and helps to distribute runoff evenly over the marsh. The forebay should be a separate cell set aside by high marsh features.
- Provide maintenance access for heavy equipment (14.76 ft/4.5 m wide and maximum 5:1 slope) directly to the forebay. The forebay bed should be hardened to prevent disturbance during clean out.

Flow channeling

- Create sheet flow to the maximum extent possible.
- Where flow must be channeled, use multiple, meandering channels rather than a single straight one.
- Open water areas should be interspersed with marsh rather than connected along the flow path.
- Minimize velocity in channels to prevent erosion.

Outlet area

- Place a micropool 3.93 to 5.9 ft (1.2 to 1.8 m) deep at the outlet.
- Install a reverse-sloped pipe 11.81 in (30 cm) below the permanent pool elevation. This outlet design avoids the clogging characteristic of constructed wetlands (Schueler, 1992).
- Install a drain capable of dewatering the wetland in 24 hours to allow for maintenance. Control the drain with a lockable, adjustable gate valve. Place an upward-facing inverted elbow on the end of the drain to extend above the bottom sediments.

Soils

- Medium-fine textures—such as loams and silt loams—work best to establish plants, capture pollutants, retain surface water, and permit groundwater discharge.
- Circumneutral pH (approximately 6 to 8) works best to support microorganisms, insects, and other aquatic animals.
- A relatively high content of highly decomposed organics (muck) is favorable for plant and microorganism growth and metal and organic pollutant adsorption. Muck soils are better than peats (less decomposed organics), which produce somewhat acidic conditions, are low in plant nutrients, and offer plants relatively poor anchoring support.
- Vegetation becomes established more quickly and effectively in constructed wetlands when soils contain seed banks or rhizomes of obligate and facultative wetland plants. Obtain soils that offer these resources.

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- Soil characteristics recommended for specific pollution control objectives are
  Control of metals—high cation exchange capacity; and
  Control of phosphorus— high exchangeable aluminum and/or iron.

Liner

- An impermeable liner is required when infiltration is too rapid to sustain permanent soil saturation, when there is a substantial potential of groundwater being contaminated by percolating runoff, or both. Infiltration losses are small at most sites with USDA SCS class B, C, and D soils. Also, sediment deposition is likely to seal the bottoms of constructed wetlands. Therefore, a liner will likely be needed only in class A soils.

Emergency spillway

- An emergency spillway is required when the wetland will be used for runoff quantity control and for any other situation in which runoff might enter from a larger storm than the largest storm the facility is sized to handle.

Buffer

- A buffer should be provided around the wetland both to separate the treatment area and the human community and, if wildlife habitat is an objective, to reduce the animals' exposure to light, humans, pets, and other factors.

- The minimum buffer width should be 26.25 ft (8 m), measured from the maximum water surface elevation, plus 16.4 ft (5 m) to the nearest structure.

- If possible, preserve existing forest in the buffer area. At least 75 percent of the buffer should be forested to repel geese and provide better protection and habitat.

Avoiding Problems

- Mosquitoes, a rare but potential problem, can be prevented with diverse habitats that support predatory insects. Mosquitofish (*Gambusia*) can control mosquitoes in permanent ponds, but use caution in introducing the fish in non-native areas. Check with the state fish and wildlife agency before taking any action.

- Avoid aesthetic problems by carefully establishing construction and with vegetation. The buffer and tall emergent vegetation conceal water level fluctuation, films on the water, and other factors.

- Constructed wetlands are inherently safer than deep ponds, but deep zones may still be a hazard to children. Avoid this danger by creating gradual side slopes, a shallow marsh safety bench (16.4 ft/5 m wide) where the toe of the side slope meets any deep pool, concealing outlet piping and locking access. Fencing should only be needed on the embankment above large outfalls.

- Discourage nuisance waterfowl by maintaining the buffer largely in forest (at least 75 percent) and avoiding turf grass around the wetland. Maintain a variety of depths, especially high marsh not favored by geese and mallards, and educate citizens by placing signs to discourage feeding.

- Undesirable plant monocultures can be limited through structural diversity and a range of depths, especially in shallow areas. Plant a diverse native selection shortly after constructing the wetland.

- Metals and organics in toxicant accumulations are tightly bound in sediments and do not become mobilized over long periods. However, maintenance creates the problem of spoils disposal. Spoils that pass hazardous waste tests can be safely land-applied or placed in a landfill (Schueler, 1992). Applying spoils on-site saves disposal costs.

Landscape Management

Landscape management (Schueler [1987] uses the term urban forestry) signifies such practices as preserving trees during construction, replanting trees, and landscaping helpful to urban runoff management. One aspect of landscape management, maintaining vegetated buffers adjacent to waterbodies, advances the principle of minimizing the impervious area directly connected (by "hard" drainage facilities) to receiving waters.

Areas established using landscape management techniques can produce runoff volumes 30 to 50 percent less than conventionally developed sites (Schueler, 1987). Evidence suggests that

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even low density residential development can produce runoff rivaling impervious areas when lawns replace natural vegetation and topsoil is removed close to relatively impermeable underlying layers.

The effectiveness of vegetated areas in capturing pollutants depends on the water's residence time before it enters the receiving water. Buffers and other landscape management spaces are often too small to provide the nine-minute residence time specified in the earlier discussion of biofilters, considered a minimum for water quality control. Of course, landscape management can still provide significant benefits, even without the ideal residence time.

While a riparian buffer guidance handbook by Heraty (1993) also provides recommendations for landscape management forestry programs, complete guidance is not yet available.

Infiltration Practices

Infiltration is the only structural technique that reduces both the peak runoff rates and runoff volumes from urban development. Infiltration reduces contaminants in runoff when runoff percolates in a soil column in which physical and chemical mechanisms operate. Infiltration devices that receive runoff at the surface also treat water through plant uptake and processes in surface soils. Unfortunately, these practices have the highest failure rates among all alternatives. Success requires great care in site selection, design, operation, and maintenance. Types of infiltration devices are

- Infiltration basins, also known as retention ponds;
- Infiltration trenches;
- Perforated pipes;
- French drains, also termed downspout infiltration systems; and
- Porous pavements.

An infiltration basin (see Figure 14.10) impounds water in a surface pond until it infiltrates the soil. Excess runoff discharges on the surface. An infiltration trench receives runoff in a shallow excavated trench that has been backfilled with stone to form a below-grade reservoir. Water then enters the underlying subsoil according to its infiltration rate. A perforated pipe, or underground trench, distributes runoff into the subsoil. French drains, consisting of pervious material such as gravel, disseminate inflowing water into the surrounding soil. These drains are usually used in small-scale applications, such as roof drains from homes and other small buildings. Porous pavements permit precipitation to drain through coarse-graded concrete, asphalt, or specially cast paving blocks with a pervious opening. The coarse-graded pavements can be used on roads, although they are subject to clogging; paving blocks are appropriate only for paved areas with very light or no traffic.

Recent studies and observations have documented extensive infiltration system failures. Schueler et al. (1992), in reviewing Mid-Atlantic region reports, found that 50 to 100 percent of infiltration basins had failed within five years of construction; up to 50 percent had failed almost immediately. The five-year failure rates for trenches and porous pavements were approximately 50 and 75 percent, respectively. Overwhelmingly, clogging by sediments brought in with runoff caused the failure. Microorganism growths in poorly drained soils and oils in runoff can also cause failure (Horner and Homer, 1990). This poor operating experience led Schueler et al. (1992) to advise against using infiltration basins and porous pavements and to use trenches only with careful geotechnical investigations and aggressive pretreatment protection and maintenance.

A study in Washington's Puget Sound found that successful infiltration basins were built on deep to excessively drained soils and not near seasonal high water tables or low spots in drainage catchments (Klochak, 1992; Gaus, 1993; Hilding, 1993; Jacobson, 1993). However, these basins risk groundwater contamination because metals retention was little to none in one soil type and incomplete in two others (Gaus, 1993). Most instances of poor infiltration were caused by water tables rising too near the surface. Vegetation was apparently not associated with infiltration, although plants can filter pollution, aerate soil, and improve the appearance if maintained properly.

Soil is the most critical consideration in specifying infiltration systems. Systems are generally built in the native soil; but when native soil is inappropriate, a soil system can be constructed with media like sand, peat, or a combination.

Infiltration systems normally convey most runoff directly into the soil to eventually enter the groundwater. However, an underdrain system can be installed below the infiltration system to collect water that does not percolate well through a restrictive subsoil layer. After being collected, the

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water can be widely distributed to increase the percolation potential. If the grade permits, it can be discharged on the surface, after being treated while passing through the upper soils. Constructed soil systems usually require underdrains. While these systems could be considered filtration practices, this guide considers them under infiltration, reserving the filtration category for units constructed in boxes and generally having a conventional surface discharge.

The most crucial issues in using infiltration devices, in addition to soil suitability, are avoiding clogging and the potential to contaminate groundwater. Infiltration facilities should be constructed in medium textured soils. They are generally unsuitable for clay because of restricted percolation and gravel and coarse sands because of the risk of groundwater contamination, unless effective pretreatment is provided. An impermeable soil layer close to the surface may need to be penetrated. If the layer is too thick, underdrains, and possibly imported soil to provide sufficient treatment depth, may be required (Entranco Eng. 1989). As a minimum measure to prevent clogging, infiltration facilities should require a pretreatment device to settle larger solids and reject runoff from eroding construction sites.

Among the various runoff treatment options, only soil infiltration systems have been reliable in removing soluble phosphorus (Minton, 1987). This result likely applies to other relatively soluble pollutants as well. Reduction depends principally on how effectively the system prevents runoff from directly entering surface water. Reduction can be complete if surface effluent is absent and percolating water cannot get to surface water through interflow in the unsaturated zone or via rapid transit of groundwater in the saturated zone. In other circumstances, dissolved pollutant reduction is incomplete but is still higher than with any other treatment method.

Expected Performance

This manual classifies performance of soil infiltration systems as follows:

- Natural soil column infiltration basins, trenches, and perforated pipes with and without underdrains;
- Underdrained systems with selected filtration media—sand and peat-sand; and
- Porous pavements.

Natural Soil Systems. In a natural system without underdrains, the system's hydrology (directness of connection with surface water) determines how much runoff is captured and how efficient the treatment. Alternative design rules for infiltration basins and their estimated runoff reductions and pollutant removals (Schueler, 1987) are to store and infiltrate either (1) 0.5 in (1.27 cm) of runoff per impervious acre contributing, (2) the runoff resulting from a 1-inch rainfall event, or (3) the two-year frequency runoff volume. Table 8.8 estimates pollutant removals.

With the first rule, Schueler estimates that 40 to 50 percent of the runoff volume would be captured in the soil over the long term. This would rise to 65 to 75 percent with the second rule, depending on the soil and the amount of impervious area (the NURP database used to make the estimates

Table 8.8—Estimated long-term pollutant removal rates (percent) for infiltration basins.

POLLUTANT	SIZED BASED ON		
	0.5-IN RUNOFF/IMPERV. ACRE	RUNOFF FROM 1-IN RAIN	2-YEAR STORM RUNOFF VOLUME
Total suspended solids	75	90	99
Total phosphorus	50-55	60-70	65-75
Total nitrogen	45-55	55-60	60-70
Metals	75-80	85-90	95-99
Biochemical oxygen demand	70	80	90
Bacteria	75	90	98

Source: Schueler, 1987.

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represents catchments with 11 to 27 percent imperviousness). The third rule would likely raise the degree of volume reduction to appropriately 90 percent. Schueler cites Maryland estimates that widespread application of the first or second rule would maintain summer baseflow levels within about 90 percent of predevelopment conditions.

In developing a management plan for phosphorus-limited Lake Sammamish, Washington, Entranco Engineers, Inc. (1989) estimated potential reduction of particulate phosphorus at 100 percent and soluble phosphorus in natural basins at 75 to 90 percent. Estimates for an underdrained system with 3 ft (0.91 m) of soil were 80 to 100 percent for total phosphorus and 50 to 85 percent for soluble phosphorus. These estimates are uncertain because backup data was lacking.

▮ ***Underdrained Systems with Artificial Media.*** A number of underdrained sand and peat-sand media configurations installed and tested differ in the layering of sand of various grain sizes, peat, and gravel. Meyer (1985) also proposes a layer of crushed limestone to precipitate phosphorus. Horner and Horner (1990) review design and performance considerations for a side-wall filter (in contrast to a basin draining through the bed) not yet built. These devices have only been extensively employed in Austin, Texas. Reported levels of pollutant reduction percentages were

Total suspended solids—60 to 80 percent;
Total phosphorus—20 to 90 percent, with most reports above 60 percent;
Nitrogen, soluble phosphorus—inconsistent in a sand-peat filter to 96 percent in a sand filter;
Metals—30 to 100 percent depending on metal and medium;
Chemical oxygen demand—40 to 90 percent;
Organics—inconsistent, but approximately 85 percent when operating well; and
Bacteria—40 to 100 percent.

In Bellevue, Washington, a large soil filter system draining to Lake Sammamish has recently been constructed to serve a housing development. The system—which includes pretreatment with catch basins, grass swales, oil/water separators, and detention—is expected to capture more than 99 percent of the total suspended solids, 50 to 95 percent of the phosphorus, and 90 to 95 percent of the copper in urban runoff from developed portions of the site (Diessner et al. 1991). The system's performance is now being monitored.

▮ ***Porous Pavements.*** Schueler (1987) distinguishes between porous pavements providing full and partial infiltration. The latter involves some type of collection system to drain surface runoff that cannot be infiltrated. Schueler estimates potential pollutant captures at 80 to 99 percent for total suspended solids, total nitrogen, chemical oxygen demand, zinc, and lead and 65 percent for phosphorus, although the actual capture would again depend on soil infiltration.

Denver's Urban Drainage and Flood Control District (1993) recommends only the modular block type of porous pavement system. The design, consisting of perforated concrete slab units underlain with gravel, is specified for use only in low traffic areas like airports, parking lanes, and driveways, and paved paths without traffic.

Site Selection, Sizing, and Design

Since all infiltration systems rely on the ability to discharge water through the soil or an equivalent artificial medium and have the same general problems, most design aspects are similar, except for media specifications for artificial systems. The following guidance is applicable to all types, with additional information on artificial media where necessary. Reference sources provide more specific detail.

▮ ***Site Selection for Natural Soil Systems.*** Needs differ, depending on whether the infiltration system is intended for quantity control alone or for quality and quantity control. While quantity control is best achieved with a rapid percolation rate, this rate could be too fast to provide sufficient contact with the soil for pollutant capture. If the runoff is quite contaminated, if the groundwater table is relatively close to the surface, or both, rapid percolation risks groundwater pollution. Therefore, the safest practices are to

- Specify a maximum and a minimum percolation rate to protect groundwater and attain pollutant capture objectives, or
- Require runoff pretreatment to meet water quality objectives before the pretreatment effluent is infiltrated for quantity control.

Infiltration authorities recommend the following criteria to reduce the substantial potential for failure, safeguard groundwater, and achieve the desired urban runoff management benefits:

- The bed of the infiltration facility should be at least 3 to 5 ft (0.91 to 1.52 m) from the

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seasonal high water table, bedrock, or relatively impermeable soil layer (5 ft is conservative and warranted, unless seasonal water rise is carefully determined; 3 ft is minimum).

- With any application, the percolation rate should be at least 0.3 to 0.5 in/hr (0.76 to 1.27 cm/hr); 0.5 in/hr is conservative; 0.3 in/hr is minimum.
- With any application, the soil should not have more than 30 percent clay or more than 40 percent clay and silt combined (Wash. Dep. Ecol. 1992).
- When the infiltration facility will provide all runoff treatment (except perhaps presettling of solids) and when it will drain to groundwater (i.e., there are no underdrains), the percolation rate should not be greater than 2.4 in/hr (6.10 cm/hr) (Wash. Dep. Ecol. 1992). This, and the preceding guideline, effectively makes only loams, sandy loams, and loamy sands eligible for installing water quality infiltration systems.
- The facility should not be constructed in fill material or on a slope of greater than 15 percent.
- Baseflows should not enter infiltration facilities. The contributing catchment must be relatively small, or any permanent or intermittent flows must be diverted. Schueler et al. (1992) recommends that infiltration basins serve 2 to 15 acres (0.81 to 6.06 ha) and specified catchments be no larger than 5 acres (2.02 ha) to drain to trenches (Schueler, 1987).

Infiltration basins frequently lack good data on the soils and associated hydrogeology (Klochak, 1992; Gaus, 1993; Hilding, 1993; Jacobson, 1993). Using regional soil survey data is always very risky, and specific on-site soils investigation must be performed. Since infiltration generally occurs below the preconstruction grade level, soils and hydrogeologic observations and tests must be performed at the final grade level. Even measurement at a single location within the prospective facility location can be inadequate to characterize the soil and its new percolation rate. Hence, measurements should be repeated at several points. Finally, techniques often used to establish percolation rates (e.g., single-ring infiltrometers) have been found lacking—a double-ring device is an improvement. Standard percolation tests should also be performed in excavated holes.

Sizing Calculations. Several possible bases are used to size infiltration devices. One is to select one of Schueler's (1987) sizing rules and a maximum allowable drain time. Schueler recommends a maximum of 72 hours, except for 48 hours in marginal soils. The Washington Department of Ecology (1992) adheres to the latter time. Another way is an approach based on Darcy's law, which expresses flow through a porous medium. The resulting equations for the surface area (A_s) and infiltration system volume (V_i) are

$$A_s = V_r / f_d \cdot i \cdot t \quad [12]$$

$$V_i = \text{Inflow rate} - \text{Outflow rate} \quad [13]$$
$$= V_r - f_d \cdot i \cdot A_s \cdot t$$

where:
- V_r = Design storm runoff volume (ft^3);
- f_d = Percolation rate (ft/hour = inch/hour/12);
- i = Hydraulic gradient (ft/ft) = $(h + L)/L$;
- h = Height of water over infiltration medium when full (ft);
- L = Depth to water table or impermeable layer from infiltration medium surface (ft); and
- t = Time to drain from full condition (hour).

The design runoff volume can be established as discussed for wet ponds. With the difficulty in getting good percolation rate values, the Washington Department of Ecology (1992) recommends a conservative approach of making several on-site measurements at the infiltration medium level, adopting the minimum of those rates, and multiplying by a safety factor of 0.5. Better measuring techniques would allow dispensing with such conservatism—or at least dropping the safety factor.

Design Recommendations. The following recommendations are important to avoid past failures of infiltration systems:

- Construction runoff should never be allowed to enter an infiltration device.
- Banks and other areas must be thoroughly stabilized to prevent erosion into the device.

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- At a minimum, pretreatment should be used to capture most of the runoff solids directed to an infiltration device. A recommended arbitrary removal criterion is 80 percent of total suspended solids.

- The facility should be at least 50 ft (15.24 m) from any slope greater than 15 percent and at least 100 ft (30.48 m) upslope and 20 ft (6.1 m) downslope of any building.

- The outlet orifice design must be consistent with the infiltration capacity (e.g., to avoid collecting more water than can infiltrate in 48 hours).

- After final grading, the bed should be deeply tilled to provide a well-aerated, highly porous surface texture.

- Plant a basin with grasses appropriate for conditions, and maintain the grass for both performance and appearance.

- The guidelines for wet ponds—introduction of flow at low velocity and with uniform distribution, side slopes, the emergency overflow, and safety—also apply to infiltration basins.

- Since constructed artificial soil systems are in their infancy, the following guidelines are subject to further testing (Horner and Horner, 1990):

  - A layered media structure seems to perform best. Most common are three layers, each about 1 to 2 ft (0.30 to 0.61 m) thick, separated by filter fabric. The upper layers have generally been various textures of sand or peat-sand mixtures. A crushed limestone layer has also been used for phosphorus reduction and pH adjustment.
  - Fibric peat is preferred over sapric peat because of the latter's poor hydraulic conductivity.
  - Surround the underdrain pipe with gravel or crushed rock.

Inspection and maintenance are also important for failure-prone devices like infiltration systems. Chapter 14 provides inspection checklists and maintenance standards.

Filtration Practices

Sand Filters

Sand filter chambers, similar to those used for many years in potable water and industrial treatment, have recently been introduced in urban runoff management. They differ from those described under infiltration practices by being installed in a box and having a surface effluent, instead of being a soil amendment with an underdrain system. These units are most appropriate in less than 5-acre (2.02-ha), mostly impervious catchments.

Figure 8.6 illustrates a design (Shaver, in press) being installed in Delaware, Maryland, and Virginia that consists of a sedimentation chamber followed by a filtration chamber.

Sizing Calculations and Expected Performance. Design criteria are still under development. Shaver (in press) recommends sizing the sedimentation and filtration chambers each at 540 ft^3 (15.29 m^3) per contributing acre. He further recommends a surface area for each chamber of 360 ft^2 (33.45 m^3) per acre and a sand depth of at least 18 in (45.72 cm).

Based on monitoring of three similar systems in Austin, Texas, the following pollutant removal efficiencies percentages are expected (Shaver, in press):

Total suspended solids	75 to 87%
Total phosphorus	19 to 61%
Total nitrogen	31 to 44%
Ammonia-nitrogen	43 to 77%
Nitrate + nitrite-nitrogen	-79 to - 5%
Lead	71 to 88%
Zinc	49 to 82%
Copper	33 to 60%
Chemical oxygen demand	45 to 68%
Fecal coliform	36 to 37%

Design Recommendations. Shaver's (in press) additional recommendations are

- Restrict the drainage area for any one filter to 5 acres (2.02 ha), which should essentially all be impervious.

- Make the outfall pipe from the sand chamber no larger than 6 in (15.24 cm) outside diameter, so that a minimum of 12 in (30.48 cm) of sand covers it. If a larger conveyance is needed, use more than one pipe.

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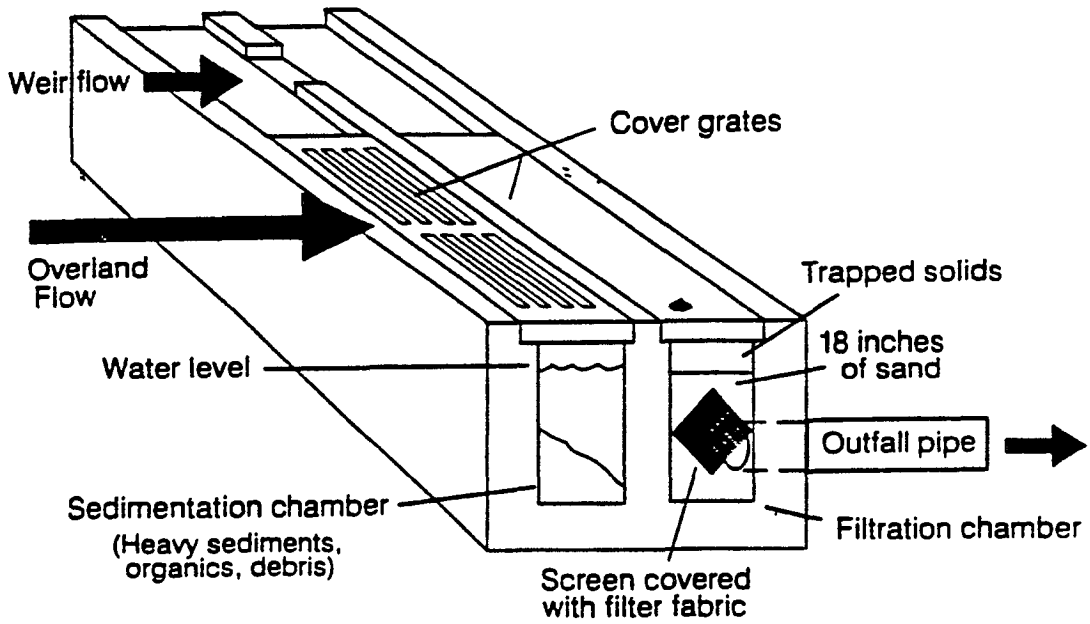
Figure 8.6—Sand filter design.



Source: Shaver, in press.

Leaf Compost Filters

W and H Pacific (1992) has developed and tested a leaf compost filter in the Portland, Oregon, area. Monitoring 13 storms showed influent event mean concentrations to be reduced, on the average, by the following:

Total suspended solids	95%
Turbidity	84%
Chemical oxygen demand	67%
Total phosphorus	41%
Total Kjeldahl nitrogen	56%
Nitrate-nitrogen	34%
Ammonia-nitrogen	42%
Zinc	88%
Copper	67%
Total petroleum hydrocarbons	87%

Soluble phosphorus consistently increased across the filter. Work is now underway to improve the medium's anionic exchange capability (Stewart, pers. commun.). The device has not been independently tested, nor have design criteria been published.

Catch Basin Filters

Fiberglass (MacPherson, 1992) and activated carbon (Hutter, pers. commun.) filters intended for small-scale installations (e.g., catch basins) have recently been introduced on the market. Neither has been independently tested, but MacPherson reported concentration reductions of 90 percent for total suspended solids, 87 percent for lead, 77 percent for zinc, and 86 percent for copper. Specific design criteria have not been issued, but the fiberglass filter has been tested in flows up to 1 cfs, and the activated carbon filter is specified for use up to 0.13 cfs.

Series Treatment Combinations

Any treatment practices previously discussed can be combined in series arrangements, or treatment trains. This takes advantage of the capabilities of each and creates redundancy to increase the probability of capturing pollutants. The effectiveness of such systems will not be additive, however, because the first device in the series will trap the fractions easiest to remove, making subsequent reduction harder. For example, if two practices can individually capture 50 percent of a pollutant, leaving 50 percent present, the overall efficiency of a series of the two is not likely to be $0.50 + 0.50 \cdot (1 - 0.50) = 0.75$. Horner (1992b)

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proposes an equation for the performance of a series of two devices:

$$E_s = 1 - X \cdot (1 - E_1) \cdot (1 - E_2) \quad [14]$$

where: E_s = Series efficiency (fraction pollutant remaining);

X = "Penalty" representing the performance reduction in the second device because of its harder removal task ($X > 1$);

E_1 = Efficiency of first device if alone; and

E_2 = Efficiency of second device if alone.

However, information was insufficient on series studies to establish X from actual data. Using this equation and an assumed $X = 1.25$, E_s for the previous example is 0.69 (69 percent) instead of 0.75.

The literature contained four performance studies of treatment trains. In one report—phosphorus removal—Meyer (1985) describes an infiltration basin design with a sand/crushed limestone underdrain filter coupled to a constructed wetland. He expected 90 percent removal of dissolved phosphorus, but no performance data have been found. Oberts and Osgood (1991) report on a detention pond that discharges into a series of six constructed wetland chambers. The system reduced total phosphorus by 79 percent and dissolved phosphorus by 57 percent in the pond, and an additional 32 and 15 percent, respectively, in the wetland. Overall system efficiencies—77 and 48 percent, respectively—were lower than the pond alone because of flows to the wetland that did not pass through the pond. The pond was believed to be so efficient because of well-distributed inflow, low-dissolved-to-total-phosphorus ratio, and phosphorus complexation by organics.

Wulliman et al. (1989) discusses a system consisting of a pond, wetland, and infiltration basin that was planned to split detention pond effluent between the wetland and infiltration basin. Modeling predicted overall 52 to 87 percent phosphorus reduction, but performance data have yet to be reported. Holler (1990) reports on a wet pond-filter (soil, limestone, and sand) system. The average wet pond reductions of both total phosphorus and orthophosphate-phosphorus were 77 percent, while the filter yielded orthophosphate and further reduced total phosphorus by only 16 percent, for an overall system total phosphorus efficiency of 85 percent.

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CHAPTER 9

Industrial Activities Runoff Management

Several federal programs provide a basis for national urban runoff management. They are briefly summarized in the following paragraphs.

Clean Water Act

In 1972, amendments were made to the Federal Water Pollution Control Act, referred to as the Clean Water Act (CWA). These amendments prohibited the discharge of any pollutant to navigable waters from a point source, unless the discharge was authorized by a National Pollutant Discharge Elimination System (NPDES) permit. The program's initial thrust was to treat discharges of industrial process wastewater and municipal sewage. These discharges were easily identified and recognized as significant sources of receiving system degradation. With control of these discharges, attention has turned to the problems of other less visible pollution sources.

National Urban Runoff Program

From 1978 through 1983, EPA conducted a comprehensive study of urban runoff—the Nationwide Urban Runoff Program (NURP)— which provided a better understanding of the nature of urban pollutants from various urban land uses. It consisted of 28 projects conducted by local government agencies across the country under the review and coordination of EPA. NURP, a landmark effort, developed quantitative data on levels of pollutants generated from urban land uses. The study focused primarily on monitoring runoff from residential, commercial, and industrial land and clearly presents information on the magnitude and spectrum of pollutants encountered in the urban environment. The NURP study results are contained in three volumes; the executive summary (volume 1) should be required reading for individuals involved in stormwater management (U.S. Environ. Prot. Agency, 1983).

Water Quality Act of 1987

The 1987 amendments to the CWA, or the Water Quality Act of 1987, contains provisions that significantly increase efforts to address water quality in urban runoff. Section 319 created a state framework to address nonpoint source pollution not covered by NPDES permits. Section 402(p) expanded the existing NPDES program to include stormwater.

Section 402(p) lists five types of runoff discharges required to obtain a NPDES permit prior to October 1, 1992 (CFR November 16, 1990, issue):

- A discharge related to a permit issued prior to February 4, 1987;
- A discharge associated with industrial activity;
- A discharge from a municipal separate storm sewer system serving a population of 250,000 or more;
- A discharge from a municipal separate storm sewer system serving a population of 100,000 or more but less than 250,000; or
- A discharge determined by the EPA administrator or a state to violate a water quality standard or significantly contribute pollutants to U.S. waters.

In addition to these activities, the 1987 CWA amendments require EPA to develop regulations governing runoff from additional sources. The five listed items are commonly called Phase 1 of the NPDES stormwater program. Additional sources will be addressed under Phase 2, which have not yet been finalized.

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November 16, 1990, Rule

On November 16, 1990, EPA issued permit application requirements for stormwater discharges associated with industrial activities. The regulations identify 11 industrial categories (EPA Region 3 Pollution Prevention Plan Development Workshop) which include

- Heavy manufacturing
- Light manufacturing
- Light industries (only through exposure of material or products to runoff)
- Recycling facilities
- Transportation facilities (vehicle maintenance, equipment cleaning, airport deicing)
- Construction projects (over 5 acres [2.023 ha] in size)
- Steam electric power generating stations
- Hazardous waste treatment, storage, and disposal facilities
- Mining/oil and gas

Design Considerations

The industrial activity category *excludes* from NPDES requirements runoff drained from areas located on industrial lands that are separate from the plant's industrial activities, such as office buildings and accompanying parking lots, *as long as that drainage is not mixed with runoff from industrial areas.* Most older industrial sites, by the nature of their drainage systems, will have mixed runoff. Industrial activity includes only runoff discharges from all areas where material handling equipment or activities, raw materials, intermediate products, final products, waste materials, byproducts, or industrial machinery are exposed to runoff.

Permit Application Requirements

To obtain an application for an NPDES permit required for industrial activities, the following information must be prepared for individual permits. Group applications or industry-specific general permits may have different requirements. Contact individual states or EPA regions for specific requirements.

- A site map indicating drainage areas served by outfalls, drainage and discharge structures, paved areas, buildings, storage areas, structural control measures to reduce pollutants, materials loading, and access areas.
- An estimate of the impervious surface area, the total area drained by each outfall, and materials treated within the last three years.
- A certification that all outfalls that should contain runoff discharges from industrial activity have been tested or evaluated for the presence of nonstormwater discharges. This can be accomplished through
  - Visual inspection of storm drain inlets and outfalls—flow observations, stains, sludges, or other unexpected conditions;
  - Review and validation of pipe locations, connections, and flow directions from available construction plans, which must be field verified;
  - Dye tests to identify flow direction, since many situations, particularly older plants where drainage systems have been gradually added or replaced, will not have accurate plans and storm drain inlets; and
  - TV line surveys where illicit connections are suspected but their sources cannot be discovered.
- Existing information regarding significant leaks or spills of toxic or hazardous pollutants at the facility within the past three years.
- Quantitative data based on samples collected during storm events including
  - Total suspended solids
  - Total dissolved solids
  - COD
  - BOD_5
  - Oil and grease
  - Fecal coliform
  - Fecal streptococcus
  - pH
  - Total Kjeldahl nitrogen
  - Nitrate plus nitrite
  - Dissolved phosphorus
  - Total ammonia plus organic nitrogen
  - Total phosphorus

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Pollution Prevention Plan

A pollution prevention plan is required in EPA's stormwater general permits and has been incorporated within most state general permits. The pollution prevention concept is also appropriate for individual permits and can include efforts relating to all phases of site use. Essential components of a pollution prevention plan are as follows:

- **Reduction of pollutants at the source.** Areas that can be expected to generate waste can include
  - Vehicle or equipment fueling areas
  - Vehicle and equipment maintenance areas
  - Painting operations
  - Vehicle and equipment washing
  - Loading and unloading areas
  - Aboveground liquid storage tanks
  - Industrial waste management areas and outside manufacturing
  - Outside storage of raw materials, by-products, and others
  - Salt storage facilities

  These areas should be individually inspected and considered for actions or modifications to existing plant operation to reduce their pollutant contribution. An example of effective control of waste generation can be as simple as covering the activity so the material does not mix with rainfall and run into the storm drainage system. During an inspection, check the following items:
  - Corroded drums or drums with plugs or openings (potential to fill with rain water and overflow)
  - Corroded or damaged tanks, tank supports, and tank drains
  - Torn bags or bags exposed to rain water
  - Corroded or leaking pipes
  - Leaking or improperly closed valves and valve fittings
  - Leaking pumps and hose connections
  - Broken or cracked dikes, walls, or other physical barriers designed to prevent stormwater from reaching stored materials
  - Windblown dry chemicals
  - Improperly maintained or overloaded dry chemical conveying systems
- **Recycling.** All of the following materials may be recycled either at the industrial facility or sent off-site for recycling:
  - Spent solvents
  - Paint thinner
  - Degreasers
  - Used oil/oil filters
  - Antifreeze
  - Cleaning solutions
  - Automotive batteries
  - Hydraulic fluid
- **Treatment of runoff.** This category includes segregating the activity to prevent runoff from draining untreated into a storm drain inlet. Segregation may be accomplished by installing a berm to prevent untreated flow into a storm drain or divert the flow into a runoff control practice. A berm alone is not adequate, however, unless evaporation is greater than rainfall. Otherwise the bermed area must have an outlet structure to drain the accumulated runoff. In these situations, use visual and possibly chemical analysis to determine if a controlled release will provide for water quality protection. The specific industrial activity may require using structural water quality controls. Controls include the following:
  - Detention basins—extended detention both dry and wet
  - Infiltration practices —use caution to prevent groundwater contamination
  - Filtration practices
- **Disposal through approved method.** Use this category when other options are unavailable or impractical. For example, in an area with water quality problems, dispose of runoff through the sanitary system. However, consider these points:
  - Temporary storage of the runoff until the sanitary system can accept the flow;
  - The nature of the pollutant being discharged into the sanitary system; and
  - Whether the wastewater treatment plant can accept and treat the pollutant being discharged.

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Historical Problem Areas

Episodic Nature

The episodic nature of runoff presents a unique problem in addressing water quality concerns through the historic NPDES approach. In that program, outfalls have a controlled rate of discharge so monitoring and sample analysis is consistent. Urban runoff is generated by rainfall, which is variable in volume, time, intensity, duration, and direction. The episodic nature of rainfall presents problems in considering a specific site. The existing drainage system's capacity may be limited for larger storms and may cause backed up runoff to flow into an adjacent system or to flow overland off-site. To determine the level of storm the system can accommodate, the existing conveyance system must be evaluated.

Another problem with urban runoff versus the historic NPDES program involves monitoring. Because runoff does not always occur at a convenient time, collecting the samples at the appropriate time may be difficult. Results will also depend on the dry period between storms when pollutants accumulate. The longer a dry period lasts, the greater the potential for water quality problems in the initial runoff.

Other Pollutant Sources

The problems associated with historic point source discharges are fairly well understood. Less recognized is how pollutants from urban sources affect the quality of urban runoff. Pollutants that are generated from various land uses are described in Chapter 2.

One possible major source of pollutants is atmospheric deposition from wind blown or borne particulate or materials—often from adjacent properties. Another possible means of pollution mobilization is acid rain, which mobilizes metal contacts. One of the studies referenced in the NURP final report, the study on the Jones Falls watershed in Baltimore, Maryland, documented this concern. Watershed monitoring showed elevated levels of copper, possibly from copper downspouts of most area homes mobilized by acid rain. In Alexandria, Virginia, rain gages near the Capitol Beltway demonstrated a linear relationship of high acidity from fossil fuel combustion by automobiles (Warren Bell, city engineer, personal communication). In many areas of the United States, nitrogen is a major pollutant. Excess nitrogen in rainfall contributes to elevated levels of nitrates or runoff acidity.

Another pollutant source is from specific industrial activities. One electrical generating site in Maryland currently uses fuel oil. The operation is relatively clean; however, significant coal dust covers the state from previous coal use. The runoff pH is very acidic and can mobilize available pollutants (e.g., metals).

Another significant pollution source relates to disturbed areas or areas without ground cover. Many industrial sites have large areas of bare dirt caused by neglect or high traffic volume. This dirt is transported in urban runoff. In one plant, suspended solids loading in monitored outfall was due to general site instability from a lack of effective ground cover.

Age of the System

In many older industrial sites, storm drain pipe systems are undocumented, undersized, partially crushed or rusted, have unknown gradients, or the present plant staff is unaware of the system's location. Flow drainage areas, pipe capacities, and runoff flow path that exceeds the existing pipe system can all cause water quality problems.

In addition, the slope of overland flow may not be in the same direction as pipe flow. Generally, the NPDES permit requirements do not consider the size and flow capacity of the runoff drain system in conjunction with its drainage areas and how frequent the system is bypassed by larger runoff flows. This situation may result in significant discharges at locations where flow is not expected. Situations like these need to be carefully examined for modernization.

Lack of Site Space

Many small industrial sites are surrounded by existing development that could limit structural water quality control practices. These sites may have difficulty installing structural controls. The following section considers this problem. In many industrial sites with limited space, existing storm drains flow into or across the property from adjacent industrial sites. Runoff control problems are compounded when extraneous flows with degraded water quality are considered.

Recommended Approach

Many EPA documents discuss in detail individual site analysis for pollution prevention and rank an approach for dealing with a problem, regardless

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of size of the site. The individual industry also can adopt a proactive approach with master planning. This approach involves determining the system's ability to convey runoff flows and its flow capacity. All land areas contributing urban runoff should be identified, including off-site areas draining onto the property. An accurate site elevation plan should be generated since visual inspection, often provided under the NPDES requirements, may be inaccurate.

After completing the inventory of drainage areas, identify the complete storm drain system along with pipe sizes, slopes, inverts, and inlet sizes. Gathering this information often necessitates walking the entire site, since many older sites have poor drainage system records.

The inventory should detail the existing land use, including pervious areas along with their cover conditions. Identify soils through the appropriate USDA SCS soil survey and conduct a hydrologic study, using local rainfall data, to determine the runoff rates and volumes for various storm conditions. Since storm drain systems are normally designed to handle peak runoff from a 10-year storm, consider initial storms in the 2-, 5-, and 10-year range to estimate storm drain capability.

Ideally, a geographic information system can incorporate information identified through these initial steps and future site intentions or actual modifications. This allows the plan to evolve along with site use. A GIS system is a valuable tool for any industry expanding or modifying a site, since alternative scenarios can be considered.

After delineating existing site information, consider consolidating outfalls to minimize monitoring requirements. Older sites often allow outfall consolidation with little site modification. Available analytical techniques can compute typical pollutant loadings for similar urban areas to ascertain expected pollutant types. This analysis, in addition to gaining information on potential sources of pollutant loads from the pollution prevention plan, is important if outfall water quality sampling necessitates additional structural control practices.

With the final site plan and an estimate of runoff rates, volumes, and quality at various outfall points, alternative water quality control practices can be considered, especially if monitoring data necessitates additional site control. Water quality estimates and site characteristics provide some guidance on the type of runoff practice appropriate for a specific drainage outfall. Therefore, a preliminary estimate of the type of practice for a given area and a rough estimate of the practice size can be developed and placed on the master plan.

Areal extents of possible management areas are important if future site expansion or modification is intended. Identify potential runoff management areas to reserve in case future management measures are necessary. If those areas are not reserved through the master plan, the industry may have difficulty complying with future regulatory requirements. Master site planning also assists the industry in making other land use decisions.

Programmatic Considerations

Permits

The NPDES stormwater program for most nonstorm use discharges does not necessarily fit the traditional point source compliance approach. The nationwide approach has been to rely on general permits so that permitting authorities can handle the large number of additional permits necessitated by the 1987 CWA amendments.

Issuing general permits is appropriate to initially implement the program and also can be part of municipal NPDES stormwater permits. But states should recognize that this program requires a long-term commitment. Eventually, state representatives should visit each site covered by an NPDES stormwater permit, evaluate its approach to site control, and determine if the pollution prevention plan provides adequate site control. Under permit authority and municipal stormwater regulations, industrial sites need to be visited initially by technical staff, probably an engineer, to evaluate the pollution prevention plan's technical merits. If the plan is adequate, an inspector can make follow-up site visits. These inspections should be conducted annually to ensure that control measures are a continual part of the site operation. Permitting is not the end result of the program—therefore, site monitoring is essential for program success.

Enforcement

To emphasize the program's importance to the regulated community, enforcement mechanisms must be in place and functioning. Since the NPDES program relies on issuing permits, the regulated community must recognize its responsibilities under the law. Enforcement procedures must

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be developed, circulated to the regulated industries, and implemented.

These procedures should be simply stated and have graduated, progressive enforcement. They should spell out state and federal legal authorities and enforcement options, including penalties provided by the CWA.

Staffing

The NPDES should have at least two, and ideally three, separate functions in addition to typically regulatory functions (data entry, program management, support). Functions include technical assistance and runoff strategy review, periodic inspections, and educating the regulated community about pollution prevention strategies, approaches, and practices. An understanding and awareness of the types of practices will increase industry's willingness to implement those practices. Functions vary in their staffing needs, depending on the number of industries needing NPDES permits. While many states have assigned only one staff member to implement the entire program, that is not nearly adequate to ensure proper program implementation.

Technical assistance must be provided by staff trained in runoff management and pollution prevention. Ideally, assistance should come from engineers trained to review and guide the industry in the structural and hydrologic aspects of specific designs. The engineer must know pollution prevention strategies, from source reduction and recycling to individual runoff management practices, along with their strengths and limitations. This professional should also conduct workshops for industry representatives and design consultants on effective on-site water quality control. Since the industry is not required to submit pollution prevention plans for review, an engineer or technician should visit individual sites to ensure that the plans have been adequately developed and implemented.

Once a pollution prevention plan is endorsed, an inspector can make subsequent inspections. Again, the number of inspectors is determined by the number of sites to be visited. Inspections made periodically ensure that the pollution prevention plan is implemented and the structural controls are maintained and functioning. Periodic inspections remind the industry to operate the program as long as the site is being used.

Education, a factor frequently ignored, is important to the program's success. Education ensures that everyone involved understands the program's underlying rationale and uses acceptable approaches and design standards. Education also ensures communication between industry and the regulatory agencies and reduces the we/they mindset. Education of adjacent property owners may also improve communication and awareness of pollution prevention activities that an industry is undertaking. If resources are limited, education should be the single most important function emphasized.

Example Site

Delmarva Power and Light, an industrial site in Maryland, determined that a runoff management master plan would assist its efforts to comply with NPDES requirements and in overall site development.

The site, an existing electrical generating facility called the Vienna Power Plant, covered approximately 25 acres (10.11 ha) and had eight large stormwater outfalls covered under NPDES permits. Some 8 acres (3.24 ha) of bare soil contributed dramatically to the suspended solids loading.

The site's master plan presented expected loadings for various pollutants under existing site conditions. New design plans reduced outfalls to four. The plans also recommended site stabilization and runoff management practices for the proposed outfalls, in case pollutant discharges necessitated implementing practices. Pollutant loadings with runoff management practices were also developed so that the site owners could understand the expectations of water quality control versus existing conditions. Table 9.1 demonstrates the results.

Total output of sediments is estimated at approximately 125,000 lb (56,700 kg) per year. After planting vegetation, the concentration of suspended sediments and the total amount of runoff was significantly reduced, resulting in an annual sediment load of approximately 29,000 lb (13,154 kg). Erosion from the site has thus been reduced by about 96,000 lb (43,546 kg) per year. Implementation of on-site runoff controls could further reduce the suspended solids output by another 10,000 lb (4,536 kg). Site stabilization from permanent runoff quality controls represents a significant reduction in the site's pollutant export.

The outfall areas were prioritized for runoff quality control, with site stabilization the highest

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Table 9.1—Annual pollutant loads (in pounds).

	EXISTING SITE CONDITIONS	OUTPUTS AFTER MANAGEMENT	TOTAL REDUCTIONS
Total P	84	63	21
PO_4	48	33	15
Total N	610	478	132
NO_3	177	136	41
TKN	433	361	62
COD	16,737	12,896	3,841
BOD	2,193	1,712	481
Zinc	32	23	9
Lead	33	23	9
Copper	8	6	2

Source: Chris Athanas, Ph.D. & Assoc. 1992.

priority. Individual outfalls and the areas draining to them were considered for additional runoff management. One area that had consolidated four original outfall points is being treated by a constructed wetland to ensure reduced pollutant discharge. Management controls have been designed for other outfall points in case monitoring requires additional controls. While these practices may never be needed, the owner has set aside areas for possible use as vegetated swales, infiltration trenches, or sand filter systems.

The master plan development cost $42,000, including detailed design plans for the constructed wetland.

Recommended Reading

References Cited

Chris Athanas, Ph.D. & Associates. 1992. Vienna Power Plant Stormwater Management Plan. Final Rep. Laurel, MD.

National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges. Final Rule. November 16, 1990. 40 CFR Parts 122, 123, and 124.

U.S. Environmental Protection Agency. 1983. Results of the Nationwide Urban Runoff Program, Vol. I. Final Rep. PB84-185552. Washington, DC.

U.S. Environmental Protection Agency, Region 3. 1993. Pollution Prevention Plan Development. NPDES Storm Water Program Workshop.

Other Sources

U.S. Environmental Protection Agency. 1991. Guidance Manual for the Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity. EPA 505/8-91-002. Washington, DC.

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Washington Department of Ecology. 1992. Stormwater Management Manual for the Puget Sound Basin. Olympia, WA.

For NPDES guidance documents, contact Permits Division (see Appendix C).

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PART II

Institutional Issues

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CHAPTER 10

Governmental Strategies for Urban Runoff

The first part of this manual discusses urban runoff management problems caused by changes in land use. Problems include changes in hydrology, erosion and sedimentation processes, and the nature and amount of materials that runoff picks up from the land surface and conveys downstream. State and local governments have implemented a variety of programs to address these problems. Programs have traditionally focused on preventing or minimizing flooding to protect homes, buildings, property, and lives of citizens. Consequently, drainage ordinances and programs have been established just about everywhere.

Part II covers institutional approaches to prevent, mitigate, or correct runoff problems. No single solution or institutional framework is recommended to solve runoff problems around the country. Flexibility is needed to establish or refine programs, based on the area's existing legal authorities and institutional framework. However, no matter what a state or local government chooses to implement, it should consider certain issues or program components. As runoff management program objectives are broadened beyond the traditional drainage focus to encompass water quality protection, runoff reuse, and open space/recreation, existing programs must evolve and become more comprehensive.

Establishing Runoff Management Strategies

Program Goals

The goals of a runoff management program must be established when the program is initiated. Until recently, this was easy since programs typically dealt only with runoff quantity problems. Since the traditional focus has been on draining runoff away from improved property as quickly as possible, runoff management has been referred to as "drainage." The increasing awareness of runoff quality problems by citizens and elected officials and Clean Water Act requirements has forced state and local governments to broaden runoff goals. Today, program goals should include quantity, quality, erosion prevention and sediment control, good aesthetic values, runoff reuse, and open space/recreation.

Even the goals of runoff quantity management are changing. This broadening includes control of both peak discharge rate and volume, especially in closed basins and for discharges to estuaries. Peak discharge control, which limits postdevelopment discharges to predevelopment levels, is evolving from control of a single design storm to several design storms. To prevent stream channel erosion, controlling the peak discharge from a two-year, 24-hour design storm is becoming more common, along with controlling the peak discharge for flood control purposes, usually a 10-, 25-, or 100-year design storm. Some runoff management entities, such as the Suwannee River Water Management District and the Florida Department of Transportation, are requiring control of the critical storm. This storm creates the biggest difference between predevelopment and postdevelopment peak discharge rates and/or volume. Analysis of design storms—ranging from a one-year, one-hour storm to a 100-year, 24-hour

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design storm—is required to determine the critical storm.

Another consideration of a runoff management program is whether it minimizes runoff problems from new development, corrects runoff problems caused by existing development and land uses, or both. While most programs address both goals, priority and allocation of resource decisions must be made to address each problem.

The program's philosophy is determined by which goals it addresses and in what priority. The two basic philosophies of runoff management are prevention and cure. Preventing runoff problems rather than trying to cure them is easier, less expensive, and more effective. Unfortunately, runoff frequently is the "orphan infrastructure," and few resources are devoted to runoff management until some type of crisis—usually flooding with property damage and even injury or death—occurs. Even then, these problems often are corrected with quick fixes that may actually contribute to or worsen problems downstream. As a result, local governments and other providers are spending most of their efforts curing rather than preventing. Chapters 11, 13, 15, and 16 discuss aspects of this topic in more detail.

Program Tools

Urban runoff management uses many tools to prevent or correct problems. Additionally, its broadening objectives are producing new tools and refining existing ones. The program's goals play a major role in selecting the appropriate tools.

Runoff tools can be separated into two types—nonstructural and structural controls. Nonstructural controls help prevent runoff problems, while structural controls help mitigate the problems. Until now, most runoff programs have focused on flood control and relied on structural controls. Additionally, several nonstructural controls require changes in property—e.g., growth management, land use planning, zoning—often a controversial topic. Nonstructural controls include source controls that limit the types and amounts of pollutants in runoff. Many of these involve controlling or modifying certain aspects of human behavior such as using fertilizers, pesticides, or household cleaners. These controls, too, are highly controversial.

In broadening runoff management goals, structural controls often require reconsidering the usual BMP design, less emphasis and use of certain practices, and changing preferred alternatives. To improve pollutant removal, detention ponds must be changed to increase residence time and minimize short-circuiting, and shallow littoral zones planted with appropriate native wetland plants. Dry detention, used widely for flood control, provides little pollutant removal benefits because of its short detention time, bottom discharge control, and paved channels. In many locations, codes require that street curbs and gutters be used with storm sewers to eliminate runoff ponding, even for short time periods. Many localities are eliminating this requirement to promote infiltration, decrease runoff volume, and improve pollutant removal. Localities are promoting the use of roadside vegetated swales, especially in low-medium density residential areas.

Another consideration is how runoff controls are combined and integrated into a development. Increasing emphasis is being placed on the "treatment train" concept, in which several types of runoff controls are used together and integrated into a comprehensive management system. This is especially true when a project uses a wet detention pond as the primary control but promotes it as a visual and recreational amenity. To help prevent the wet pond from turning into an eyesore, swales rather than storm sewers can be used, and vegetated littoral zones added. Increasingly, small off-line depressional storage areas are being integrated into site plans, usually as part of the site's required open space and landscaping. Chapters 7, 8, 12, and 14 discuss these topics in more detail.

Program Approaches

Runoff management has two primary approaches:

- The on-site, piecemeal approach; and
- The comprehensive watershed approach.

Program goals determine which approach a state or local government selects. Selecting an approach also depends on the types of tools to be used to prevent or solve runoff problems. Finally, selection depends on the political will of elected officials and their financial commitment to the program. The piecemeal approach, the most widely used, is typically preferred when a program

- Is single-goal oriented, especially if it focuses on flood control;
- Is aimed at managing runoff from new development;

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- Is oriented primarily on structural controls;
- Is preventable in nature, especially from new development; or
- Regarding the impacts of new development, has limited financial resources that prevent it from developing a runoff master plan.

The watershed approach, which is gaining popularity, is preferred when a program

- Is multiple-goal oriented;
- Is aimed at curing existing runoff problems;
- Is oriented toward using nonstructural controls; or
- Has adequate financial resources, usually from a dedicated funding source such as a runoff utility.

Many programs around the country begin with a piecemeal approach and evolve into a watershed approach. While reasons for this evolution vary tremendously, it is often related to citizen pressure or changes in state or federal statutory or regulatory requirements, such as

- Increasing attention and pressure to reduce the water quality impacts of runoff discharges;
- Downstream flooding caused by the random location of numerous on-site systems;
- Reducing costs by promoting the use of nonstructural controls; or
- Recognizing the relationship between land use changes and stormwater problems.

Chapters 11, 12, 13, 15, and 16 discuss these topics in more depth.

Common Aspects of a Runoff Program

Establishing an urban runoff management program typically includes considering and resolving a number of needs or program elements.

Legal Authority

The program must have adequate state and local legal authority to accomplish its mission and use all its tools. Runoff programs generally protect the public's health, safety, and welfare. However, authority is needed to create, adopt, and enforce ordinances and regulations. Provisions must be made to establish performance standards and associated design criteria for various control measures. The state should grant statutory authority for local entities to set up dedicated funding sources, such as a runoff utility.

Administration

Administration is a major component of a runoff program, with its organizational location a key consideration. A number of other questions must be answered. Will the program be part of the state's environmental or water agency? Within the agency, will the program be a distinct entity or part of a larger program, such as wetland and floodplain management? What relationship does the runoff program have to the NPDES or the nonpoint source program? Locally, will the program be a distinct entity or part of public works or streets and drainage? Will its maintenance be the responsibility of a runoff utility, public works, streets and drainage, or parks and recreation?

Another administration consideration concerns the program's function. Will the program have separate administrative, planning, permitting, engineering, and operation/maintenance groups? Who will evaluate and monitor the system's performance? Who will manage program finances and legal needs? Who will conduct public education programs?

Planning

Effective runoff services and infrastructure should not be haphazard—often the normal method of operation. Planning is an essential program element to maximize cost-effectiveness and help meet goals. A runoff master plan based on a community's land use plan should be developed to provide a long-term map for capital improvement and operation/maintenance needs, particularly when addressing both runoff quantity and quality. Typically, a runoff plan covers a 20-year period and is broken down into five-year phases. Developing a plan helps determine the capital improvement costs, provides an implementation schedule, and identifies funding needs.

Capital Improvements

Designing and constructing runoff conveyances, storage, and treatment facilities is expensive, especially without a long-term plan. Engineering

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expertise is essential. More and more frequently, runoff programs have interdisciplinary staffs of planners, modelers, biologists, and landscape architects. Decisions must be made about whether to maintain this expertise in-house or rely on outside consultants. Regional facilities should meet additional needs such as open space, recreation, and public education.

Operation and Maintenance

For maximum benefits, structural controls must be properly maintained and operated. Policy questions include whether a local government should accept ownership of runoff facilities, especially for residential development; which facilities to own (e.g., those that provide service for both private and public lands); and, if ownership is not accepted, how to assure that systems are maintained and operated properly. In deciding whether to accept ownership of a runoff system, a local government must consider the type of facility and its maintenance needs. Today, development projects often incorporate runoff systems as green space or landscaping. Such areas need extensive, regular maintenance such as mowing to keep them aesthetically pleasing. In such cases, the local government must determine whether it wants to be subject to citizen complaints about the site's appearance.

Another consideration is how to handle material removed from runoff conveyances, especially runoff treatment systems. One question is whether such substances are considered hazardous or toxic waste. Tests performed on these materials generally indicate that they are not hazardous or toxic waste, so waste can be used for landfill cover. However, some very specialized runoff controls, such as oil/grease separators, may contain materials requiring special disposal.

Regulation

Generally, a runoff program includes regulations and a permitting program. Local governments must decide if the legal expertise required to develop, interpret, and enforce regulations should exist within the program or in another area. Permitting programs require staff with good public communication and interaction skills plus excellent, broad-based technical skills. Staff must apply and interpret complex technical rules and review site plans that will raise land use planning, hydrology, soils, geology, and engineering concerns. The site must be inspected regularly to assure that permit conditions are being met. Enforcement must be a priority to assure that regulations are followed. Enforcement can include many tools including stop work orders, administrative fines or tickets, and even prison. Governments must decide if enforcement will be conducted by general program staff or by specialized law enforcement personnel.

Monitoring and Evaluation

Regular evaluation procedures help determine whether the program is achieving its goals and being administered in an efficient, cost-effective manner. Procedures can include actual environmental monitoring such as water chemistry, biological communities, and sediment chemistry. Monitoring program objectives must be clearly decided when initiating the program. Decisions must be made about whether monitoring will be part of the runoff program or whether another agency or government will perform these tasks. Regular administration evaluations assure that regulated parties are treated consistently, equitably, and efficiently.

Education Programs

Since everyone who lives or works in a watershed contributes to its runoff problems, governments must undertake public education programs. Programs should be directed at the regulated community to help it understand the regulations and to increase compliance and efficiency in the permitting process. Plan reviewers, inspectors, designers, and contractors may need special training, and even certification programs. Education programs can often be conducted with professional associations such as the state engineering society, state bar, or general contractors association.

Educating the public about runoff programs, their purposes, and how every citizen must be a part of the solution is a crucial and continuing need. Citizens must understand how everyday activities contribute to runoff problems. Simple pamphlets inserted into utility bills, booklets, videos, and displays at local events have been used successfully. Special programs such as "stream (lake, bay) watch," "adopt-a-stream (lake, bay)," and "eco-neighborhoods" are proving successful in encouraging citizens to buy into programs. Youth group involvement in programs such as storm sewer stenciling is also highly effective.

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Technical Assistance

Runoff and watershed management programs rely on cooperation from many levels of government, the private sector, and citizens. As runoff programs become more comprehensive, new and complex problems arise. States and local governments need to provide technical assistance and take advantage of technical assistance offered by the federal government, other states, local governments, or private concerns. In many cases, a problem or control technique has already been addressed.

Good Science

One of the inherent needs of a runoff or watershed management program is sound, scientifically defensible information. This information is needed to develop regulations, BMP design criteria, accurate monitoring and evaluation techniques, and a better understanding of the relationships between land use changes and impacts on aquatic resources. Unfortunately, budget constraints at all levels of government have led to decreases in funding for essential scientific studies and research. To solve runoff problems, especially those caused by existing drainage systems, the nation must make a financial commitment to develop new control technologies, refine existing controls, and improve our understanding of the actual effects of intermittent discharges on aquatic systems and their biota.

Funding

As with any activity or program, adequate financial resources are essential to achieve program objectives. Legislators and local governments can enact the best laws and ordinances, but if resources are inadequate for implementation, legislation will not achieve the desired results. While protecting the environment ranks high in citizen polls, environmental programs do not fare well at budget time. One reason, of course, is intense competition for limited resources. Public health, safety, and welfare concerns such as crime, medical care, and education receive priority over environmental programs. For this reason, innovative alternative funding sources must be found for runoff and watershed management programs. State dedicated funding sources might include special fees on certain products such as cement, asphalt, oil, fertilizer, pesticides, or water; additional documentary stamp fees; or even specialized property or sales taxes. Locally, runoff utilities are the most widespread and equitable dedicated funding source. Additional funding sources can include permit, inspection, and impact fees.

Other Sources

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CHAPTER 11

Regulatory Strategies for New Development

An overall governmental or institutional strategy for effective management must include several key program components, including the development, promulgation, and enforcement of regulations. These regulations are necessary to technically define the goals of the runoff management program and to insure that they are achieved.

This chapter focuses on the regulations typically required to address the runoff management impacts of new land development by implementing permanent structural facilities or control measures. The chapter discusses key regulatory needs or roles necessary to establish effective facility design, design review, and construction inspection programs for permanent runoff control practices.

Finally, the chapter reviews the numerous federal programs that directly and indirectly affect a state or local runoff management program, reflecting the growing federal role in runoff. This summary, which includes both positive and negative aspects of the programs, can serve as a reader's guide to the extensive and confusing array of federal programs that affect local runoff management issues.

Facility Design

After establishing the goals of a runoff management program for new land development, strategies to achieve them must be defined. As described in Chapter 8, strategies can use structural and nonstructural controls, either separately or, preferably, in combination. Program regulations ensure that these strategies are properly implemented through specific regulatory needs or roles. In using structural controls or facilities, regulations must ensure proper facility design. To help achieve this, the following regulatory needs should be addressed.

Performance and Safety Standards

The regulations must establish a facility's performance and safety standards. Performance standards involve the outflow characteristics required to comply with the regulations—and achieve the overall program goals. Examples of requirements are (1) that the peak rate of runoff discharged by the facility after site development should not exceed a certain level from a specified range of storm events, and (2) that an extended detention time must be established for frequent storms to promote pollutant removal, with a specified removal rate.

The inherent risks of water impoundment by structural facilities require that safety standards be established to ensure acceptable risks from the facility's presence and operation. Requirements range from emergency spillways that safely convey the runoff from extreme storm events through the facility to safety measures that facilitate both normal and emergency maintenance activities.

The regulations should also address long-term maintenance by specifying who is legally and physically responsible. The regulations should also provide procedures to conduct periodic facility inspections and to notify the responsible party of the maintenance need. They should also provide enforcement powers to compel those recalcitrants who ignore such notification. Finally, the regulations must address the possibility that the facility might not be maintained or be abandoned and provide for the possibility of government ownership and maintenance.

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Because facility performance, safety standards, and regular maintenance are so vitally important, regulations should be promulgated through official and legally binding forms—laws, ordinances, resolutions, and official regulations. These avenues will ensure that the regulations are not changed arbitrarily but only by informed consensus and official action.

Computational Methods and Data Sources

Unlike performance and safety standards, the details necessary to design and construct structural runoff management facilities are best promulgated in documents with flexible formats such as handbooks, manuals, and guidelines. This flexibility is due to several factors:

- The site-specific nature of runoff and the structural facilities used to manage it;
- The relative accuracy and varied suitability of the computational methods currently used (see runoff and soil erosion estimating techniques in Chapter 1); and
- The constantly evolving body of knowledge and experience on all aspects of structural runoff facilities.

Beneficial changes to the standard methods and details can more easily be made in handbooks and manuals to respond to the specific needs of the site and facility. These informal publications also recognize the designer's professional discretion and legal responsibility. In addition, new and enhanced methodologies, technologies, materials, and data can be incorporated into the facility design process, eliminating the time-consuming and bureaucratic procedures of modifying existing laws, resolutions, and ordinances. In fact, these documents should acknowledge and encourage designers to develop and use improved techniques and features.

Regulatory discretion for design aspects such as computational methods and structural details requires competent and responsible personnel to design, oversee, and approve the facility. The next section provides more information on facility design review.

Regulations are required so that runoff management program goals can be achieved by safely constructing structural management facilities. Those promulgating design regulations must distinguish between standards and requirements fundamental to the program's goals and objectives and those that should be flexible to respond to scientific and practical improvements in runoff management. Regulations should not be subject to change without informed and official deliberations. In any case, competent and responsible personnel and an open attitude toward program enhancement are vital.

Facility Design Review

The second role of runoff management regulations is to provide an objective and thorough design review process. This is particularly true if discretion and flexibility have been incorporated in the facility design standards. Since discretion demands knowledge and responsibility, the program must include provisions for a timely, thorough, and objective design review prior to construction. The following guidelines are recommended:

Legal Responsibilities

Before developing review procedures and requirements, the legal ramifications of the design review process and implied by approval of the design should be addressed. In seeking the advice of legal counsel, clearly state the objectives of the review process. Make clear that, unless otherwise stated, the facility's designer is ultimately responsible for the performance, safety, and longevity of the structural facility—not the design reviewer, whose interests and authority are limited by the overall runoff program.

Because of the liability issues, designs should be supervised, approved, and certified by a licensed professional such as an engineer or architect. Seek legal counsel in all legal aspects of a runoff management program. Issues might include the extent of certification required on documents and computations submitted for approval, the time limit of the approval, and the extent of changes allowed before resubmission is required.

Minimum and Recommended Requirements

Regulations should establish both minimum and recommended submittal requirements for facility designs seeking approval. Minimum submittal requirements ensure that those conducting the design reviews have enough information to perform their task. Minimum requirements also ensure that the application process is fair and allow ap-

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plicants to accurately budget the time, effort, and expertise needed for approval. This accuracy helps establish fair and adequate review fees.

Recommended or optional submittal requirements can help more complicated projects or designs. Optional requirements include preapplication meetings between the designer and reviewer during the design process to address more complex project features. If used properly, these meetings can save considerable design and review time and lead to more effective structural facilities. This is particularly true if the preapplication meeting—and the entire design review procedure—operates in an open and cooperative manner and all design aspects, including the need for and type of facility selected, are objectively reviewed.

A comprehensive design review procedure should include a process to review and appeal denials and rejections. This process should include decision-review meetings between applicants, designers, and reviewers. These meetings can often resolve problems promptly and efficiently; save time, effort, and emotions; and preserve support for the runoff program.

Wherever feasible, regulations should establish maximum time limits for design reviews. While time limits can sometimes be onerous to individual reviewers, developers, and applicants, they allow both the reviewing agency and the applicant to better budget staff time and expenses. Time limits also provide the reviewer an incentive to obtain the required design information from the applicant. Programs that establish maximum time limits must also clearly define what constitutes a complete submittal, and allow the reviewer adequate time to determine completeness. The program should also allocate adequate time for logging, filing, notification, and other administrative procedures.

Level of Review

The design review process also entails deciding the level of review to conduct. This could range from a reviewer's simple check of plans, data sources, and computational arithmetic to a comprehensive and independent analysis of the proposed structural facility. Often, a combined approach is best, with the reviewer making arithmetic checks of standard or less critical design computations and independent computations of more critical aspects. The proper mix of review techniques depends on the legal responsibilities of the review process, the specific aspects of the design being reviewed, and the implications of design error and/or facility malfunction.

Self-Examination and Monitoring

This aspect of the design review process, including time spent by review personnel and the problems encountered, will help identify shortcomings, inefficiencies, and deficiencies in the process. This could include the extent of required submittal data, staff knowledge and training, and various administrative procedures. In many instances, the self-monitoring process can be used to identify deficiencies in the knowledge and/or abilities of the applicant or designer. These deficiencies can then be addressed through techniques ranging from more descriptive application forms and instructions to seminars and workshops on design, submittal, and review procedures and requirements.

Interaction and Dialogue

A truly effective design review process includes some interaction and dialogue with the design community that it oversees and facility construction and maintenance personnel. Such interaction—formally at regularly scheduled meetings and workshops or informally through professional or trade organizations—can help identify and correct review practices and specific facility requirements that are causing design, construction, or maintenance difficulties. The complexity of runoff processes and the growing scope of the programs intended to manage it make such a proactive approach to problem identification and resolution vital to the success of any regulatory program.

Facility Construction Inspection

Once the runoff facility design has been developed, reviewed, and approved, the facility must actually be put into service through construction. The importance of this point, however obvious or simple, should not be overlooked. Until a structural control measure is constructed and begins functioning, it has absolutely no effect on runoff and solves no runoff need or problem. Too frequently, facility design or review procedures become ends in themselves. The program goals are not realized by the production of a set of plans

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stamped "approved," but through construction and operation. Therefore, not only should the regulatory aspects of structural runoff facilities be focused on producing an effective, safe, efficient, and durable facility, they should also be focused on getting it constructed.

The same is true for construction inspection programs. The primary focus must be on constructing effective, safe, and durable structural facility. The return on investment is not realized until the project is constructed and functioning.

Legal Issues

In many ways, the regulatory needs of a construction inspection program are similar to those for facility design review. Prior to program start-up, all legal aspects and implications of the program must be thoroughly reviewed and accepted. This includes satisfactorily addressing the legal implications of the inspection process and the approvals it produces. All involved must understand that, unless otherwise stated, the ultimate responsibility for safe and proper construction rests solely with the builder, not with an inspector who has limited program interests and authority.

Construction Inspection and Reporting

A formal construction inspection and reporting procedure includes provisions for preconstruction and project start-up meetings, inspection schedules, documentation and dissemination of findings and observations, periodic progress and problem solving meetings, and postconstruction documentation and certification. As with preapplication meetings during the design review process, preconstruction meetings can be key to efficient and productive construction. These meetings can provide all parties an opportunity to familiarize themselves with the various procedures, personalities, and potential problems before construction begins and in the relatively calm environs of a meeting room rather than the immediate and highly-charged atmosphere of a construction site.

The regulations should provide a clearly defined role by describing the construction inspector's responsibilities and authority and suggest periodic review meetings to address problems and plan construction phases. The regulations should also require that the as-built drawings of the facility be subject to the review and approval of the inspecting agency. Finally, the regulations should provide certification procedures to officially designate the project's completion. This designation helps contractors and owners, who may need to terminate construction performance bonds and other sureties, and design review and construction inspection agencies.

Interaction

An effective construction inspection program includes interaction and interchange among facility designers, builders, and maintenance personnel. This interaction can take place formally at regularly scheduled meetings and workshops or informally through professional or trade organizations. It allows difficulties in design, construction, or maintenance to be identified and corrected. The complexity of runoff processes and the growing scope of management programs make proactive problem identification and resolution vital to success.

Federal Programs Affecting Runoff Management

Since passage of the 1972 Clean Water Act, a variety of agencies have introduced numerous federal programs to manage and protect water resources. Many of these programs directly affect runoff management by reducing its impact on aquatic systems, not only at the federal level, but also at state and local levels. Unfortunately, some of these programs—especially older ones—have single focus goals and/or legal mandates. These often conflict with the multifaceted environmental protection goals of more recent programs, particularly those that seek the holistic ecological goals of watershed management. Attaining runoff and watershed management goals will depend, in part, on modernizing existing laws and programs to make goals more consistent with those of more recent laws emphasizing environmental protection. The success of this modernization process, in turn, will depend upon how well we can integrate existing laws into watershed-based runoff management programs.

Before we can undertake such a process, we must understand each of the various federal programs that affect the development of local, state, and even federal runoff management programs and regulations. The following section lists the numerous federal programs that can affect, adversely or beneficially, the management of runoff and other nonpoint sources of pollution.

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U.S. Environmental Protection Agency

Clean Water Act

■ **Section 104, Water Quality Cooperative Agreements.** Supports programs and projects for the prevention, reduction, and elimination of pollution. Some eligible activities include special water quality studies, investigations of pollution control techniques, river corridor watershed management planning, and pilot and demonstration projects. Special programs funded through Section 104 include

- **Near Coastal Waters.** Improves the environmental conditions of near coastal waters through a watershed management approach. Eligible activities include developing and implementing regional strategies in targeted areas.
- **State Wetlands Program.** Increases the ability of state programs to protect wetland resources. Eligible activities include developing new state wetland protection programs or refining existing programs, watershed protection demonstration projects, state wetland conservation plans, and section 404 program assumption assistance.
- **Wetlands Protection Program.** Receives funding for activities in targeted watersheds such as advance wetland identification, public education, and enforcement.
- **Assessment and Watershed Protection Support.** Provides very limited funding for watershed planning priorities, regional targeting, and monitoring in support of section 305(b) reports.
- **Section 104(g).** Encourages the establishment or enhancement of small community outreach programs.

■ **Section 106, Water Pollution Control.** Administers programs to prevent, reduce, and eliminate water pollution. This is the primary federal grant funding source for state water quality management programs. Eligible activities include nearly all aspects of the prevention and abatement of surface and groundwater pollution—planning; monitoring; permitting; enforcement; and training, public education, and technical assistance.

■ **Section 205(j)(1).** Authorizes water quality management planning programs by states. Eligible activities include identifying pollution control methods to protect and restore waterbodies and monitoring programs conducted statewide or in targeted watersheds. Funded by a 1 percent set-aside of the state's Title II grant funds, it is being replaced by section 604(b).

■ **Section 303, Water Quality Standards and Implementation Plans.** Requires states to develop, adopt and enforce water quality standards that are at least as stringent as those adopted by the EPA and that will protect, maintain, and restore the chemical, physical, and biological integrity of all waters. It requires the regular review and, if needed, revision of water quality standards; the establishment, allocation, and enforcement of total maximum daily loads for certain waterbodies; and a continuous state water planning process.

■ **Section 304, Information and Guidelines.** Requires EPA and the states to establish water quality criteria and effluent guidelines for a wide variety of substances, especially hazardous and toxic ones. It requires states to develop a list of waters needing control strategies for toxic and other pollutants.

■ **Section 305, Water Quality Inventory.** Requires EPA to biennially report to Congress on the environmental quality of the nation's water resources and identify waters that do or do not meet their designated uses. States develop State Water Quality Assessment reports (305[b] reports) and submit them to EPA, which uses the information as the basis for its report.

■ **Section 314, Clean Lakes Program.** Establishes projects and programs to control pollution sources to lakes and to protect and restore the quality of lakes. Eligible activities include identification and classification surveys of all publicly owned lakes, state lake water quality monitoring and assessment, and public education. Lake restoration projects typically include three phases: a diagnostic/feasibility study; a restoration/protection implementation program; and postrestoration monitoring.

■ **Section 319, Nonpoint Source Program Implementation.** Supports activities that implement the states' EPA-approved nonpoint source management plans. These include basic program implementation tasks that help institutionalize the program within a state; watershed nonpoint source management program implementation

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within targeted watersheds; nonpoint source control practice installation at demonstration sites; and groundwater nonpoint source assessment and management programs.

■ **Section 320, National Estuary Program.** Authorizes development of comprehensive conservation and management plans, usually over a five-year period, for specific legislatively designated estuaries. It does not provide funding to implement approved plans, although other CWA funds (e.g., 319, Title II and VI) may be used.

■ **Section 402, National Pollutant Discharge Elimination System.** Establishes regulatory programs for point sources of pollution but exempts most agricultural activities. This program was originally designed to reduce pollution from point sources such as domestic and industrial wastewater discharges. This program now includes certain runoff discharges from specific industrial activities, including construction sites, and runoff discharges operated by local governments with a population over 100,000.

■ **Section 404, Permits for Dredged or Fill Material.** Establishes a regulatory program to control the discharge of dredged or fill material into navigable waters (wetlands). This program is administered by the U.S. Army Corps of Engineers, using permitting guidelines developed in coordination with EPA. The section allows a state to administer the program, with EPA having veto power.

■ **Section 604, Title VI Water Quality Management Planning.** Requires each state to reserve 1 percent of the State Revolving Loan Fund grant for water quality management planning activities required by section 205(j) and 303(e). Eligible activities include projects to determine the nature, extent, and causes of water quality problems; to identify cost-effective and acceptable point and nonpoint source controls; and to develop implementation plans.

Federal Safe Drinking Water Act

■ **Section 1443, Underground Injection Control.** Establishes federal and state programs to protect groundwaters from these sources. It provides grants to states to fund all types of related activities.

■ **Section 1442, Wellhead Protection.** Provides technical assistance and funding to states and local governments designing and implementing wellhead protection programs. Eligible activities include delineation of wellhead protection areas; identification, mapping, and sampling of contamination sources; public education; and development of ordinances.

U.S. Department of Agriculture

■ **Agricultural Conservation Program (ACP).** Administered by the USDA Agricultural Stabilization and Conservation Service (ASCS), ACP is designed to control erosion and sedimentation and encourage voluntary compliance with federal/state requirements to solve point and nonpoint source pollution. It provides financial assistance to individuals in all U.S. counties to implement conservation practices. Recently, water quality improvement has received special emphasis. However, allowable BMPs and funding amounts are set by county and state committees, which are usually dominated by agricultural interests.

■ **Conservation Reserve Program (CRP).** Administered by the USDA ASCS, CRP is intended to return certain agricultural lands—which are highly erodible or otherwise critical in protecting and restoring water quality—to a conservation use, typically as grass or forests. Farmers receive payment per acre to conserve these lands for a contracted period, typically 10 years.

■ **Wetlands Reserve Program (WRP).** Administered by the USDA ASCS, WRP is intended to restore and protect farmed or converted wetlands. Farmers receive direct payments and conservation planning and technical assistance to install necessary restoration practices on areas they agree to maintain under a conservation easement.

■ **Resource Conservation and Development Program (RC&D).** Administered by the Soil Conservation Service, RC&D encourages and improves the capability of state and local entities in designated rural areas to plan, develop, and implement programs, typically in targeted critical areas.

■ **Soil and Water Conservation.** Administered by the USDA SCS, this program provides technical assistance to the public through total resource planning and management to improve water quality and natural resources and reduce pollution sources. USDA SCS also publishes detailed soil surveys for each county and provides a variety of useful natural resources management information.

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■ **Watershed Protection and Flood Prevention (Small Watershed Program, PL-566 Program).** Administered by the USDA SCS, it provides technical and financial assistance to state agencies and local governments to develop and implement plans that protect, develop, and use land and water resources in small watersheds. Recently, this program has been broadened to emphasize protecting and restoring water quality, especially from flooding, erosion, sedimentation, and use/disposal of water problems.

U.S. Department of the Interior

■ **National Water Quality Assessment Program.** Administered by the U.S. Geological Survey, it addresses a wide range of major water quality issues, with special emphasis in the next few years on pesticide impacts on water resources. The program will include nationwide surface and groundwater quality monitoring and assessment.

■ **Water Data Program.** Administered by the USGS, it consists of four water quality monitoring networks, the most important of which is the National Stream Quality Accounting Network (NASQAN). Data on stream flow and height, lake stage and storage, groundwater levels, well and spring discharge, and the quality of surface and groundwaters is collected and stored in National Water Data Storage and Retrieval System (WATSTORE).

■ **Federal State Cooperative Program.** Establishes a partnership for water resources investigations between the USGS and state and local agencies. This program is the foundation for much of the planning, development, and management of the nation's water resources.

■ **Coastal Wetlands Planning, Protection and Restoration Program.** Administered by the U.S. Fish and Wildlife Service, it provides funds to acquire coastal lands or waters and to restore, enhance, or manage coastal wetland ecosystems. Projects must provide for the long-term conservation of these lands and waters.

■ **Land and Water Conservation Program.** Administered by the National Park System, it was established to create and maintain a national legacy of high quality recreation areas. It provides funding for federal acquisition of authorized national park, conservation, and recreation areas and to state and local governments to help acquire, develop, and improve outdoor recreation areas.

Federal Highway Administration

■ **Federal Aid Highway Program.** Assists state agencies in developing and improving an integrated, interconnected transportation system. Funds may be used for planning, research and development (including BMPs), restoration, roadside beautification, and wetland mitigation. It provides funding for erosion and sediment controls needed to minimize highway construction impacts but not typically to treat and manage highway runoff. However, the Surface Transportation Program authorizes funding for highway runoff quality controls and for mitigating damage to ecosystems, habitat, and wildlife.

U.S. Army Corps of Engineers

Civil works projects are specific line-item congressional appropriations in the biennial Water Resources Development Act. They provide help to communities for a variety of water resource problems including flood control, coastal and shoreline erosion, environmental restoration, and water quality management. Projects must include mitigation of unavoidable environmental damages and must also consider environmental restoration through opportunities created with projects.

The following programs have great potential to adversely affect aquatic systems and impede runoff management to protect or restore water quality:

■ **Small Flood Control Projects.** Pursuant to section 205 of the Flood Control Act of 1948, the Corps is authorized to reduce flood damages through projects not specifically authorized by Congress. However, the Corps is restricted to making improvements to natural water courses—typically structural, such as bank hardening or dredging—and cannot consider watershed runoff improvements.

■ **Snagging and Clearing for Flood Control.** Pursuant to the Flood Control Act of 1937, it allows the design and construction of flood control measures that typically increase drainage and decrease water quality.

National Oceanic and Atmospheric Administration

■ **The Coastal Zone Management Act of 1972.** Allows states to prepare and implement comprehensive management programs for coastal re-

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sources that balance competing demands on resource protection, protection of public health and safety, provision for public access, and economic development. States with federally approved programs receive federal grant funds to develop and implement a wide variety of coastal resource management initiatives.

- **Section 6217, Coastal Nonpoint Pollution Control Program.** Jointly administered with EPA, which is responsible for establishing minimum nonpoint source management measures. States with federally approved coastal zone management programs must develop and implement nonpoint source control programs to restore and protect coastal waters and must comply with the minimum nonpoint source management measures.

- **National Estuarine Research Reserve System.** Establishes and manages a national system of reserves representing different coastal regions and estuarine types. The reserves serve as field laboratories and public education centers.

- **National Marine Sanctuary Program.** Identifies areas of the marine environment of special significance and provides authority for comprehensive and coordinated conservation and management. It also provides for research and monitoring activities and public education.

Information Sources

Further information on these programs can be obtained from *Watershed Protection: Catalog of Federal Programs* (EPA-841-B-93-002), a 1993 publication of the U.S. Environmental Protection Agency's Office of Water, Washington, DC.

U.S. Environmental Protection Agency. 1991. Guidance Manual for the Preparation of NPDES Permit Applications for Storm Water Discharges Associated with Industrial Activity. EPA 505/8-91-002. Washington, DC.

———. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA-840-B-92-003. Off. Water, Washington, DC.

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CHAPTER 12

Site Planning and Other Nonstructural Management Practices

In the long run, preventing runoff problems is easier and much less expensive than correcting problems later through expensive infrastructure construction and resource restoration. This chapter presents a variety of effective management practices that can be used to prevent runoff problems. These preventive controls, called nonstructural management practices or best management practices, include regulatory practices, such as buffer zones or limits on impervious areas, and source controls, such as public education, growth limitations, and protection of sensitive areas to reduce runoff pollution sources. Unlike structural controls, which address runoff problems on a particular site, nonstructural controls are used throughout an entire community, watershed, or special protection zone.

Most nonstructural BMPs are associated either with land use changes or with educating citizens to encourage a change in lifestyle activities. Accordingly, local governments primarily develop and implement nonstructural management practices and programs, although state and regional agencies can join the implementation team. Recently, federal agencies and programs have begun to emphasize pollution prevention activities.

The nonstructural management practices tool box contains a large number and variety of nonstructural BMPs. An urban runoff management plan for the Santa Clara Valley in California, for example, includes more than 100 potential nonstructural BMPs. Local governments and other users of nonstructural measures should screen BMPs to determine those most appropriate for a given area.

Historical Problem Areas

In most parts of the United States, many state and local governments have been discouraged from implementing programs to control or regulate land use and development. This reluctance developed because of an abundance of easily developed land and a lack of understanding about the negative impacts of growth and development on natural resources. With real or perceived concerns about potential property rights questions and sensitivity about restricting a person's use of private property, governments have proceeded cautiously in establishing land use controls, setting specific development design or performance requirements, or restricting citizen activities. Currently, eight states have implemented statewide growth management programs, and many state and local governments have instituted various types of zoning, permitting, or other programs that restrict activities or new development. However, developing and implementing these programs is frequently controversial.

Many source controls involve changing citizens' lifestyles or activities. Every citizen who lives in, works in, or visits a watershed contributes to urban runoff problems through everyday activities. Whether traveling in a motor vehicle on a paved or unpaved road, using fertilizers or pesticides, using household cleansers, or walking the family dog, each individual contributes pollutants to the watershed. Educating citizens to encourage

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a change in habit is difficult. First, we must convince citizens that runoff is a pollution source, that their everyday activities contribute to this pollution problem, and finally that changing their ways helps prevent pollution.

Site Planning and Other Nonstructural BMPs

Institutional Framework

Local governments are typically the public entity responsible for reviewing and approving development plans. Local governments influence and guide urban development, depending on state laws and local ordinances, by identifying where and how development should occur through local land use plans and associated policies. These plans and policies are implemented through specific ordinances and mechanisms known as land development codes or regulations, which establish the legal basis for reviewing and approving development plans, monitoring implementation, and enforcement. Many nonstructural management practices—limits on site clearing and impervious areas, landscaping, buffer zones, and others—can be incorporated into local land development codes. (See Chapter 11 for summary of regulatory programs.)

Development plan review by local government addresses a wide range of public policy concerns including traffic circulation, safety, health, landscaping, tree protection, and public services. Plan review and approval protects natural resources, especially water resources, by addressing potential water quality degradation sources such as construction, runoff, and septic tanks. Plan review should also include preservation of critical areas and wildlife habitats. Local governments can prevent problems and solve existing and potential problems by implementing a comprehensive site plan review process. Effective development reviews lead to more efficient use of land, water, and cultural resources and can help eliminate or reduce difficulties experienced by landowners.

In developing regulations, local governments need to screen various nonstructural management practices to determine those most beneficial in a particular area or situation. Screening methods should include criteria specific for the watershed's conditions and for the goals of the watershed program. Typical criteria include

- **Pollutant control and effectiveness.** This criterion should be from pollutants of primary concern or known pollution problems. Consider reliability and longevity of the controls along with siting and design constraints.

- **Control acceptability.** Controls should be accepted by the public and by public agencies responsible for implementing and maintaining BMPs.

- **Technical and economic feasibility.** Some BMPs may require considerable technical expertise, staffing, and financial resources. Cost considerations should include planning, design, construction, operation, and maintenance.

- **Legal authority and considerations.** Local land development codes must provide adequate legal authority to implement and enforce requirements. Evaluate risks or liabilities that may occur in implementing control measures.

- **Existing government framework.** Governments vary greatly around the country. The roles, powers, and duties of multiple levels of local and regional governments greatly influence the effectiveness of a potential nonstructural BMP, especially one that relies on widespread implementation.

Although local governments have unique requirements and steps in the development review process, certain elements common in most procedures include

- **Comprehensive plan amendment.** In most cases, proposals for land development should conform to the local government's adopted land use plan and map. If the proposed development is not consistent with the plan, an amendment to the local plan or map may be necessary.

- **Rezoning.** Once the development and local plans are consistent, an official change in the site's designated zoning may be necessary.

- **Development plan review and approval.** Through this process, plans for land improvements, buildings, and related activities are reviewed for compliance with local land development regulations. This review can include multiple steps such as subdivision

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approval (e.g., conceptual, preliminary, and final plat). The process usually involves preparing a site plan, especially for commercial, industrial, and multifamily developments.

- **Engineering plans.** This step includes preparing and receiving final approval of designs for utilities, wastewater management, runoff management (including erosion and sediment control), roads, and building construction.

- **Building permits and approvals.** Necessary federal, state, regional, and local permits should be obtained before beginning construction. In many areas, no land clearing is allowed until certain permits such as clearing and grading, erosion/sediment control, and runoff management are obtained.

Planning with Nature

The United States' rich and diverse environment has a tremendous variety of natural systems, with many well suited to urban development. However, many systems have low tolerances for intensive development and, if radically altered, can no longer perform their basic functions. A main purpose of site planning is to encourage the use of comprehensive design principles that preserve the integrity of the natural environment. In this sense, site planning is a preventive measure and, frequently, a neglected element of land development.

Natural systems provide unique and beautiful environments that attract visitors and residents alike. These systems also supply, transport, cleanse, and store water; assimilate and filter wastes; modify and moderate the climate; provide storm protection and dampen floodwater; produce food; oxygenate and purify the air; recharge aquifers; build land; and provide recreational and economic opportunities. Perhaps the greatest benefit provided by natural systems is their self-maintaining capability. When used within their tolerance levels, natural systems provide a variety of services efficiently, dependably, and at no cost to humans. This self-maintaining capability is in direct contrast to most constructed systems that require money and energy to maintain. Like any other complex system, natural systems can operate efficiently only as long as their ecological integrity is maintained. If essential components are damaged or destroyed, or if the system as a whole is overstressed, the natural biological processes will break down and the system will fail. Therefore, economic sense dictates that each system fulfill its proper function and maintain peak efficiency by thoughtful, insightful resources management.

Principles of Runoff Management

The following principles should be used to develop a site plan:

- Preventing problems is much more efficient and cost-effective than attempting to correct problems after the fact. Sound land use planning decisions based on the site planning principles discussed later in this chapter are essential as the first, and perhaps the most important, step in managing runoff problems. All new development plans (e.g., subdivisions, shopping centers, industrial parks, office centers) and redevelopment plans should incorporate nonstructural management practices, including source controls, along with a comprehensive runoff management system.

- Every piece of land is part of a larger watershed. Since we all live downstream, a runoff management system for each development project should be based on and support a plan for the entire drainage basin.

- The runoff management system should mimic and use the features and functions of the natural runoff system, which is largely capital, energy, and maintenance cost free. Every site contains natural features that contribute to runoff management under existing conditions. Depending on the site, existing features such as natural drainageways, depressions, wetlands, floodplains, highly permeable soils, and vegetation provide natural infiltration, help control runoff velocity, extend the concentration time, filter sediments and other pollutants, and recycle nutrients.

Each development plan should carefully map and identify the existing natural system. Use natural engineering techniques to preserve and enhance the natural features and processes of a site and to maximize the economic and environmental benefits. Natural engineering is particularly effective when the runoff system is integrated into a site's landscaping, open space and recreational areas, or in "blue-green" developments using permanent lakes and cluster tech-

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niques. Engineering design can and should be used to improve the effectiveness of natural systems, rather than negate, replace, or ignore them.

- The volume, rate, timing, and pollutant load of runoff after development should closely approximate the conditions before development. To accomplish these objectives, two overall concepts must be considered: (1) maintaining the perviousness of the site to the greatest extent possible; and (2) slowing the rate of runoff. Give preference to runoff management systems that use BMPs to maintain vegetative and porous land cover and include on-site storage mechanisms. These systems promote infiltration, thereby reducing, filtering, and slowing runoff.

- Maximize on-site runoff storage. Storage provisions can reduce peak runoff rates; aid in groundwater recharge; provide settling of pollutants; lower the probability of downstream flooding, stream erosion, and sedimentation; and provide water for other beneficial uses. Where practical, the blue-green development approach should be employed, since it inherently provides storage, environmental protection, and enhanced community amenities.

- Runoff should never be discharged directly into surface or groundwaters. Runoff should be routed over a longer distance, through grassed conveyances (swales), wet ponds, vegetated buffers, and other practices that increase overland sheet flow. These practices increase infiltration and evaporation, allow suspended solids to settle, and remove pollutants before they reach downstream receiving waters and groundwaters.

- Plan, construct, and stabilize runoff management systems, especially those emphasizing vegetative practices, before development. This principle frequently is ignored, causing unnecessary off-site problems, extra maintenance, regrading, revegetation of slopes and grassed waterways, and extra expense to the developer. Construct and stabilize the runoff management system, including erosion and sediment controls, at the start of site disturbance and construction activities.

- Design the runoff management system beginning with the project's outlet or point of outflow. The downstream conveyance system should contain sufficient capacity to accept the discharge without adverse downstream impacts such as flooding, streambank erosion, and habitat destruction. Downstream conveyance systems may need stabilization, especially near the system outlet. Another common problem is a restricted or submerged outlet. This can cause runoff to back up and exceed the storage capacity of the collection and treatment system, resulting in temporary upstream flooding. This situation may lead to hydraulic failure of the runoff management system, causing resuspension of the pollutants and/or expensive repairs to damaged structures or property. In such circumstances, more than one outlet or an increase in the on-site storage volume may be needed.

- Whenever possible, follow the topography to construct the components of the runoff management system. This step will minimize erosion and stabilization problems caused by excessive velocities and slow the runoff, allowing for greater infiltration and filtering.

- Runoff, a component of the total water resources, should not be casually discarded but used to replenish those resources. Runoff is a misplaced resource, with location and timing determining whether it is a liability or an asset. Given the water quantity and quality problems facing our nation, we must consider runoff an asset. Treated runoff can potentially provide many beneficial uses such as irrigation of farms, lawns, parks, and golf courses; recreational lakes; groundwater recharge; industrial cooling and process water; and other nonpotable domestic uses.

- Whenever practical, integrate multiple-use temporary storage basins into the management system. Too often, planned facilities are conventional, unimaginative, aesthetically unpleasing ponds. Recreational areas (e.g., ballfields, tennis courts, volleyball courts), greenbelts, neighborhood parks, and even parking facilities provide excellent settings for temporary runoff storage. Such areas are not usually used during precipitation, so runoff ponding for short durations will not impede their primary functions.

- Design storage areas with sinuous shorelines. Curves increase the length of the

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shoreline and create greater development opportunities, especially in using the blue-green concept of permanent lakes. The increased shoreline also provides more space for the growth of littoral vegetation to provide greater pollutant filtering, more diversified aquatic habitat, and greater attractiveness (aquascaping).

- Retain vegetated buffer strips in their natural state or create strips along the banks of all waterbodies. Vegetated buffers prevent erosion, trap sediment, filter runoff, provide public access, enhance the site amenities, and function as a floodplain during high water periods. They also provide a pervious strip along a shoreline to accept sheet flow from developed areas and help minimize the adverse impacts of untreated runoff.

- Maintain the runoff management system. Failure to provide proper maintenance reduces the system's pollutant removal efficiency and hydraulic capacity. Lack of maintenance, especially to vegetative systems requiring harvesting or revegetating, can increase the pollutant load of runoff discharges. The key to effective maintenance is to assign responsibilities to an established agency or organization, such as a local government or homeowners association, and to regularly inspect the system to determine maintenance needs. An even better tactic is to design a system that is simple, natural, and as maintenance free as possible.

The Site Planning Process

Site planning requires determining specific uses for definitive land areas and planning development to achieve a community character and an amenable quality of life. To achieve this end, assemble and analyze all pertinent site information—social, ecological, cultural, economic, political—to determine the project's ultimate design or feasibility.

Site planning can help preserve the site's integrity and diverse natural systems. Assessing the opportunities and constraints imposed by a site's features helps avoid or minimize potential problems and hazards, decrease construction and maintenance costs, and attain a community character that produces an amenable quality of life.

Innovative development techniques, such as planned unit or cluster developments, are extremely well-suited for site planning. Not only do these techniques reduce costs, they also allow greater flexibility and can incorporate natural and cultural resources into the development plan. These techniques foster a harmony between the development and existing natural systems, creating opportunities for amenities such as open space, recreation, and beauty not commonly found in developments.

Site plan contents will vary, depending on state requirements and local ordinances. However, site plans typically include a development plan and a street and utility layout. Most important, a site plan includes plans for grading, soil erosion and sediment control, runoff management, and landscape. Development and infrastructure plans created in harmony with the site's constraints and opportunities greatly influence their effectiveness in protecting site and watershed resources. Coordinate these elements to assure a logical sequencing of events. For example, a sediment basin in the erosion and sediment control plan can become a permanent runoff detention basin. Additionally, all initial and final elevations in the grading plan should be consistent with facilities in both the erosion and sediment control plan and the runoff management plan.

Developing a site plan requires a careful step-by-step analytical approach, which often includes the following steps:

- **Conduct a site evaluation.** Assess existing natural and cultural features and determine suitability for the proposed development activity.

- **Develop site maps.** These allow visual inspection and analysis of site features and their relationship to the alternative site development plans.

- **Collect additional information.** This is needed to finalize conceptual plans.

- **Review site plan goals.** Goals should properly address requirements of state and local laws, ordinances, permitting regulations, comprehensive plans, and land development codes.

- **Develop and integrate the individual components of the site plan.** Each component should include goals, desired performance, design considerations for chosen BMPs, operation and maintenance needs, costs, and scheduling.

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Conducting a site evaluation is the heart of the site planning process. It includes collecting and analyzing the information to prepare a final development plan in harmony with both the natural and cultural communities. The following section discusses this process in more detail.

Site Evaluation

Site selection is the most critical stage of the development process. Developers must begin planning for a new project before the land is purchased to evaluate the suitability of potential sites. Usually a developer lacks the luxury of choosing an ideal location but must rely on what is available at a price that can return a reasonable profit. Whether the project begins with a site or an idea, the site's physical characteristics and location in the community will determine the feasibility of the concept. Site selection and evaluation must consider two important factors:

- The opportunities and constraints the site brings to the proposed development—elevation, hazards, soil types, water table elevation, runoff management, and
- The community impact, especially in adjacent and downstream areas.

In analyzing the site and its surroundings, include all natural, cultural, and aesthetic features that affect it and illustrate the information graphically (site maps). These features influence final site selection and provide clues to site personality that will help establish and select guidelines for later development. The following steps are useful in selecting a site or analyzing one already selected:

- Collect basic data for surface and subsurface features. Analyze and interpret aerial photographs, maps or charts, previous environmental and cultural resource studies, and field surveys. Much of this information can be obtained from local planning departments as a result of local government comprehensive planning efforts.
- Organize and present the basic data graphically. Recent advances in the technology and application of computerized geographic information systems facilitates mapping and analysis.

Table 12.1—Site selection, analysis, and planning factors.

NATURAL FACTORS	
Climate	Solar orientation, wind, precipitation, and humidity
Geology	Bedrock and surficial
Physiography	Geomorphology, relief, and topography
Hydrology	Surface and groundwater
Soils	Classification of types, limitations, and capabilities
Vegetation and wildlife	Plant communities and habitats
Critical areas	Identification and protection
CULTURAL FACTORS	
Existing land use	Ownership of adjacent property and off-site nuisances; projected future land use of site and adjacent property
Traffic and transit	Vehicular and pedestrian circulation on or adjacent to site
Density and zoning regulations	Legal and regulatory controls
Socioeconomic	Market analysis, suitability
Utilities	Wastewater, stormwater, water, gas, steam, electricity, and telephone
Historical and archaeological	Historic buildings, landmarks, and archaeological sites
AESTHETIC FACTORS	
Natural features	Location, protection, views
Spatial pattern	Views, spaces, and sequences

Source: Livingston et al. 1988.

- Analyze and interpret maps singly and in combination. Identify critical areas needing preservation or special treatment; evaluate appropriate locations for buildings, roads, and utilities; and prepare alternative conceptual development plans.
- Interpret maps for planning decisions. Contact representatives of state and local government agencies for various jurisdictional determinations where appropriate.

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- Prepare composites map. These illustrate the general and specific development limitations and opportunities of the whole or part of the selected site.

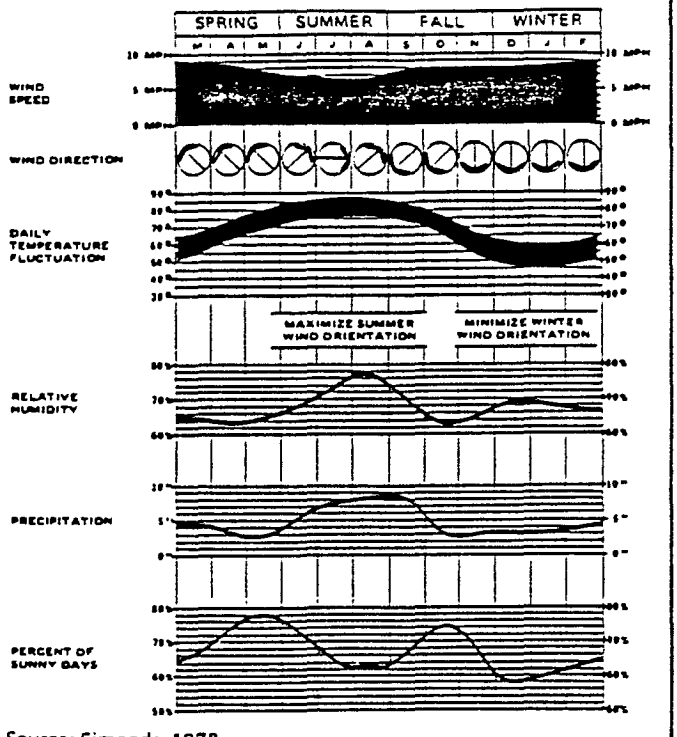
A number of important natural, cultural, and aesthetic factors should be considered in site selection, analysis, and planning (Table 12.1). The remainder of this chapter discusses each of these factors, along with design or development guidelines.

Natural Factors

Climate

Planning Considerations. The chief climatic control factors are latitude, physiography, temperature, and proximity to waterbodies. Climate is usually characterized within well-established probabilities. However, site planning must be concerned with extremes as well as averages. Floods, droughts, hurricanes, and coastal storm surges should all be considered during the development planning phase. Precipitation and temperature are major factors affecting vegetation.

Figure 12.1—Sample summary of site's climatic data.



Source: Simonds, 1978.

Proper building orientation can ameliorate hot and humid climates by taking advantage of shade and prevailing breezes. In colder climates, building orientation and positioning help reduce cold winds and provide solar reflection and heating. A summary of a site's climatic data (Figure 12.1) can help plan an environment for living.

Design Guidelines

- Arrangements, materials, and conformation of site plans and structures should be designed according to the climate and the site's microclimate—variations to the climate due to on-site factors such as water and trees.
- Sites along lake shorelines and ocean coastlines, especially along the Gulf of Mexico and the Southeast Atlantic, are vulnerable to storms—including hurricanes—with high winds and storm surges. Coastal developments should preserve the remaining protective sand dunes, ensure that floor levels of structures are above flood levels, and carefully consider the potential effects of an intense storm or hurricane to minimize property damage and personal injury.
- Use open patterns in hot and humid climates to take advantage of prevailing summer winds.
- Take advantage of the cooling provided by waterbodies and shade trees when locating housing.
- Shield heat-prone paved surfaces, such as streets or parking areas, in the shelter of structures that provide shading.

Sources of Information

- **U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Asheville, North Carolina.** This agency collects and compiles climatological data for many areas throughout the country. The amount of information varies, but most stations record daily temperatures and precipitation. Some stations have detailed monthly reports and an annual summary that tabulates records from stations statewide. Most major libraries receive these publications.

Geology

Planning Considerations. Although a site's underlying rock structure is used much less frequently than the surface soil layers, it is of critical importance. Surveying and analyzing subsurface

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geological conditions provides essential information that might affect development. This is especially true for karst areas that have thick formations of easily dissolved limestone, creating a high number of sinkholes.

The subsurface geology is a source of raw materials, a reservoir for water and waste disposal, and gives the land backbone—allowing it to support heavy structures. It also contains important mineral deposits. Improperly analyzing and using this resource can result in jeopardized water supplies, ineffective disposal systems, and damaged buildings and roads. Knowledge of subsurface geology is also needed to answer questions about the weight-bearing capacity, availability of potable water, physical limitations, suitability of the site, and infiltration potential on runoff control. An area's surface physiography is a direct result of its geology.

Development Guidelines

- Karst topography has important implications since sinkholes can form at any time. Therefore, geologic mapping and evaluation completed prior to design should consider all environmental factors that affect design and construction. This preliminary feasibility study should consider adverse geologic conditions (i.e., location of sinkholes and other limestone formations) and the economics of grading and other land modifications.

- Potential sinkhole formation should be evaluated. Roadways, structures, sewage lagoons, landfills, and runoff systems should not be located in areas likely to develop sinkholes.

- Recent evidence indicates that vast dendritic underwater networks connect many sinkholes, allowing rapid transmission of pollutants through this underground river system. Extreme care is needed to prevent introducing runoff/pollutants into groundwater, a major source of fresh water.

Sources of Information

- **Department or bureau of geology.** Most states have a geology department or bureau within a state resource management agency. This department will often have environmental geology maps and reports that provide basic data to create and execute sound programs for waste disposal, water resources and land management, building and highway construction, geologic hazards identification, and mineral extraction. Many departments also publish numerous in-depth studies for small areas, but site-specific investigations may still be needed.

- **Universities.** Many universities have geology departments with studies useful to the planner or developer.

- **U.S. Geological Survey.** This agency publishes many types of technical reports and maps useful in determining a site's geological characteristics.

- **Well Logs.** These records, prepared by well drilling contractors, identify the type of material and depth of various subsurface formations. Many states require these logs.

Physiography

Planning Considerations. Physiography is the study and description of landforms or irregularities of the earth's surface. Knowing the original topography, drainage, and vegetation of different landforms is important to minimize potential development problems and hazards in siting/design of building and grounds.

States generally have several major physiographic divisions, which can be further broken down into major landforms. These landforms and divisions are combined and described by the USDA SCS's major land resource areas (MLRAs). An MLRA is a land area characterized by particular soil patterns, including slope and erosion, climate, water resources, and land use. The Agricultural Handbook (U.S. Dep. Agric. 1976) describes each MLRA in the country.

The most important physiographic element to the developer is site topography. Topographic information is critically important because hills and valleys, plateaus and ridges, height, and slope degree all affect the area's ecology and suitability for development. Topography influences the type and cost of development, controls the direction and rate of water runoff, influences the overall utility layout, adds variety to the landscape, influences the weather and climate, and affects the types of vegetation and wildlife. A slope analysis (Figure 12.2) performed on hilly sites determines the best land uses for various portions. Moderately sloping sites are preferable to steep or level land. Improvement costs rise sharply on slopes over 10 percent, unless they are specially planned and treated. Preserving the area's natural amenities—trees, terrain, and views—can significantly reduce development costs.

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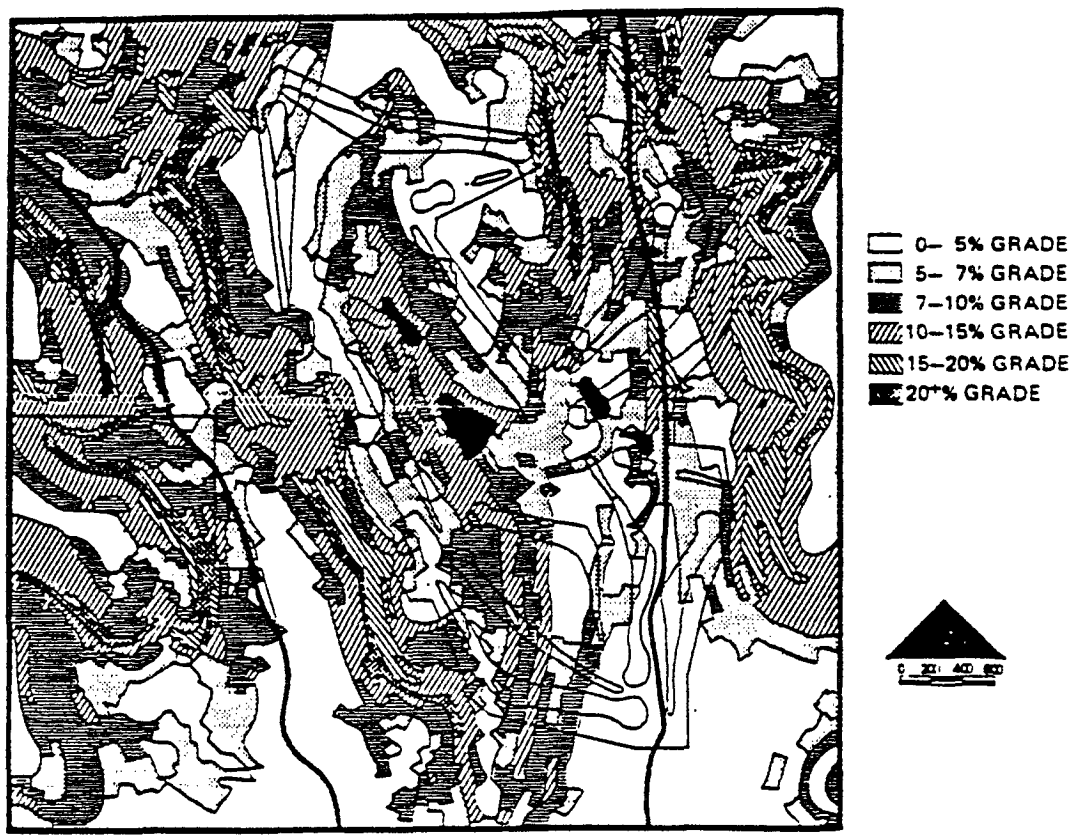
Figure 12.2—Slope analysis for hilly site.



Source: Rubenstein, 1980.

Development Guidelines

- Obtain a topographic site survey before purchase. A thorough topographic survey will provide such physiographic data as the elevation, amount, and direction of slope, ridges, and valleys; location of rivers, lakes, sinkholes, and wetlands; outline of wooded areas, rocky areas, or outcroppings; and scenic vistas.

- Preserve the natural topographic features. This step involves preserving floodplains, streams, sinkholes, and other waterbodies by building well back from their edges, thereby creating common open space along shorelines.

- Let the topography guide the land use plan. A community designed in harmony with nature benefits from the services provided by nature, uses the natural landscape rather than creating a new, artificial landscape, and requires less time, effort, and expense.

- Control or prevent development on steep slopes, highly erodible soils, and areas with threatened or endangered species.

- Place roads parallel to the contours on ridges to minimize the need for cut and fill. Stabilize cut and fill banks with minimum maintenance materials to prevent continuing erosion problems.

- Use cluster development when sites contain steep slopes or other physiographic characteristics that would increase development costs or disrupt the natural systems.

Sources of Information

- **On-site inspection.** This visit is the cheapest, most thorough, and most reliable source of information. However, the inspector must be knowledgeable and experienced.

- **U.S. Geological Survey.** Topographic quadrangle maps are reliable for actual to-

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pography, but the scale and contour interval are usually too large to be useful for smaller properties. The maps also show location of urban areas, constructed structures, highways, railroads, waterbodies, and other physiographic features.

- **USDA SCS.** Detailed soil surveys, which include aerial photographs, delineate general slopes, wet areas, and other sensitive areas.

- **Aerial photographs.** These photos can help one get the feel of an area, although thorough, accurate interpretation usually requires the services of a professional. Aerial photographs may be available from a state transportation or revenue department, regional planning commission, county tax assessor's office, or private firms authorized to sell aerial photographs.

- **Local registered land surveyors.** These professionals can supply and interpret site topographic maps.

Hydrology

Planning Considerations

- **General hydrology.** This science explores the behavior and properties of water in the atmosphere and on and under the earth's surface. The movement and exchange of water between the earth and atmosphere is called the hydrologic cycle. Although most areas receive adequate annual precipitation, a large portion is returned to the atmosphere by evaporation from land and water and by transpiration from plants. Continued growth and development create more impervious surfaces, which increase urban runoff, much of which is then discharged to surface waters that ultimately flow into the sea. This represents a tremendous loss of valuable fresh water. To avoid water shortages and prevent lowered water quality, water management must become a primary factor in decisions affecting land use, population distribution, and the protection of our country's natural resources.

- **Surface waters.** Surface runoff varies from place to place, depending on the timing and amount of precipitation, soil, topography, and nature of underlying rock formations and on whether the waters are lakes, estuaries, or coastal. Stream density is low where water, moving downward to the aquifer, is enhanced by thin or porous soils overlying the limestone. In other areas, stream density is high. In some systems, especially broad swamps or floodplains, the water moves slowly in broad bands. Some streams are almost entirely spring-fed and have a well-sustained flow. The flow of other streams consists largely of runoff or groundwater inflow. Flow varies greatly, with little or no flow during dry periods and high flows and floods during wet periods.

- **Wetlands.** One of the country's most valuable resources, wetlands provide a natural way to manage and store water and maintain water quality. As extremely productive ecosystems, wetlands are vital fish and wildlife habitats. They provide a variety of benefits—such as cleaning water to maintain water quality, storing and dampening floodwater, recharging aquifers, modifying the climate, and providing recreational, educational, and aesthetic values—with no cost or maintenance. Unfortunately, many wetlands have been drained or altered so that they no longer provide these benefits. Development should not destroy or alter remaining wetlands; it should preserve or, where feasible, restore them by using their services (e.g., wastewater treatment, runoff management).

- **Floodplains.** Flooding is a natural characteristic of all rivers, but one of unknown probability. Floodplains formed naturally as waterbodies exceeded their normal levels during periods of high precipitation. Because floodplains provide a place for floodwater storage and detention and reduce floodwater velocities, they function as nature's safety valve. Before humans changed the landscape, there were floods but no flooding problems. But since we began to encroach upon floodplains, problems have occurred, waterbodies have become degraded, and injuries and damages have escalated. Floodplain planning and management reduce these economic losses and the need to build expensive structural runoff management systems.

Floodplains also perform valuable environmental functions including wildlife habitat; recreational, aesthetic, and scientific needs; open space; groundwater recharge; water quality maintenance; and sediment control.

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Development in floodplains usually reduces, modifies, or eliminates their ecological functions. It also places an economic burden on the general public, which must reestablish these functions through costly public works projects and pollution abatement controls such as runoff management systems.

■ **Groundwater.** This is one of the country's most valuable, and in many places abundant, resources. Many areas are underlain by thick, porous, and permeable layers of sedimentary rock that serve as prolific groundwater resources and yield tremendous quantities of fresh water. These underground reservoirs are called aquifers. The two main aquifer types depend on their geologic development condition. One type is the nonartesian or unconfined aquifer, not covered by an impervious layer, the upper surface of which is sometimes referred to as the water table. Withdrawal requires pumping or directly using exposed surface water. This surface aquifer is usually recharged by local precipitation and is vulnerable to contamination from overlying land uses.

The other type is the artesian aquifer, confined above by a less porous or impermeable layer and under sufficient hydrostatic pressure to cause the water to rise over the containing layer to outlets such as springs or sinkholes. The potential for aquifer contamination is present where connections or inlets are made from the land's surface to the artesian aquifer, either naturally or artificially.

Because artesian aquifers supply many people with drinking water, sinkholes and other inlets to the groundwater system must be protected from pollution. Many areas have maps that depict the approximate altitude of the top of the rock or sediment that composes a particular aquifer. These maps can determine where the aquifer rock is exposed at or near the land surface. Development in such areas must be carefully planned to prevent aquifer contamination.

Many aquifers are recharged in areas where the aquifer's hydrostatic pressure head is lower than the water table. These areas should be protected by special development review requirements—such as the Wellhead Protection Ordinance—to ensure that the recharge potential is not diminished (i.e., by limiting impervious surface area) and that inappropriate land uses, which employ potentially polluting substances, are not allowed within the area.

In coastal areas, special care must be taken to prevent salt water intrusion into the aquifer. In these areas the aquifer's permeable limestone is shielded against upward intrusion of salt water by relatively impermeable beds of clay and marl but not against lateral encroachment of seawater. Such encroachment can result from overdrainage by canals or from overpumping the aquifer. Proper planning and water management are becoming increasingly important in protecting our nation's supply of potable groundwater.

▮ *General Design Guidelines*

■ Postdevelopment runoff from the site should approximate the rate of flow, volume, and timing of runoff that would have occurred following the same rainfall under predevelopment conditions to preserve riparian areas and streambanks.

■ Thoroughly map all waterbodies, recharge areas, and natural water retention/storage areas as part of the topographic survey. This survey determines existing drainage patterns, delineates wetlands protected by law, defines the area of floodplains in which special building regulations may apply, and identifies vital recharge areas. Depending on the size and type of development, some delineation, description, and engineering evaluation of the surrounding watershed may be appropriate.

■ Preserve the existing natural runoff management system. When incorporated into the area's overall runoff management plan, natural systems provide water quality and storage benefits more efficiently and less expensively than a constructed system. The natural runoff system components may also provide open space and recreational opportunities.

■ Restore and rehabilitate degraded wetlands. Reestablishing the natural hydrology and integrating the wetlands into a final component of the site's runoff management system realizes many natural benefits of wetlands, including runoff pollution removal through retention and detention.

■ Lands that contain waterbodies should be developed using techniques such as planned unit developments or clustering. In planned communities, sensitive areas such as flood-

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plains and wetlands are preserved to provide their natural functions, including runoff pollution control. Additionally, planned developments can reduce site development costs and provide residents with an enhanced quality of life.

- Preserve or restore natural shorelines and stabilize shoreline vegetation. In the natural state, shorelines are relatively erosion-resistant and represent an equilibrium of many forces. The irregular convolutions fulfill important functions such as holding soils, reducing surface runoff and erosion, percolation, filtering runoff, and providing food and habitats for aquatic organisms.

- Avoid alteration of natural stream channels. Disturbances can devegetate and destabilize the stream channel and bank, causing loss or alteration to the habitats of aquatic animals.

- Plan water-related developments to maximize the land potential and still protect natural resources such as riparian habitat. In Figure 12.3, Plan B allows for scenic vistas from the highway, maintains part of the shoreline for public use, provides public and private access, and increases property use, thereby increasing the developer's potential return.

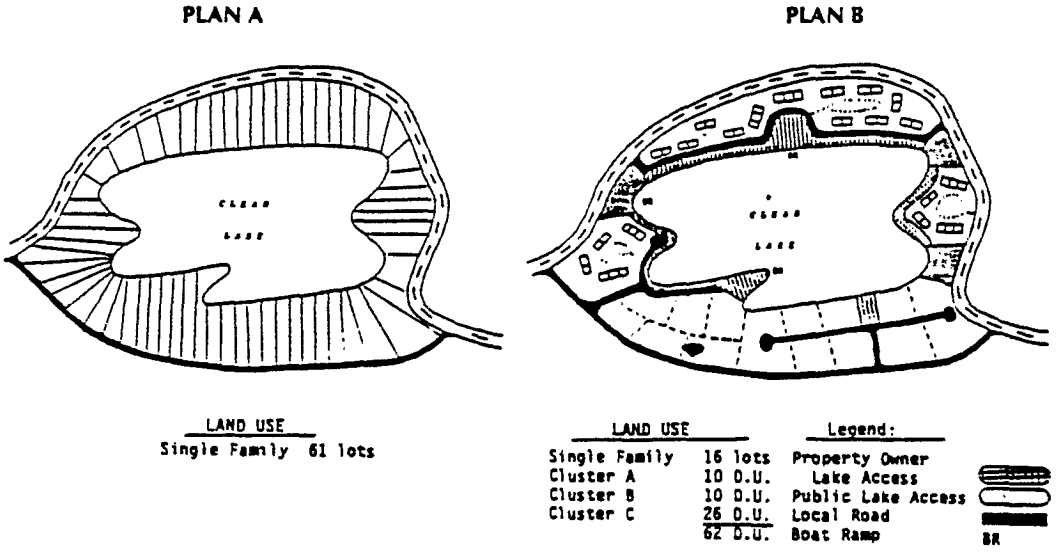
- Establish buffer zones, either fixed or variable—the size depends on soils, slopes, and floodplain—along all waterbodies. Buffer zones protect adjacent developments from the water and protect the water from the developments.

- Vegetated filter strips that filter runoff before it reaches the water should be left in a natural state or reestablished if clearing has occurred. Alternatively, a swale and berm system can be set back from the shoreline. This system slows and filters runoff from the development and can be used as a recreational area (e.g., jogging trail) during dry periods.

- Waterfront property frequently has steep slopes as it descends to the water. Areas without natural vegetation can be terraced, increasing potential use and reducing runoff and erosion. This is especially effective when a swale and berm system is incorporated into the terrace system.

- Do not remove shoreline vegetation to create a sandy beach. Removing vegetation destroys roots that stabilize soils and eliminates the natural filter and habitats for aquatic animals. If shoreline vegetation has already been removed, local native plant varieties suitable for the site conditions can be

Figure 12.3—Plan to maximize land potential and protect natural resources.



D.U. = Dwelling units
Source: Livingston et al. 1988.

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replanted. Access to water is best accomplished via boardwalks, decks, or pier structures. If a sandy beach is essential, remove vegetation only on a small part of the shoreline—less than 20 percent or as allowed by state or local regulations.

- To minimize maintenance and reduce nutrients introduced into the waters, maximize the use of native plants in landscaping, especially those requiring little water (xeriscape). Avoid using introduced varieties and lawns requiring fertilization, especially in waterfront areas.

- If on-site wastewater disposal systems are used on waterfront properties, place them as far as possible from the water, preferably in front yards. Base minimum setback requirements on soil, geology, hydrology, groundwater, and other characteristics that influence environmental effectiveness and safety. Alternative on-site disposal systems, such as aerobic units, may be required in some areas to protect the environment from nutrient and pathogen loadings. In other areas, site conditions may make on-site systems unreliable and likely to cause adverse health and environmental impacts.

- Groundwater recharge areas should have low-density development with limited impervious surface. To augment the recharge ability of a developed area, retain runoff on-site and allow it to infiltrate. If possible, treated wastewater should be recycled and allowed to percolate into the soil (i.e., use treated effluent to irrigate lawns, open spaces, or golf courses).

- In areas with high water tables, avoid contaminating the groundwater. Use on-site disposal systems only with 4 ft (1.22 m) of suitable soil between the drainfield bottom or percolation pond and the water table to ensure that the effluent is properly filtered.

- Fill should not be placed within the 100-year floodplain, as this increases flood heights and velocities. It also moves sediment into receiving waters, causing associated problems. In addition, locate only low-intensity land uses (i.e., open space, recreation, silviculture, and agriculture) with appropriate best management practices within the floodplain.

Information Sources

- **U.S. Geological Survey.** With offices throughout the country, the USGS maintains a highly diversified database on water resources, ranging from hydrologic record networks to interpretive investigations of water resources.

- **State departments or bureaus of geology.** These agencies may publish the results of local geological, hydrogeological, or water resources investigations.

- **Water management districts or boards.** Some states have established regional water management (watershed) districts or boards with broad responsibilities to protect and manage water resources. They often conduct scientific investigations and administer certain types of water planning, management, and regulatory programs.

- **State environmental protection, water quality, health, or natural resources agencies.** These agencies have a variety of resource management information and data, including pollution source permitting information. Agencies usually offer technical assistance, as well.

- **USDA SCS.** With offices in nearly every county, USDA SCS provides technical assistance, conservation planning, and implementation services to local landowners. It also publishes detailed soil surveys that identify soil types and locate vegetation and waterbodies.

- **Local governments.** Many city and county governments have water resources departments with considerable knowledge of local hydrology and water quality and quantity conditions.

- **Regional planning councils or councils of governments.** These agencies often review and approval large developments and prepare and coordinate implementation of regional water management plans or programs. They usually serve as clearinghouses for planning and technical information and publications.

- **U.S. Environmental Protection Agency.** EPA regional nonpoint source coordinators can provide resources and technical information. Regions work with state, federal, regional, and local agencies on pollution control efforts.

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Soils

Planning Considerations. In many instances, major soil-related problems are discovered after a site has been selected, with construction well under way or completed. These problems can cause construction delays and increase the project's total cost. By consulting a soil survey during the planning process, alternative designs can be prepared and sites selected. Knowing soil types, topography, and surface drainage patterns is beneficial in planning and designing almost any type of land development project; it is essential for erosion control planning.

With soil maps and accompanying supporting data in soil surveys, developers can determine the soil conditions in proposed construction areas. Modern soil surveys provide great savings of time and money and result in improved designs, more effective planning, and more accurate preliminary cost estimates.

A USDA SCS detailed soil survey is especially valuable in determining a site's suitability for a particular land use. These surveys contain aerial photographs that map soil classifications and other information. Detailed soil surveys also contain interpretations of soil characteristics, information on the soil suitability for selected urban uses such as wastewater treatment, community development, transportation facilities, recreation development, and water management. However, interpretations do not replace specific on-site investigations for engineering design and construction. Interpretations should be used primarily for land planning, evaluating land use alternatives, and planning site investigations prior to design and construction. Important soil properties and characteristics include permeability, infiltration, seasonal wetness and the water table, depth to bedrock, texture, shrink-swell potential, erodibility, and slope. Variations in soil properties affect the soil's ability to support heavy loads, serve as a medium for wastewater or solid waste disposal, percolate rainwater, hold its shape and slope after excavation, or grow vegetation.

Important soil characteristics needed for planning include

- **Erodibility.** This is the major soil consideration for erosion and sediment control. An erodibility factor (K) indicates the susceptibility of different soils to the forces of erosion. A soil survey report lists the K factor for each soil type within the survey area. These K factors are used in the Universal Soil Loss Equation to determine soil loss from an area over a period of time due to splash, sheet, and rill erosion. K factors can be grouped into three general ranges:

0.23 and lower	low erodibility
0.23 to 0.36	moderate erodibility
0.36 and up	high erodibility

Soil particle cohesiveness varies with different layers of the same soil, causing varying degrees of erodibility at different depths. Therefore, excavation depth must be considered in determining soil erodibility on a construction site.

- **Permeability.** Permeability is a major factor influencing erosion. Soil permeability is the quality that enables soil to transmit water or air. Deep, permeable soils are less erodible simply because more rainfall soaks in, reducing surface runoff. Permeability, which varies with different layers, must be considered when excavating. Antecedent soil moisture conditions also affect soil permeability.

The hydrologic soil group (HSG) is a direct indication of the soil's infiltration rate. Soils are grouped into four hydrologic soil groups, according to their infiltration and transmission rates:

A. Soils with high infiltration rates even when thoroughly wetted—low runoff potential.

B. Soils with moderate infiltration rates when thoroughly wetted.

C. Soils with slow infiltration rates when thoroughly wetted.

D. Soils with very slow infiltration rates when thoroughly wetted—high runoff potential.

- **Texture.** Soil texture refers specifically to the proportions of clay, silt, and sand smaller than 2 mm (.08 in) in diameter contained in a soil mass. Soil texture is a primary factor in erodibility and is reflected in the erodibility factor. Erodibility increases with greater silt and very fine sand content and decreases with greater sand, clay, and organic matter content. Soils with high clay content are generally more resistant to detachment; but once detached, clay particles are easily transported. These clays and silts are very difficult to settle out once they get into the water column, sometimes necessitating the

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use of coagulating agents to prevent their discharge into conveyances or receiving waters.

- **Shrink-swell potential.** Certain soils have clays that shrink when dry and swell when wet. In this situation, special foundations are required to allow for this variation. Identify these soils by consulting the soil survey and take the necessary precautionary steps.

- **Flood hazard.** Although soil survey information does not replace hydrologic studies, it does estimate where floods will likely occur. The hazards of flooding and ponding for various soil types are rated in soil surveys, and flood-prone areas are shown on survey maps.

- **Soil reaction (pH).** Soil survey information includes the pH of the individual soil layers. This factor is used to plan vegetation on disturbed areas, especially critical slopes.

- **Wetness.** Soil surveys have many types of data available including natural soil drainage, depth-to-seasonal water table, and suitability of winter grading for various soils. With this information, engineers can determine such things as seasonal limitations on using heavy, earth-moving machinery and estimating flood hazards or damage to underground structures due to soil wetness.

- **Depth to bedrock.** Soil surveys indicate bedrock types and where bedrock will be encountered at a depth of less than 5 to 6 ft (1.52 to 1.83 m). This information is helpful in determining location, time, and cost of excavation.

- **Slope.** Soil surveys record slope ranges and identify areas where cuts and fills are needed. The longer and steeper the slope, the greater is the potential for soil loss due to increased velocity of surface runoff.

Soil surveys are also helpful in interpreting the effect of soil properties on various land uses. For example, an interpretation may determine that soil can be used as topsoil, road fill for highway subgrade, or sand and gravel. The interpretations also show soil limitations for such purposes as building foundations, highways, streets, roads, parking lots, pipelines, underground utility lines, and septic tank absorption fields.

Often the survey will provide adequate information; sometimes it may only provide warnings or indications of soil-related problems likely to be encountered. In this case, a more in-depth, on-site investigation may be needed.

Design Guidelines

- Use the detailed soil survey or map the soils to help develop the land use plan. Knowledge about the location of wet soils, high water tables, clay soils, erodibility, and slope can help prevent many problems.

- Use USDA SCS and/or Soil and Water Conservation District expertise to develop a conservation plan that minimizes erosion, sedimentation, flooding, and nonpoint source pollution. The USDA SCS has soil, plant, and water resource data; technical information; and standards and specifications for BMPs that apply to most local areas.

- Follow the USDA SCS's "seven principles of erosion and sediment control":

1. Plan the development to fit the site's topography, soils, drainage patterns, and natural vegetation.
2. Minimize the extent and duration of the area exposed at any one time.
3. Apply erosion prevention control practices to minimize erosion and on-site damage.
4. Apply perimeter control practices to protect the disturbed area from off-site runoff and to prevent sedimentation damage to areas below the development site.
5. Keep runoff velocities low and retain maximum amount of runoff on-site.
6. Stabilize disturbed areas immediately after final grading.
7. Implement a thorough maintenance and follow-up program.

Information Sources

- **USDA SCS and Soil and Water Conservation District.** USDA SCS generally has a state office along with regional and county/district offices and detailed soil surveys for many counties. It continues to map soils in those areas without soil surveys. In addition, the USDA SCS/district provides technical assistance in conservation planning and other issues to local landowners. The state office usually publishes a directory of USDA SCS offices and staff.

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Vegetation and Wildlife

Planning Considerations. As more people become urbanites, the value of plants and animals in a development increases. Aesthetically, landscaping and its accompanying wildlife provides residents with a sense of well-being and enhances the quality of life. The living resources in a well-planned development can effectively bridge the gap between the created and the natural environment.

Plants and animals also prevent and solve environmental problems in a development. For example, the variety and abundance of plants and animals in an area are important indicators of natural conditions and can interpret a site's constraints and opportunities (Table 12.2). Vegetation and wildlife also provide many other benefits (Table 12.3).

The importance of vegetation as an economic incentive has risen greatly in recent years.

Table 12.2—Vegetation indicators of site conditions.

ABSENCE OF PLANT COVER	SPARSE HERB AND SHRUB COVER	THICK HERB AND SHRUB COVER	BRUSH AND SMALL TREES	BLADE AND REED PLANTS	HIGHLY LOCALIZED TREE COVER
Bedrock at or near surface	Bedrock near surface	Recently logged or burned	Landslide/fire, flash flood scars	Organic soil, standing water	Wet depression, steep, organic soil
Active dunes	Recent, sterile soils/dunes, fill	Too wet for trees	Old field or woodlot regrowth	High-ground water table	Slopes in agricultural areas
Recent human use, cultivation	Recently disturbed (fire, flood fallow)	Managed grazing	Shale/clay substrate	Springs, seepage zones	Flood-prone areas
Recent fire	Active slope or erosion	Organic soil	Organic soil		
Recent loss of water, cover		Old field regrowth	Moisture deficiency		

Source: Marsh, 1978.

Table 12.3—Benefits of plants and animals in a development.

	VEGETATION	WILDLIFE
Recreation	Exercise trails Nature trails Tree climbing, swings	Bird watching Nature photography Fishing
Environmental	Absorb carbon dioxide Produce oxygen Protect watershed (filter runoff and reduce runoff speed) Screen wind, rain, sun Cool air Buffer noise Wildlife habitats	Recycle and redistribute nutrients Propagate vegetation Control pest species Preserve genetic stock
Aesthetic	Screen incompatible land use activities Provide attractive, diverse scenery Influence walkways	Provide enjoyment of wild animals

Source: Marsh, 1978.

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Table 12.4—Comparison of specific site effects.

VEGETATION AND WILDLIFE AREAS	6,000-ACRE PLANNED DEVELOPMENT	6,000-ACRE UNPLANNED DEVELOPMENT
Acres of semimature woodland developed[1]	8	35
Acres of mature woodland developed[2]	35	90
Miles of tree-lined roads incorporated into developed areas	1.3	.9
Miles of tree-lined roads widened	0	1.3
Acres of wildlife habitat developed	10	235
Number of interruptions in wildlife corridors	0	4

[1] Clearing semimature woodland at $650 per acre would cost $5,000 in the planned community and $23,000 in the sprawl community.
[2] Clearing mature woodland at $1,600 per acre would cost $56,000 in the planned community and $144,000 in the sprawl community.

Source: Quennel, 1972.

More developers are incorporating existing vegetation into site plans because of the high costs of land clearing and landscaping. The initial cost per acre may be higher when working around trees and other natural areas. However, because the total number of acres cleared and the amount of landscaping is smaller, the total cost is reduced. Table 12.4 compares the cost of a planned and an unplanned development.

Residential preference surveys identify parks and green spaces as important reasons to choose one neighborhood over another. Realtors have found that wooded lots consistently bring higher prices than those without vegetation. For example, in residential areas, a mature shade tree may have an estimated value of $1,000 to $3,500; other plantings may improve the real estate value of an average lot by $3,000 to $7,000.

Resource Inventory. The diversity in landforms and climate has produced a variety of habitat types that contain different combinations of plants and animals. Investigating a site's biological communities is essential to understanding the site's importance to the integrity of the ecosystem. Identifying and assessing plant and animal resources is an important part of site planning. Species could be identified and mapped, along with other site inventories such as hydrologic, physiographic, geologic, and soil surveys. Ultimately, these parameters must be considered together to develop a land use plan that balances ecological constraints and benefits with intended uses.

Vegetation. Natural vegetation is an important resource and habitat for wildlife. Inventory vegetation using a quality rating scheme from aerial photos and/or data from field surveys. Where the site is small (100 acres [40.47 ha] or less), interpreting photos may be as time consuming as field surveys. The following factors should be considered in analyzing a site's vegetation:

1. The number of distinct plant communities and their distribution;
2. The uniqueness of each plant community;
3. The presence of subareas that have recently been disturbed (e.g., clear cutting, cultivating, grazing, burning, bulldozing);
4. Accessibility of the area; and
5. Correlation with the site's physiographic features.

The inventory is used to document what plants occur naturally on the site, identify the forces and processes controlling their distribution, and determine where to find certain plants or plant groups. If the site has been environmentally degraded or overtaken by exotic species, readily determining the natural vegetation and environmental relationships may be impossible. Consult with local botanists, state foresters, and other

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trained professionals or examine historical records and photos to establish types and distribution of native vegetation.

- **Wildlife.** Local wildlife can be inventoried directly by taking a population census or indirectly by assessing the quality of local habitats. Habitat analysis is the simpler approach, as the analysis can be performed from secondary sources (e.g., aerial photography). Consider the following terrestrial ecosystems factors in the analysis:

1. The number and types of plant communities per unit area,
2. The number of forest or woodland openings,
3. The presence of water,
4. The presence of movement corridors,
5. The size of the area, and
6. The variety of the wildlife appropriate to the habitat.

The value of wetland areas that support a rich variety of wildlife primarily depends on water quality. As with terrestrial ecosystems, perform separate habitat analysis for species requiring different habitats.

To take a population census, seek the help of trained wildlife observers. Census methods range from direct observation to analysis of indirect evidence. Regardless of the method, survey wildlife populations at several points in time to account for natural environmental fluctuations.

Special consideration must be given to endangered species and their critical habitats. Agencies such as the U.S. Fish and Wildlife Conservation Service, the State Department of Natural Resources and the State Committee on Rare and Endangered Plants and Animals list endangered species. However, state statutes will usually specify which organization's list is officially recognized.

▮ ***Design Guidelines.*** The resource inventory and site surveys should examine basic structural, functional, and locational patterns. If the area is in a natural state, these elements probably work effectively to support the living community. If the area is a constructed landscape, the natural systems may be degraded and work marginally, if at all. In either case, the plan should aim for compatibility between natural and constructed environments. A degraded natural system can be strengthened or even fully restored by a carefully planned development. For example, ditched and drained wetlands can be revitalized by introducing pretreated runoff.

The following principles will help developers plan for wildlife and vegetation, in consultation with local biologists familiar with the areas:

- **Transition zones.** This zone between two habitats—such as the area between two forests or between a forest and a waterbody—is extremely important to wildlife. It supports wildlife not found in either habitat. Often the transition zone provides an exclusive habitat for a very selective, sometimes endangered, species or community of species.

- **Water.** Proximity to water enhances an area's ecological productivity. Swamps, marshes, and bogs support a rich variety of plants and animals—many of which are valued as game species. Saltwater wetlands are important breeding grounds for fish and crustaceans.

- **Alternative habitats.** Other habitats where wildlife may relocate have potential impacts, especially on endangered species.

- **Timing of construction.** Construction should be timed to avoid critical periods in vegetation and wildlife reproduction, especially for threatened or endangered species.

- **Choice of plantings.** Wildlife existence, both in number and quantity of different species, depends on habitat availability. Choice in planting or preserving specific habitats can effectively encourage certain wildlife species. When transplanting, include varying age classes of trees and shrubs. Select native species, especially those that require little fertilization, pesticides, or water, instead of troublesome exotic species.

- **Animal-plant interactions.** Developments that reduce the wildlife that some plants depend on for reproduction may eventually eliminate these plants. For example, berry-producing plants depend on birds for seed propagation, and furry mammals often help distribute thorny seeds.

- **Exotics.** Exotic species may compete with native varieties and eventually become nuisances. Sites with communities of exotic species may be good areas to develop and reestablish native communities.

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Table 12.5—Comparison of six community types.

PROTOTYPE	COMMUNITY DESCRIPTION*	IMPACTS TO VEGETATION AND WILDLIFE
Type I: Planned Mix	20 percent of each of the following — single-family conventional, single-family clustered, townhouses, walk-up apartments. 2,000 units of each type. Neighborhoods are contiguous; large areas of open space are preserved.	Less species disruption where significant tracts of land are preserved as permanent open space.
Type II: Combination Mix	50 percent planned unit developments with contiguous and related land uses; 50 percent sprawl pattern. Housing mix same as Type I.	Greater disruption than in Type I. Open areas can be retained.
Type III: Sprawl Mix	Random, leapfrog development with many small lots vacant. Housing mix same as Type I.	Similar to Type I. Leapfrog development pattern bares only small pockets of undisturbed area.
Type IV: Low Density Planned	75 percent of dwelling units single-family clusters; 25 percent conventional, single family. Contiguous neighborhoods, but low density with vacant lots. Open spaces preserved, land uses comprehensively designed.	Low density development decreases amount of open land preserved in natural condition. Careful planning can protect areas of special significance as species habitats (i.e., woodland, swamp).
Type V: Low Density Sprawl	Most prevalent form of current development. 75 percent of dwelling units are conventional single-family; 25 percent are clustered single-family dwellings. Small percentage of passed-over land.	Virtually no land will be left totally undisturbed, thus eliminating habitats and causing a disruption in ecological balance.
Type VI: High Density Planned	10 percent of dwellings clustered single-family; 20 percent townhouses; 30 percent apartment; 40 percent high-rise apartments. Housing types are mixed with contiguous neighborhoods. Planned open spaces, related land uses.	Adverse effects lessened through careful planning to conserve special habitats and through high density development that preserves large tracts of undisturbed land.

* All communities contain 10,000 dwelling units
Source: Quennel, 1972.

■ **Fish.** Fish population in lakes and streams is closely tied to water quality and habitat. A decrease in dissolved oxygen concentration below 5 parts per million or major changes in flow character—including temperature changes caused by removing shade trees—may eliminate valuable game fish. Excessive runoff loadings—e.g., nutrients, metals, sediments—will increase aquatic plant problems and eventually cause fish populations to shift towards more "trash" species.

■ **Coastal vegetation.** Coastal vegetation along sandy and estuarine beaches protects inland areas against wind and waves. Dunes and mangrove areas provide physical barriers against high tides, wind, and waves. Marshes act as sponges, absorbing water during storms and high tides.

■ **Natural stormwater systems.** Modified natural stormwater systems reduce habitat for frogs, snakes, and salamanders. Preserve and incorporate natural areas into a comprehensive runoff management plan. This plan should incorporate a "treatment train" of runoff management practices, along with natural and landscaped areas, into a multipurpose amenity for the development plan.

■ **Compare planning approaches.** Land development has often disturbed natural cycles and flows of energy, producing undesirable economic and environmental effects. Table 12.5 describes six community development prototypes.

Structural Considerations

■ Runoff management areas should double as open space, landscape, and wildlife habi-

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tats. Because edge conditions are important, designs that maximize edges will be most successful in drawing and keeping wildlife. Plant native plants such as canes, marsh grasses, and riparian shrubs around basin edges. Many of these plants have beautiful flowers, allowing a designer to aquascape the shoreline to enhance visual amenities and increase property values.

- Direct roads away from high quality natural habitat areas, especially wetlands.

- Networks of waterways can be effective in interweaving the constructed landscape with wild areas.

- Maintain proper water level in wetlands with spreader swales and outlet control structures.

- Disturb the smallest area possible, retaining the maximum natural vegetation.

- Avoid clearing, scraping, leveling, and constructing seawalls and buildings on beaches and dunes.

- Construct observation blinds and interpretive nature trails through natural areas to provide recreation and enjoyment of wildlife.

Nonstructural Considerations

- Confine planted lawns and grass mowing to small areas to enhance seedling and wildflower growth and increase buffer effects.

- Retain wildlife corridors that connect habitats and water areas.

- Help protect and maintain areas with rare and unique natural features, including endangered species.

- Use open space, blue-green design space, and green space. They serve as recreational areas, wildlife buffer zones, and increase the aesthetic appeal.

- Where large-scale planned development is the predominant pattern, improved site design and landscaping makes it easier to retain the natural ground cover.

- Leave a buffer zone of vegetation in its natural state along the shore of waterbodies and adjacent to wetlands.

Information Sources

- **State game and fish commission.** Information on various species and habitats is usually available from state agencies. Agencies may have a special nongame wildlife program to further wildlife conservation by detecting and preventing population declines in animal species before they reach the verge of extinction. Agencies usually have information to assist the developer in considering wildlife.

- **USDA SCS/District.** The USDA SCS publishes lists and guides to native vegetation species or those well adapted to local conditions. The USDA SCS operates plant material centers around the country to study plants to determine suitability for conservation use (e.g., erosion control).

- **State universities.** Frequently, a state designates a state agricultural school. The school may have several agricultural and environmental resource programs and typically will focus on three areas—teaching, research, and extension. Normally, a college of agriculture and school of forestry conduct university level instructional programs; the Agricultural Experiment Center conducts basic and applied research; and the Cooperative Extension Program disseminates information through extension directors in each county. Numerous publications on successfully growing plants are available from these offices.

- **Natural Areas Inventory.** This is a joint project between a state agency (e.g., Department of Natural Resources) and The Nature Conservancy to provide a detailed, computerized account of a state's native flora and fauna. The inventory could provide a planner or developer with information concerning natural communities for landscaping, restoration, or preservation.

Critical Area Identification and Protection

Planning Considerations. A primary objective in site planning is to identify and locate critical areas. Typically, these are environmentally sensitive areas that, because of their inherent characteristics or location, create certain constraints on development. These constraints usually include environmental concerns and often

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include economic considerations. The site planning process creates a development plan that minimizes disturbing critical areas and works them into the plan as natural areas and other amenities. Critical areas may include steep slopes, highly erodible soils, stream corridors, shorelines, wetlands, floodplains, native forests, karst geology, high groundwater tables, and other similar areas.

▮ ***Design Guidelines.*** If possible, avoid developing critical areas. Use them instead as natural areas, open spaces, and parts of the runoff system. When designing guidelines for critical areas

- Avoid alteration or construction within natural drainageways, stream corridors, wetlands, floodplains, natural depressional storage areas, or on steep slopes.
- Maintain and protect dense vegetation adjacent to waterbodies and wetlands to serve as natural buffers and filter strips.
- Establish setbacks from all critical areas where no development is allowed.
- Preserve or limit the clearing of shoreline vegetation, which helps to stabilize the shoreline, filter pollutants, and provide habitat for fish and wildlife.
- Preserve porous soils to take advantage of infiltration capacity.
- Avoid disturbing highly erodible or unstable soils to minimize erosion and sedimentation potential.
- Preserve and incorporate the natural runoff management system.
- Protect and incorporate native forests to provide shade and wildlife habitat.

Cultural Factors

A site's suitability and a project's success are closely related to cultural factors that have a direct effect on future inhabitants. The following factors are important in gaining public acceptance of proposed projects.

Existing Land Use

▮ ***Planning Considerations.*** The pattern of existing area land uses should be investigated to ensure compatibility. The developer should meet with adjacent property owners and local planning department staff to discuss the future development under consideration and if it will conflict with uses on the proposed site.

Investigate off-site nuisances—i.e., visual, noise, or odors—and safety hazards. Visually disruptive elements may include power lines, water towers, industrial complexes, highways, and junkyards. Possible noise disturbances include heavy automobile, rail or air traffic, or noise made by stadium crowds. Objectionable odors may originate in landfills, wastewater treatment facilities, and polluted waters.

In studying the site's location in relation to adjacent properties and the community, determine and assess all existing linkages. Linkages involve moving people, goods, communication, or amenities through an area. Inventory community facilities—shopping centers, schools, hospitals, employment centers, residential areas and recreation—determine if they can adequately serve the site. If not, make plans to improve them through future development.

Density—an important environmental, sociological, and legal element in most types of development—influences privacy, freedom of movement, and social contact among people. Local governments usually have zoning regulations concerning density standards to help maintain a certain quality of life. A project's permitability by the state environmental agency may also be related to density factors.

▮ *Information Sources*

- **On-site inspection of the surrounding area.** Observation is the easiest way to determine the existing land use.
- **Local government planning or zoning departments.** Contact these agencies at the earliest planning stage to determine if the proposed development is acceptable. Many potential conflicts and delays can be avoided by discussing development plans with local officials during the conceptual design phase. Review local comprehensive plans and policies to ensure consistency with the proposed development.
- **Regional planning councils or councils of governments.** These agencies, frequently involved with long-term land use planning, should be contacted early in the development process, especially for large projects or those of regional significance.

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Traffic and Transit

▮ ***Planning Considerations.*** If the type and size of development is significant, investigate the adequacy of existing transportation facilities. This investigation should determine the relationship of traffic patterns, whether adequate roads exist or must be supplemented, and whether public transportation is available. Large projects may require a trip generation survey to determine the proposed development's effect on existing traffic patterns. The survey should consider traffic's origin and destination, its purpose, the time of day, and the traffic volume generated by inhabitants or project users.

The conventional gridiron street pattern produces an unsafe, unpleasant circulation system with arbitrary street dimensions, through traffic, visual monotony, and lack of neighborhood identity. A curvilinear pattern or clustering arrangement in residential developments minimizes through traffic, disruption of the natural terrain and landscape, and expenses associated with road construction and other improvements. Well-planned curvilinear and cluster planning developments reduce the length of roads, utility lines, and sewer and water mains. Compared to conventional development, clustering can reduce the total road and impervious surface area and the cost of roads by 14 percent and utilities by 33 percent.

▮ *Information Sources*

- **Local governments.** Consult with local authorities to determine any long-range transportation plans and improvements. Obtain copies of local land development regulations (e.g., subdivision, zoning, and land development codes) that contain specifications for street rights-of-way and construction. Some local governments will also have traffic count information.

- **State department of transportation.** This department schedules highway improvements and publishes them in a long-term construction plan. It also conducts traffic counts and analyzes the data.

Density and Zoning Regulations

▮ ***Planning Considerations.*** Communities use planning and zoning to effectively balance land uses such as recreation, conservation, residential, commercial, and industrial development. Establishing appropriate development densities and intensities—number of buildings per acre and building bulk versus remaining land on the lot—is a fundamental problem. As density and intensity of development increase, so does the stress on natural and financial resources. The goal of community planning and zoning is to minimize these stresses and ensure that public facilities—such as street, school, sewer, water, and runoff services—are adequate. Sound site selection and planning principles are indispensable in achieving this goal. Planning and zoning regulations also benefit the developer by protecting the housing market.

Some state legislatures have enacted local government comprehensive planning and development acts to assure responsible growth. These regulations usually requires local governments to develop comprehensive plans to address future growth. Plans are implemented by adopting land development regulations such as zoning ordinances and land development codes.

▮ *Information Sources*

- **State land planning agency.** This agency implements the growth management program and works with local governments to develop and approve local plans. Various types of planning information and technical assistance may be available.

- **Regional planning councils or councils of governments.** These agencies may have regional policy plans that serve as a foundation for local comprehensive plans and include policies to minimize the regional impacts of large developments.

- **Local governments.** Obtain specific regulations such as zoning ordinances, land development codes, local comprehensive plans, subdivision regulations, and housing codes before selecting a site and designing the project.

Socioeconomic Factors

▮ ***Planning Considerations.*** To determine a project's feasibility, study the community and its socioeconomic structure. Social factors broadly affect community facilities and services. New facilities may displace homes, businesses, or community activities. A new highway may sever an area's cohesion by creating physical or visual barriers that affect business, property values, and character. Stormwater facilities, especially regional systems, can be viewed as detrimental to an area or neighborhood. Local governments need to assure that such systems are attractive, properly maintained, and well-designed to include recreational opportunities.

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A market analysis can determine the socioeconomic feasibility of a project. Such studies help justify the need for the proposed development to local planning agencies. They also help ensure the developer a return on his investment. Generally, anticipate a building rate of 80 percent in 10 years, phasing development as demand warrants. Consider also the cost-effectiveness of rehabilitating income-producing historic structures listed in the National Register of Historic Places over new construction with the added benefit of investment tax credits.

Utilities

▮ ***Planning Considerations.*** Every project should include provisions for six essential services—water supply, sewage disposal, solid waste collection, paved roads, runoff management, and utilities (electricity, telephone, gas). These services make a piece of raw land usable and shape its future resale value. Contact utility companies early in the site planning process to ensure that project needs can be met. Just as important, plan utility locations to minimize environmental disturbances on the site, and use appropriate erosion, sediment, and runoff controls during the installation of utilities to minimize adverse effects.

- **Potable water supply.** Water is probably the most critical basic need for community growth. Ensuring a continued, safe, adequate supply requires special planning. In addition to drinking water, most water systems provide fire protection, which requires high water pressure. If the area has no central water system, obtain information about the water quality for individual wells, the effect of many wells on the aquifer, and the potential for saltwater intrusion.

- **Sewage treatment and disposal.** In general, central wastewater treatment facilities should be provided for all lots under one-half acre (0.20 ha) and for any size lots not suitable for on-site disposal systems, either conventional or alternative designs such as aerobic units. Septic tanks should be used only on lots with proven adequate percolation rates, with slopes less than 12 percent, with bedrock and seasonal high water tables at least 4 ft (1.22 m) below the bottom of the drainfield, and with a distance of at least 200 ft (60.96 m) from any surface waters. Consider specific setback requirements for developments near water since the potential of these wastewater systems to degrade water resources depends on many variable, site-specific factors (e.g., soils, slopes, water table, geology, relative location).

- **Solid waste collection.** In rural areas, homeowners usually take refuse to a sanitary landfill or collection station. Urban subdivisions and commercial developments should include provisions for an authorized agent to collect solid waste to prevent litter and debris in runoff.

- **Streets and roads.** All roads should be built to county or municipal standards and dedicated to the local government for maintenance. In most cases, residential roads should be paved and include swales for runoff management. Storm sewers are needed only on more intensively developed projects; even then, swales could be a valuable component of the treatment train.

- **Runoff management.** The project should include a runoff management system that protects against flooding and ensures the water quality of receiving waterbodies. The system should meet local requirements (i.e., design storm) using the runoff management principles presented earlier.

Historic and Archaeological Resources

▮ ***Planning Considerations.*** Thousands of recorded archaeological and historic sites, many listed on the National Register of Historic Places, demonstrate the nation's rich cultural heritage and colorful history. Many communities have historic structures of exceptional architectural quality and appeal. Many archaeological sites have high scientific and cultural value. As urban populations increase, so does the demand for more comprehensive protection of historic and archaeological resources. This demand should be considered in land development decisions.

Include an inventory of all historic and archaeological elements in development planning. Infrastructure planning is important because of the special requirements for preserving older buildings, streets, significant structures, and unique landforms. Architecture, landscape, and other design studies that affect the total environment should not conflict with existing cultural themes. On the contrary, development projects that blend into the cultural atmosphere can produce attractive and lucrative developments.

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Historic structures and archaeological sites can have valuable and important community uses, while preserving their cultural value. Urban environments that are functional and offer a sense of community identity have many benefits for the developer, the residents, and the community.

Information Sources

- **Local governments.** Consult local governments for assistance with identifying and restoring culturally significant buildings and other structures and sites. Many local governments have designated historic districts that impose special development regulations. A comprehensive plan may also be a valuable resource.

- **State government.** The state may have a bureau of historic preservation that records all existing historic and archaeological sites. It may also help evaluate an area's historic/archaeological significance and the impacts of development on significant sites.

Aesthetics

Aesthetic factors should also be analyzed on development sites. These factors can differentiate a "typical" development from one with extraordinary appeal and intrinsic beauty and value. A development with carefully considered and incorporated natural features and spatial patterns will have a greater appeal because of its community character.

Natural Features

Planning Considerations. The landscape of the United States provides many sites with outstanding natural earth, water, and vegetation features. Incorporating mountains, rolling hills, oceans, lakes, streams, wetlands, forests, sinkholes, and springs into the development accents its architecture, reflecting the area's natural character rather than competing with it.

Spatial Patterns

Planning Considerations. A site's spatial patterns include factors such as views or scenic vistas. Views, pleasing or objectionable, frequently bear heavily on a building's orientation. An outstanding view should be preserved or accentuated. Views must also be compatible with proposed activities and their relation to each other, because nuisances both on and off the site may disrupt them. Vegetation, slope, fences, or walls can screen objectionable odors, noises, or visual elements such as billboards, power lines, junkyards, or parking lots. Power lines can be placed underground, and parking lots can be depressed below grade and heavily landscaped.

Other Nonstructural Management Practices

Many of the varied nonstructural management practices and source controls available are good examples of common sense and a stewardship ethic. Nearly any technique that reduces the potential adverse impacts of our daily activities on a watershed's natural resources can be considered a nonstructural control. Following is a brief discussion of common nonstructural or source controls. Many can be incorporated into local land development codes, while others require a commitment of all residents for success.

Site Characteristic Practices

- **Buffer zones or critical area zones.** In these areas, special design and performance criteria may apply and a naturally vegetated zone is maintained. Land development codes often establish a minimum distance that the zone must extend from a sensitive feature, depending on a variety of site specific characteristics.

- **Setbacks.** Discrete distances—such as the distance between a septic tank and a well, shoreline, or stream—are established by state or local regulations and used to protect sensitive areas and meet environmental goals. Both setbacks and buffer zones can be protected by a variety of legal mechanisms including purchase, easements, or conservation easements.

- **Minimum natural area.** Some local codes specify a minimum portion (e.g., 20 percent) to be maintained in its natural condition, unless the site is already degraded, to preserve critical features and reduce overall development impacts.

- **Landscaping and tree protection.** Local codes often specify landscaping requirements (e.g., plant types and sizes) and protect certain trees, usually based on diameter and species, to reduce clearing. This protec-

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tion reduces erosion, sediment, and runoff problems. These requirements, together with any requirements for minimum natural area, must be carefully integrated to assure compatibility.

- **Shoreline vegetation management.** Shoreline vegetation protects and enhances waterbodies. Clearing for waterfront development should be limited to a minimum. Developers, waterfront property owners, and local governments should practice aquascaping by establishing diverse, aesthetically pleasing native aquatic plants along shorelines of runoff ponds, lakes, streams, and other waterbodies. Restoring these watershed resources can reduce the need for more expensive structural controls.

Characteristic Practices of Natural Runoff

Minimize Impervious Surface Area

Limiting impervious area is the most effective way to preserve a site's predevelopment runoff characteristics. Local codes may specify the maximum proportion of impervious cover allowed (e.g., 75 percent). Techniques include

- Reducing building setbacks, which reduces the lengths of driveways and entry walks. This technique is most applicable along low-use residential roads where traffic noise is not a problem.

- Reducing street widths by eliminating on-street parking or reducing lane width is most applicable to residential neighborhood roads.

- Reducing sidewalks to one side or combining them with bicycle trails/walkways that go through back yard easements or natural areas. Whenever possible, these trails should be made of pervious materials.

- Using pervious pavement materials, such as pervious asphalt or pervious concrete, gravel, or combinations of geotextiles with sand, gravel, and sod. Take care when using pervious pavements to prevent clogging. Special design, preparation, batching, pouring, and finishing procedures, along with long-term maintenance needs, require that these pervious pavements be used appropriately.

- Using alternative development designs, such as cluster development, to reduce the length of roads, sidewalks, and other impervious areas.

Preserve and Mimic the Natural Runoff System

Traditionally, runoff systems were built solely to convey runoff away from homes, buildings, and developed areas as quickly as possible, with little regard for its effect on downstream land or water resources. Techniques that promote infiltration by slowing and filtering runoff include

- Routing roof runoff to pervious areas, such as lawns, grassy swales, or depressed landscaped areas. Prohibit connecting downspouts directly to storm sewers or discharging downspouts onto parking lots, driveways, or other impervious areas.

- Protecting floodplains, wetlands, natural depressional storage areas, and highly pervious sites. Incorporate them into the final runoff management plan as part of the treatment train.

- Using grassy swales instead of storm sewers as runoff conveyances, especially in residential developments. Swales, especially those with check dams or raised driveway culverts, encourage runoff capture and infiltration. Use public education to teach citizens that water standing in a swale for a day is not bad and to prevent citizens from altering or using swales to dispose of yard materials or other garbage.

- Using depressional landscaping techniques that allow small areas, including landscaped islands within parking lots, to provide some storage and infiltration.

- Placing storm sewer inlets in grassy areas instead of paved areas. For example, a successful treatment train within a shopping center parking lot consists of landscaped areas around the perimeter that includes a grassy swale adjacent to the curb line. Regularly spaced curb openings (curb cuts) allow runoff to flow off the parking lot into the swale. The swale conveys runoff toward a storm sewer inlet, raised about 6 in (15.24 cm) above grade, and then to a wet detention basin. Depressed landscape islands with curb cuts contain storm sewer inlets, also raised 6 in.

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Good Housekeeping Practices

Practices that reduce sources of potential pollutants in runoff should be undertaken by all watershed residents. Public education is vital to acceptance and use of these practices.

- **Street or parking lot sweeping.** Particles that accumulate along streets and on parking lots should be removed before they enter the runoff waste stream. Mechanical broom sweepers effectively remove particles larger than 400 µm but cannot remove smaller particles that contain the majority of street pollutants. Vacuum sweepers, more efficient in removing smaller particles, are ineffective on wet pavements. While street sweepers undoubtedly remove large quantities of solids and other materials from streets and parking lots, their effectiveness depends on many factors. Using street sweepers regularly in highly impervious areas like central business districts may be one of the only effective BMPs for a highly developed area. Research must determine if materials collected by street sweepers pose any environmental threats and how to dispose of this material.

- **Detecting and prohibiting illicit connections.** Illicit connections of sanitary sewers, industrial discharges, commercial floor drains, sump pumps, and basement drains greatly contribute to water quality problems caused by runoff. These often serve as conduits that introduce solvents, oils, and even toxic materials into runoff. Local governments should conduct regular investigations (i.e., smoke tests, dye tests, dry weather flow sampling) to detect and eliminate illicit discharges.

- **Proper handling, use, and disposal of fertilizers and pesticides.** Controlling the rate, timing, and method of chemical applications can minimize use and limit runoff contamination in a watershed. Many state agricultural agencies provide educational materials on the proper type and amount of fertilizers needed for a particular landscape. U.S. Department of Agriculture agencies provide fertilizer and pesticide management guidance in selecting the most environmentally safe chemical and minimum effective dosage.

- **Proper handling, use, and disposal of household chemicals.** A wide variety of cleansers, oils, solvents, paints, and other household materials pose certain risks to the environment. Some wastes are legally defined as hazardous or toxic and must be disposed of using stringent procedures imposed by federal, state, or local laws. Some states have established programs such as amnesty days that encourage citizens to safely and freely dispose of potentially hazardous household wastes. Citizens need to know how to safely use and dispose of many household materials including antifreeze, gasoline, waste motor oil, car batteries, old tires, floor or furniture polish, most cleaning products, chlorine bleach, paints, paint thinners, turpentine, mineral spirits, wood preservatives, weed killers, and roach and ant killers.

- **Proper solid waste management.** Solid wastes and litter that accumulate on the land are easily transported by runoff. Properly collecting and disposing of solid wastes—and recycling appropriate materials—can greatly reduce runoff pollutant loadings. Litter laws, adopt-a-road or shore programs, and eco-neighborhood programs are effective in encouraging citizens to "clean their own nests."

- **Proper disposal of pet wastes.** The wastes our pets leave behind can be a major source of bacterial loading to our waters. Requiring owners to properly dispose of animal wastes can help reduce these loadings and keep our waters open to recreation.

- **Recycling used waste oil.** Many gallons of waste oil are dumped into storm sewers for disposal. However, this oil can be recycled and used for many activities. Many states, local governments, and private companies have established used-oil recycling programs and centers.

- **Organic debris disposal.** As laws limiting the landfill disposal of yard wastes become more common, the proper management of grass, leaves, pruned branches, and other debris becomes increasingly important. Composting by homeowners or at collection centers reduces organic debris and associated pollutants from the runoff waste stream. Additional benefits include increased soil organic matter, resulting in improved water and nutrient holding capacity, and nutrients, which reduce the need for fertilizers.

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- **Roofing or otherwise enclosing areas.** Loading docks, storage areas for raw materials, wastes or final products, and equipment maintenance and storage areas are likely pollutant sources carried in runoff. Roofing or enclosing these areas so they are no longer exposed to rainfall or runoff will prevent oil, gasoline, fuels, solvents, hydraulic fluids, sediment, organics, nutrients, and other pollutants from entering runoff. However, since roofing increases impervious area, this effect should be mitigated.

- **Proper siting and storage of materials.** Many commonly purchased and used materials can contribute to runoff pollution. For example, many businesses store and sell bags of fertilizer and pesticides from pallets in an open parking lot. These bags often tear or rip, allowing material to spill onto the paved surface. A storm sewer inlet directly downstream provides a direct conduit to transfer this material to a downstream waterbody. Such areas may need roofing. At a minimum, storm drains should not be located downstream. Aboveground storage and secondary containment may be necessary for materials and in locations vulnerable to groundwater contamination.

- **Waste reduction and prevention.** Waste reduction usually involves using several integrated techniques to eliminate or reduce the amount of potentially hazardous materials used at a site. It may involve source reduction through good housekeeping, technology or process changes, or modification of input materials; recycling, reclamation, and reuse of materials; and treatment to reduce material toxicity.

- **Proper spill prevention and containment.** Facilities that store or use certain types of potentially hazardous materials may be required to prepare a written plan outlining their approach to preventing and containing spills. These plans document the operational procedures and management approaches. Pollution prevention plans typically specify procedures for preventing pollution caused by storage and use areas, manufacturing processes, treatment systems, or shipping areas; emergency containment and cleanup procedures to be used in case of spills, leaks, or other discharges; inspection procedures and schedules; and methods to maintain inventories of potentially hazardous materials from the time the material is received or manufactured until it is treated and discharged or shipped out.

- **Storm sewer screens.** Simple screens of chain link fencing placed at the outfall point of storm sewers capture cups, leaves, and other large debris. Of course, these screens must be regularly inspected and cleaned.

Operation/Maintenance Practices

Unlike traditional drainage facilities, urban runoff treatment systems are designed to capture and retain pollutants, especially solids. The accumulation of these materials can seriously impair the system's operation and greatly reduce its effectiveness, resulting in pollutant discharge and possibly increased flooding. Therefore, the long-term operation, maintenance and management requirements, and costs for a stormwater practice should be important considerations in selecting BMPs. Additionally, institutional frameworks must be created to assure that runoff systems are regularly inspected and maintained.

Stormwater System Operating Permits

One way local governments can reduce their liability for pollutants discharged from their runoff system is to assure that discharges are already properly managed. In states where new development must install on-site runoff management systems, a stormwater operating permit system implemented by the local government or stormwater utility can ensure that runoff facilities are maintained and operated properly. Operating permit systems typically require annual inspections of privately owned runoff facilities and certifications that all needed maintenance has been performed. Additionally, local governments can review the implementation of runoff pollution prevention plans required for industrial runoff sources discharging into the local system.

Storm Sewer Inlet or Catch Basin Cleaning

These inlet devices capture large debris, along with smaller sediment and organic materials. However, pollutants can be washed out if inlet devices become too full and rainfall occurs. Regular inspection and periodic maintenance (i.e., general vacuum cleaning) is essential for maximum environmental benefits. More frequent cleaning is required at certain times, such as when leaves fall.

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Highway and Utility Right-of-Way Maintenance

These activities involve materials that add to runoff problems. Shoulders and roadside swale systems should only be scraped or excavated if necessary to maintain the integrity and safety of roads. Vegetation should be mowed or maintained as necessary to keep areas stabilized and the use of nutrients and pesticides should be reduced.

Winter Road Management

In areas with snowfall and extended periods of freezing temperatures, special maintenance activities are needed on roads and bridges to keep them safely open to traffic. Since the late 1940s, road salt has been one of the most popular road deicers, with more than 11 million tons used annually. However, snow removal and storage along with salt application and storage can corrode bridges, roads, and vehicles and contribute to several adverse environmental conditions, including damage to roadside vegetation, stratification of ponds and lakes, increased chloride levels in surface and groundwaters and contamination of water resources. These effects can be reduced or prevented by

- **Carefully siting snow storage areas.** Runoff or seepage from the snow pile should not go directly into surface or groundwaters. Ideally, these areas will be served by BMPs that capture pollutants attached to the snow and soil particles.

- **Minimizing or eliminating the use of salt (sodium chloride).** Determine and use proper application amounts. Consider alternatives to salt, such as calcium magnesium acetate (CMA), calcium chloride, urea, sand, potassium chloride, magnesium chloride, or other substances. Each has advantages and disadvantages, both environmental and economic.

- **Proper salt storage.** Some 80 to 90 percent of environmental problems from salt come from careless or improper storage. Elements of a good salt storage policy include

1. Not locating salt storage areas near waterbodies or other sensitive features.
2. Storing salt in permanent roofed structures. If salt cannot be stored indoors, use an impervious liner and a waterproof cover.
3. Storing salt on an impermeable surface, not bare ground.
4. Routing runoff from the salt storage area to an appropriate runoff management system.

Public Education Practices

Many previously discussed structural practices—swales, retention areas, and detention lakes—require public education programs to be readily accepted and used. Programs concerning the following topics or activities have proven effective:

- **Storm sewer stenciling.** Stenciling storm sewer inlets with messages such as "Dump no wastes, drains to lake (bay, river)" can greatly increase public understanding of the relationship between pollution sources and receiving waters. These programs often are conducted by youth groups or civic associations.

- **Econeighborhood programs.** These programs designate econeighborhoods and secure residents' commitments to follow good housekeeping practices.

- **Education displays, pamphlets, booklets, and utility stuffers.** Educational materials cover a wide variety of everyday citizen activities that can adversely affect water resources. Citizens need to understand how their activities around the home and yard can contribute to water quality problems.

- **Public awareness.** Public information and education can reduce nonpoint source pollution by changing individual behavior and lifestyles. An information program that educates citizens can also encourage them to become part of the solution. This chapter and Appendix C provide numerous sources of information for public awareness programs.

Recommended Reading

Many excellent sources of information are available on the use of nonstructural runoff management practices. Numerous urban and planning textbooks provide relevant material. Federal, state, regional, and local agencies have produced many helpful booklets and brochures on the cor-

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rect use of household and yard chemicals and other materials—these are frequently available from Agricultural Extension Service offices.

Many state, regional, and local governments offer detailed best management practices manuals, several of which are referred to in other chapters. Additionally, local governments have model land development ordinances and codes. Regional planning councils and councils of governments often have model land development regulations.

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CHAPTER 13

Legal Authorities

A good runoff management program is founded on legal authority, design and implementation criteria, and adequate resources. This chapter is mainly concerned with legal authority.

The evolution of sediment control and urban runoff management programs has been gradual. In attempting to address local problems and concerns, several areas of the country have provided leadership. The runoff management issue has emerged from concerns over flood damage and public safety.

Historically, society has relied on water for transportation and commerce, necessitating significant development in areas adjacent to waterways. Over the last 200 years, the frequency and magnitude of flooding, the associated damages, and the potential for loss of life have inspired public efforts to reduce the adverse impacts. These efforts have naturally evolved into considering changes in upstream land use, since those changes affect impact on downstream flooding potential.

Early runoff management efforts relied on channelizing streams and constructing large regional detention facilities to control upstream peak discharge release rates and prevent increasing downstream flood frequency or elevation. Most early ordinances only controlled peak discharge rates from new development activities. Common criteria varied with policies to control the postdevelopment 10-year storm to the predevelopment 10-year peak release rate, and other similar variations.

Concerns about water quality and controlling sediment during construction were localized and occurred only when the magnitude of land development necessitated action. With the 1970s and the first Earth Day, the public gradually became aware, however grudgingly, of impacts beyond water quantity control. Approximately half the states have some form of erosion and sediment control laws, although few are aggressively implementing a program. Fewer states have implemented runoff management programs concerned with water quality. The problem in implementing comprehensive sediment control and urban runoff management programs for new development activities is not inadequate technology—the problem is a lack of commitment.

While most jurisdictions are familiar with the adage, an ounce of prevention is worth a pound of cure, many implement sediment control and runoff programs only after significant resource damage has been done. Many areas should implement effective programs now, before runoff impacts become so great that solutions are limited and costly. One major benefit of the 1987 amendments to the Clean Water Act and section 6217 of the Coastal Zone Act Reauthorization Amendment of 1990 is the increased national awareness of sediment control and urban runoff management needs and requirements. Still, state and local governments must recognize that these issues are important, even without federal initiatives. Efforts must be initiated to prevent existing water quantity and quality problems from intensifying.

Program Considerations

Identifying and Documenting the Problem

In initiating a sediment control and runoff management program, consideration must be given to identifying and documenting the problem. The impetus could be a water supply reservoir that is becoming fouled with nutrients or other pollutants, making drinking water treatment expensive.

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Most water quality programs—for example, Chesapeake Bay and Puget Sound—focus on downstream resource protection. The National Estuary Programs, the Clean Lakes Programs, and others provide examples of state, regional, and local government responses to documented problems.

Problems must be clearly identified and documented. For example, a resource problem in fisheries is a dramatic decline in clam landings over the last 10 years; the cause, however, is increasing development in contributing drainage areas. Another example is the dramatic decline in stripped bass landings in the Chesapeake Bay. The problem must be clearly defined before solutions are considered.

Prelaw Educational Efforts

Education is the key to garnering the necessary political support. To win support, the problem must be clear to the average individual. Individuals must buy in to the need and the personal impact of the proposal.

In Delaware, for example, individuals spent approximately six months on problem identification before beginning the sediment and runoff effort. The effort included documenting construction and degraded stream system problems with slides at public presentations to environmental groups, municipal leagues, Kiwanis clubs, engineering societies, and the general public.

Education should include the components of the proposal, the types of practices required, and the industries impacted. Supporters must clearly define the proposal and effectively respond to concerns. The proposal should answer all concerns; if not, it must be modified or the provision eliminated. A response should not transfer responsibility to another source or entity.

To succeed, the proposal and its components must be important to the agency responsible for its implementation. Reaching consensus before the law is formally considered avoids adversarial situations, which take an enormous amount of time and negatively affect implementation.

Sediment and Runoff Law

The sediment and runoff law should provide a framework for the overall program. The law should have general design criteria or technical considerations to avoid the need for future amendments and political review by individuals unfamiliar with the issues. Delaware's law and regulations provide an example (Appendix A and B). Components to be considered in developing a statewide or regional program or law include the following:

- A statement of policy followed by text that provides a specific approach to implement the policy.
- Definition of important terms to avoid misunderstanding in their use.
- Delineation of the types of activities regulated under the law. Clearly identify activities not intended for coverage to avoid confusion over their status. For example, if agricultural land management activities are not included, specify this exception.
- Outline of funding resources. If the program is funded through permit fees, define the authority to collect fees. Discuss legal mechanisms, such as a runoff management utility, as a future option.
- Definition of agency responsibilities. If the program is implemented at a state level, define the role of the state agency in conjunction with those local agencies; if implemented at the local level, define responsibilities of other related local programs.
- Specification of the effective implementation date. Programs directed toward new development activities usually incorporate an existing building permit process to ensure plan design and approval. In addition, situations where plans have been approved but not yet implemented must be defined and a cutoff point specified for older plan redesigns or reconsiderations in light of new requirements.
- Definition of responsibility for review of state and federal activities.
- Definition of enforcement procedures to ensure consistency among projects and to educate regulated individuals about their serious responsibilities under the law.
- Other local requirements, such as phasing the program into the region or watershed or requiring educational assistance on program implementation. For example, both Delaware and Maryland mandate education by requiring contractors to certify that a responsible representative has taken a state course in erosion and sediment control.
- Definition of penalties and appeals procedures.

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Sediment and Runoff Regulations

As the law provides a broad paintbrush for an overall program, regulations provide specific detail for day-to-day program implementation. Detailed regulations provide a means to implement the law's general requirements. Delaware's sediment and runoff management regulations provide an example of statewide regulations (see Appendix B).

Some components to consider in developing statewide or regional regulations include the following:

- The scope of the regulations, mentioning specific areas of additional emphasis.
- Term definitions. Give careful consideration to each, as they often determine policy issues and answer numerous questions about aspects initially given broad interpretation.
- Specific exemptions, waivers, and variances. Variances are particularly important where increased flexibility is needed to fit a strategy to a specific site.
- Details of the process of permit application and approval time frames and obligations.
- Specific design criteria. Criteria should address the level of control, preferences in practices, and information required on each project. Each application should include information, specified in the regulations, to enable the approval agency to make and defend its decision.
- Detailed construction inspection and enforcement requirements. Enforcement must be progressive, not random.
- Definition of any appeals procedures or hearing requirements.

Advice from Impacted Industries

A first step in developing and implementing a sediment control and runoff management program is to open and maintain a dialogue with the impacted industries. These include homebuilders, contractors' associations, developers, and consultants. Representatives must understand the program goals and their legal obligations. To ensure industry involvement, the various entities should be asked to assign a representative to attend meetings and review draft documents prior to public release.

Another way to receive input is through required educational programs. Delaware requires contractors and inspectors to receive training on sediment control and runoff management. The state has successfully received feedback from the impacted industries in a nonadversarial forum and has modified the program as a result.

Detailed Design Guidance

The permit review process places consultants who represent land developers in a difficult position. To provide a cost estimate of their services, consultants must understand the system design obligations. This understanding can only be ensured through a good relationship and good design guidance developed or accepted by the permitting agency. Thorough guidance results in fewer problems with individual plan review, fewer submissions, and a greater assurance that the design meets the best available standards for success.

The guidance should include all acceptable options for sediment control and runoff management and contain illustrated details and case studies to explain design standards and procedures. Legally, the regulations should refer to the design guidance; guidance modification should include public review and comment. A meaningful guidance document should be developed when the program is implemented, not just adapted from somewhere else—unless the document reflects a clear understanding of the original principles.

Problem Areas

In areas with existing runoff management programs, more than one entity or agency involved in policy may create a problem. Conflicts can be extremely frustrating and take time and resources away from program implementation. However, conflicts often come from a greater awareness of linkages between two or more previously unrelated programs. While linkage often improves program performance, conflicts can overshadow this positive aspect, and both programs can suffer. For example, conflicts can occur between emerging NPDES programs and traditional sediment and runoff or nonpoint source control programs. Conflicts can also exist when sediment, runoff, and wetlands programs are linked with traditional public works programs, planning agency responsibilities, and any number of other potentially conflicting areas. All entities need to recognize the compatibility of these programs and that overall goals can be enhanced through communication.

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A major problem can occur when sediment control and runoff management responsibilities are added to an existing building permit program. Far from improving both programs, experience has shown that overlapping responsibilities can reduce the emphasis on one program and weaken the overall effort. Sediment and runoff programs, along with other programs, need individual attention to succeed. Individual identities must be defined within the organization, not just function as an add-on. For example, a sediment and runoff program added to a sewer line review and approval program can reduce the effectiveness of both programs, especially in inspection and enforcement. Inspectors need a defined area of responsibility, not a requirement to inspect a project for multiple reasons.

Since the sediment and runoff program is a regulatory program, enforcement action will occasionally be required. However, if permit or inspection agencies are reluctant to engage in enforcement, the program's credibility can be reduced. While most contractors and developers willingly comply with laws and regulations, they periodically challenge the requirement to implement an environmental control. Erosion and sediment control are seen as temporary practices, and the industry sees avoiding these controls as a way to cut costs. Providing an enforcement presence and a willingness to take action improves the chance of properly installing controls.

Implementing an effective sediment control and runoff management program costs money. Few programs are adequately staffed or funded. This is especially true if the budget depends on permit fees or if the program is part of an agency's overall budget and must compete with other important areas. A dedicated source of revenue should be developed to maintain a sense of continuity.

Finally, a single individual cannot implement a statewide sediment and runoff program, even through a system of general permits. These programs are important components of a whole urban environment and must be treated on a level equal to other urban programs.

Recommendations

Programs should be consolidated, or at least closely coordinated, with existing related programs. In addition, communication must be established with other agencies (i.e., local land use, public works, and building permit) and other environmental programs (i.e., wetlands, groundwater, drainage, or others) that could affect the sediment and runoff program. While agencies must be educated about the direction and importance of the sediment and runoff program, program staff must be sensitive to issues and priorities of these agencies—especially on the issue of wetlands and the location of runoff management structures. Diverse programs need to work together, especially in times of limited fiscal resources.

Education, a constant theme in this guide, cannot be stressed enough. Educational efforts and activities, which significantly enhance the chances of legislative or regulatory approval, must be continuous to remind people of the importance of runoff control, both during and after construction projects.

Programs must be consistent in their implementation. Projects must be reviewed consistently, and any variation in review or approval procedures should be documented to avoid challenges to the final decision. Consistency must also be applied to site review and enforcement procedures. Written enforcement procedures should be developed and circulated to the impacted industry so that all concerned will understand enforcement steps to be taken if required controls are not implemented. Enforcement procedures should be progressive, with severity increasing as noncompliance continues. Steps could range from withholding occupancy permits until controls are implemented to halting work until environmental controls are correctly installed. Civil and/or criminal penalties can also force site compliance.

A successful program requires an open line of communication to the regulated community. One vehicle, a regulatory advisory committee, is important not only in program development but also in day-to-day implementation and evolution. Advisory committee meetings provide an interested and sympathetic forum to uncover design or implementation problems. Regular meetings reduce the "we-they" syndrome.

Other Available Sources

This guide refers to numerous localities and states that have implemented programs. In addition, case studies are presented in Chapter 16. Contact individual agencies mentioned throughout the guide for additional information.

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CHAPTER 14

Inspection and Maintenance of Runoff Control Practices

This chapter presents key elements and characteristics of both a comprehensive construction inspection and a postconstruction maintenance program, including preconstruction planning using postconstruction standards.

Effective runoff management using structural practices and facilities requires successful execution of all phases of development.

These phases include

- Comprehensive analysis of site conditions and potential adverse impacts and problems during the project planning phase;
- Accurate and intelligent design of practices and facilities for convenient maintenance that will prevent or minimize adverse impacts and protect aquatic resources during and after construction;
- Competent and comprehensive review of practices, facility designs, and plans during the permit application phase;
- Proper construction and implementation of the practices or facilities according to the approved plans and applicable permit conditions; and
- Proper operation and thorough maintenance of the practices or facilities after installation.

All of these phases can benefit significantly from increased understanding of the fundamentals of the runoff and soil erosion processes at the heart of any runoff management program, and from increased design, construction, and inspection skills and experience. Similarly, failure to competently complete any of the phases can lead to program failure and environmental damage.

Recent investigations and experience have highlighted the serious adverse impacts of inadequate planning, design, implementation, construction, inspection, and postconstruction maintenance. Correcting these weaknesses first requires comprehensive and aggressive inspection programs while constructing land development sites. These programs must do more than focus on the proper construction of permanent structural facilities intended to provide long-term management of site runoff. They must also concentrate on the proper installation and maintenance of the site's short-term erosion and sediment control measures. Finally, continuing inspection and maintenance programs are also needed to ensure effective and safe operation of the structural facilities after site construction is completed.

Despite the importance of construction inspection and postconstruction maintenance programs, several factors complicate or hinder their development. One is the legal authority to both perform inspections and enforce facility maintenance requirements (see Chapter 13). Although federal and state governments have begun developing inspection and maintenance standards, land development's diffuse nature and the country's long-standing tradition of local land use control require that local governments acquire legal authority. A second factor is the costs of these programs and local government's ability to meet them. A third is the inherent institutional and regulatory difficulty of adequately managing the diversity of permanent runoff management facilities and temporary soil erosion control practices currently available.

Although the subject is complex, the benefits of understanding how to develop a runoff management program are great. The chapter begins with an overview of key elements of the inspection and maintenance program. It explores the

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interrelationship between construction inspection and a facility's early planning, design, and permit phases, emphasizing the effect on long-term performance and maintenance. Much of this material is based on the *Stormwater Management Facilities Maintenance Manual* developed by the New Jersey Department of Environmental Protection and Energy (1989).

The remainder of the chapter contains two detailed presentations. One focuses on an inspection and maintenance program for construction site erosion and sediment control practices. The second focuses on permanent drainage and runoff management facilities at a land development site. It describes a program embracing both short-term inspection when the facilities are constructed and long-term inspection and maintenance to ensure effective operation. Both presentations emphasize inspector training and education, contain recommendations regarding program structure, and discuss key program elements. They also provide examples of field inspection checks. These presentations should give readers a head start in developing their own programs and, in particular, training the staff charged with program performance.

The presentations were derived from two courses at the University of Washington's Center for Urban Water Resources Management and Engineering Professional programs. Course manuals are available for erosion and sediment control inspector training (Reinelt, 1991) and permanent drainage system inspector training (Reinelt, 1992). Local governments and state agencies in the Puget Sound area of Washington State have worked actively to improve runoff management through effective inspection and maintenance and have contributed to these materials.

Inspection and Maintenance Overview

An effective inspection and maintenance program has a number of aspects. This overview discusses the importance of the key program elements—construction inspection and maintenance; the numerous aspects of preconstruction activities; enforcement options; funding techniques; and education and training.

Understanding Key Program Elements

The overall success of any runoff management program hinges on understanding each term. However, this cannot be done by simply quoting dictionary definitions because of the many aspects of land development involved in each. The following detailed descriptions should aid understanding:

▮ ***Construction Inspection.*** This activity involves the careful field observation of construction activities and materials and their end products or measures. While construction activities—complexity, duration, manpower, and hazard—and construction materials—character, quantity, and cost—can vary widely, runoff management categorizes them in two ways. The first category includes activities and materials used to construct temporary erosion and sediment control (ESC) measures at land development sites. These measures control the amount of soil lost from erosion and minimize the adverse downstream impacts of subsequent sedimentation during site construction. The second category includes activities and materials used to construct permanent runoff management and drainage facilities that address both quantitative and qualitative effects on runoff produced by the developed site.

The key distinction between the categories is time. In the first, the effects of site development on soil erosion and sedimentation are temporary and limited to the construction period when soils are exposed to rainfall and runoff. As such, the measures and materials used are temporary and removed when the site is permanently stabilized. These measures range from temporary seeding and mulching of exposed soils to constructing sediment basins and barriers.

The second category deals with the more critical effects of the site's development on urban runoff quantity—volume, rate, and timing—and quality over the site's postdevelopment life. These measures, intended to minimize and mitigate development effects, must last as long as the site is used. Permanent measures include runoff detention and infiltration basins, storm sewer systems, and swale/channel networks.

Regardless of the timing or duration of the various measures, the construction program is responsible for ensuring that construction activity adheres to approved plans, designs, standards, and generally accepted construction techniques.

The importance of continuing inspections cannot be overstated. After temporary measures or permanent facilities are completed, continuing inspections ensure that measures perform as intended and remain in sound, safe condition. Inspections of ESC measures normally take place

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along with general construction inspection of the development site. Inspection of permanent facilities, however, must occur after site development and construction are completed; it therefore requires that an inspector take separate action. Effective inspections are usually combined with permanent facility maintenance.

▮ ***Maintenance.*** For both runoff facilities and ESC measures, this activity involves repairing, replacing, restoring, or replenishing the various components and materials of the measure or facility. Maintenance activities include preventive and corrective measures, with time the key distinction between the two. Preventive maintenance requires replacing components or materials before they cease to function adequately, often according to a schedule. Corrective maintenance is performed after failure or malfunction occurs, often quickly in an emergency. Obviously, preventive maintenance is preferred over corrective maintenance because of safety, time, cost, and overall effectiveness.

Maintenance keeps both the temporary ESC measure and the permanent facility functioning safely and at optimum efficiency levels. Maintenance can also correct design or construction deficiencies, improve performance, and enhance safety above constructed levels.

Preconstruction Inspection and Maintenance

Once the regulations have been satisfied on paper through planning, design, and permit stages, the project is ready for construction. The methods and materials used in construction must be competently inspected to ensure that the goals of the planning, design, and permit stages are met in the field.

ESC measures and runoff facility maintenance are vitally important. Structural facilities cannot perform their duties and achieve their goals without regular maintenance. Maintenance is particularly acute for structural facilities used to address runoff quality impacts. As particulate settling and removal efficiency has increased, the sediment and debris accumulation within runoff facilities has increased the maintenance need.

Runoff facilities also must be maintained structurally to ensure their continued safety and protect people and property. This is particularly true of facilities and measures that impound runoff, even for a short period. Structural failure causing release of stored runoff will usually result in greater downstream flooding and damage than would have occurred without the facility. This threat may greatly outweighs all benefits.

Inspection is also key to a maintenance program. Whether preventative or corrective, maintenance must be preceded by an inspection to evaluate the required procedures, materials, equipment, personnel, urgency, time, and cost. Effective and efficient inspection activities should be performed regularly and should emphasize prevention rather than correction. In addition, inspectors must be highly knowledgeable and experienced and take responsibility for the results of construction or maintenance. As such, inspector training is a vital component of any runoff management program. Training must be comprehensive, covering all aspects of the runoff management and soil erosion processes, from theory to practical applications.

Preconstruction stages and activities can cause significant construction and maintenance problems. Avoiding problems requires a close look at all preconstruction stages, from the regulations that define the structural measure or facility, through the technical planning and design stages, to the permit stage, where construction is authorized.

▮ ***Regulatory Aspects.*** Chapter 11 presented the various regulatory needs of a comprehensive runoff management program, including those for effective construction inspection and facility maintenance programs. This section addresses inspection and maintenance problems caused by the very regulations that initially created these programs.

While structural measures and facilities must be based on effective standards and accurate designs to achieve desired goals, the quality or level of standards, designs, and objectives means nothing unless the facility or measure is actually constructed. Unfortunately, in developing the various regulations, the importance of construction is sometimes lost or forgotten. While considerable effort is devoted to goals and how to achieve them, facility construction is sometimes treated as an afterthought or, even worse, a given or guaranteed end-product requiring little, if any, official attention.

The same is also true for facility maintenance. Despite the importance of maintenance to short and long-term performance, regulations requiring maintenance often lack purpose, effectiveness, or are simply nonexistent.

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Therefore, consider the following in developing runoff regulations:

- Recognize the fundamental need for facility construction and maintenance to truly achieve program goals and objectives.

- Consider construction and maintenance of equal importance with planning, designing, and permitting. The regulations should promote the importance of inspection and maintenance at all stages and by all personnel.

- Regulations should officially designate a responsible party, frequently the development site owner, to have ultimate responsibility for the proper construction and continued maintenance. This official designation provides the opportunity for appropriate preparation and budgeting prior to actually assuming responsibilities. It also facilitates enforcement or other legal remedies necessary to address compliance or performance problems once the facility has construction approval.

- Regulations should clearly state the inspection and maintenance requirements during and following construction and address both temporary measures and permanent facilities. Construction requirements should be based on many standard construction practices and specifications, promulgated by various private organizations and government agencies, and fully comply with all applicable local, state, and federal laws. Inspection and maintenance requirements should also comply with all applicable statutes and be based on the needs and priorities of the individual measure or facility. A clear presentation will help owners and builders comply and inspectors enforce requirements.

- Regulations must contain comprehensive requirements for documenting and detailing construction and maintenance. For construction, this includes detailed, well-researched plans and specifications that fully describe the facility's construction. Plans and specifications should include pertinent information on locations, dimensions, elevations, materials, processes, and times. Drawings should be easy to use in the field under adverse weather conditions. Regulations should also require enough copies of plans and specifications to supply field and office personnel, builders, inspectors, and regulators. Provide a dissemination procedure guaranteeing that all involved have identical approved plans and specifications.

Requirements are similar for maintenance. A facility operation and maintenance manual must be prepared containing accurate and comprehensive drawings or plans of the completed facility and detailed descriptions and schedules of inspection and maintenance. An emergency action plan should also be required for regional and other large runoff impoundment facilities. This plan should contain measures for various emergency conditions, such as structural failure, neglect, vandalism, or accident. The plan should also include the types and sources of repair materials and a list of individuals, agencies, and officials to be notified quickly if the facility appears to or actually malfunctions or fails. This list might include local and state government and public safety officials, downstream residents, and business owners. The plan should also contain the method of notification.

- The regulations should delineate the procedure for construction or maintenance noncompliance. This process should provide informal, discretionary measures to deal with periodic, inadvertent noncompliance and formal and severe measures to address chronic noncompliance or performance problems. In either case, the primary goal of enforcement is to construct a safe and effective facility—the enforcement action should not become an end in itself.

- Regulations must also address the possibility of total default by the owner or builder by providing a way to complete construction and continue maintenance. For example, the public might assume construction and/or maintenance responsibility. If so, the designated public agency must be alerted and possess the necessary staffing, equipment, expertise, and funding to assume this responsibility. Default can be addressed through bonds and other performance guarantees obtained before the project is approved and construction begins. These bonds can then be used to fund the necessary construction or maintenance activities.

- The regulations must recognize that adequate and secure funding is needed for all

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aspects of facility construction, inspection, and maintenance and provide for such funding. In fact, the program goals or accomplishments might be limited to available funding. Funding sources and techniques are summarized later in the chapter.

- To minimize overall inspection and maintenance effort and expense, the regulations should encourage and provide a way to regionalize runoff facilities. Situations where numerous independent on-site facilities are replaced by one or several regional facilities have been particularly effective for runoff quantity control and flood prevention. Regionalization also results in overall savings in planning, design, and construction efforts and costs and requires less total land disturbance. Finally, designing and implementing regional facilities requires planners, designers, regulators, developers, and residents to adopt a watershed approach to runoff. Such a comprehensive approach should be promoted at every opportunity.

Planning and Design Aspects. The efforts of planners, designers, and those who review and approve the final facility have a profound influence on inspection and maintenance activities. This influence is particularly true for permanent runoff management and drainage facilities, which are generally more complex and require greater effort from these groups. Temporary ESC measures may also be significantly affected, particularly regarding the measure selected and its location.

According to the New Jersey *Stormwater Management Facilities Maintenance Manual* (1989), approximately two-thirds of the maintenance problems encountered during a review of 51 constructed facilities were at least partly due to a combination of inadequate and misguided planning, design, and review. The result was increased maintenance effort and cost, reduced facility performance, and increased safety threats to both residents and maintenance personnel.

Fortunately, enlightened and focused planning, design, and review can improve inspection efficiency and effectiveness and reduce maintenance effort and expense. Therefore, inspection and maintenance should be a primary consideration throughout the entire planning, design, and review process, equal in importance to achieving required performance and safety.

The following inspection and maintenance issues should be addressed in planning, designing, and reviewing runoff management and ESC facilities and measures:

- **Durability.** The use of strong, durable materials, components, and fasteners will greatly reduce the maintenance required. These savings normally more than justify any additional expense incurred. Durability extends across the entire range of facility components—from basin and pond outlet structures where reinforced concrete remains the material of choice, to vegetative covers and landscaping where durability is defined by hardiness and suitability to local conditions.

- **Constructability.** "The road to maintenance headaches is paved with good planning and design intentions that somehow went awry" (New Jersey Dep. Environ. Prot. Ener. 1989). All concerned must remember that the structural measure or facility must be safely and properly constructed before it can provide any runoff management benefits. Therefore, runoff program goals and the ideas of those seeking to fulfill them must, within reasonable effort and expense, be constructable in the field.

  Required materials must be available and construction techniques feasible. Construction plans and specifications—the builder and inspector's instruction manual—must be clear, informative, and contain all necessary information presented in a format that assists, not impedes, field use. Anyone who has struggled in the field with construction plans on a cold, windy day knows that construction details and notes are easier handled on the same sheet than scattered randomly throughout the entire set of plans.

- **Maintainability.** Throughout the planning, design, and review or permit process, every attempt should be made to eliminate or facilitate maintenance, whether selecting facility goals or materials. This applies to the facility's location, materials, configuration, and the techniques and equipment necessary to construct and maintain it.

  Questions of maintainability should be raised about the vegetation used and the habitats or ecosystems created by and within a runoff facility. How complex are these systems? How difficult will they be to manage? Will those responsible for overall facility maintenance be able to do it themselves, know where to find help, and be able to af-

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ford it? If the answer to any of these questions is no, the runoff facility may wind up harming rather than protecting the environment.

- **Accessibility.** Small oversights in planning, designing, and reviewing a runoff facility or measure can result in big inspection and maintenance problems. To perform inspection and maintenance tasks, personnel must have access to the facility and be able to bring the materials and equipment with them. Access can be as simple as hatches in gratings and gates on fences or as complex as access easements across private property. The best intentions of the most dedicated inspector or maintenance worker will go unfulfilled if they or their equipment cannot get to the facility to inspect, clean, repair, or replace.

  Efforts to facilitate access and enhance safety can often yield significant savings in inspection and maintenance. For example, mosquito control personnel are considerably more efficient if they can drive by a runoff facility and check for unintended standing water rather than parking, locking the vehicle, and walking several hundred feet or yards. This is particularly true when their inspection route includes tens or even hundreds of facilities—not uncommon in densely developed areas. Therefore, addressing accessibility simply by locating the facility to be viewed from the roadway can greatly reduce inspection efforts and expense.

To further fulfill inspection and maintenance needs, planners, designers, and reviewers periodically ask themselves the following series of questions:

- *Who* will perform inspection and maintenance? Arrangements should be made during the preconstruction, not postconstruction, stage to identify, train, equip, and fund the required personnel. If not, one of the postconstruction stages may be "facility failure."

- *What* must be done? What construction activities need to be monitored? What intermediate or final conditions need to be inspected? Will the inspector require a level or other surveying equipment? What facility components will require periodic inspection once construction is completed and the facility begins operation? What regular maintenance tasks must be performed? What emergency measures may have to be taken? What kind of material or equipment will be required?

- *When* will inspection and maintenance be required? Certain maintenance tasks, such as grass mowing, may need to be performed regularly during spring and summer but not at all in winter. During the wet season, can muddy, saturated slopes be accessed? Will equipment be available for slopes? Are roads and paths wide enough to provide access? Dams and embankments may require annual or biannual inspections for structural integrity, while trash racks may need to be inspected after every rain. And, although all inspections cannot be scheduled in advance—a fact that upsets managers and financial staff—they are certainly advisable after a major storm or flood.

- *Where* will the inspection or maintenance be performed? Do those responsible have both legal and physical access to the facility or measure? Where will the equipment and materials be staged or stored? Where will the grass clippings, sediment, trash, and debris be deposited? Locate these places prior to construction rather than during or, even worse, after construction is completed.

Structural ESC and runoff management measures and facilities require competent inspection and regular maintenance to perform as required and provide safety to workers and residents. The efforts of planners, designers, and reviewers directly affect the need for and complexity of such inspection and maintenance. Enlightened planning, design, and review that recognizes and seeks to improve this relationship can significantly reduce inspection and maintenance costs and increase their effectiveness.

Enforcement Options

A public agency will sometimes need to compel those responsible for facility construction or maintenance to fulfill their obligations. Therefore, the inspection program must have enforcement options for quick corrective action. Rather than a single enforcement measure, the program should have a variety of techniques, each with its own degree of formality and legal weight. The inspec-

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tion program should provide for nonconforming performance and even default and contain suitable means to address all stages.

To avoid the need for enforcement measures, a spirit of cooperation should begin during the project's design review and permit stages by developing facility designs suitable to all parties. Education and training efforts and predesign or preapplication meetings can develop and promote such cooperation and allow each party to familiarize itself with the needs and interests of others.

Prior to receiving construction approval, the developer or builder should provide performance guarantees. The public agency overseeing the construction can use these guarantees, usually a performance bond or other surety in an amount equal to the facility's construction cost, to fund construction in case the builder defaults. As described under the next section, the developer or builder should provide sufficient funds to finance the construction inspection before the project begins. The dedicated inspection funds and the performance bond insure that construction can be completed regardless of the builder's ability or willingness.

Once construction has begun, the responsible public agency can issue a stop work order to compel the builder or developer to comply with project specifications and other requirements. Other techniques include withholding certificates of occupancy for completed portions of the development and formal civil or criminal action. Ideally, the cooperative attitude developed during preconstruction will continue through the construction period. This attitude, promoted through comprehensive preconstruction meetings and regular and informal progress and problem-solving meetings, can help avoid the need for formal and severe enforcement actions.

Public Funding Techniques

Funding techniques are critical to an effective inspection and maintenance program. The following paragraphs discuss four general techniques, each applying to specific inspection and maintenance efforts. The information is based largely on Chapter 6 of the *Stormwater Management Facilities Maintenance Manual* (New Jersey Dep. Environ. Prot. Ener. 1989). (See Other Sources for additional information on funding.)

Tax Revenues

Tax revenues are an obvious source of funding, particularly for the long-term inspection and maintenance of existing runoff and drainage facilities. The benefits and protection to the public from continued safe and effective operation of the facility justifies using revenues from general or specialized taxes. However, using these funds to inspect the construction or installation and maintain ESC measures at land development sites is more difficult to justify.

To use tax revenues, particularly from a general fund, the inspection and maintenance program must annually compete with all other programs included in the government's annual operating budget. This inconsistent and unreliable funding makes securing a long-term financial commitment to inspection and maintenance difficult and subject to political pressures. Nevertheless, tax revenues remain a popular funding source because the collection and disbursement system is already in place and familiar. In fact, this established and well-known system is often the first funding choice.

Turning instead to revenues from specialized taxes helps overcome some difficulties inherent in using general tax revenues. Relating the specialized tax program to runoff management and/or erosion and sediment control provides the necessary link between the revenue source and use. This method also avoids competing with other programs for general tax revenues. However, specialized tax programs must receive public and political support and legal authorization.

Utility Charges

Using utility charges to fund inspection and maintenance is a somewhat recent application of an already established financing technique. As noted in the *Stormwater Management Facilities Maintenance Manual* (1989), New Jersey began creating utility authorities and using charges collected within its service area to finance publicly owned water and sanitary sewerage systems in the early 1900s. Today, utility charges remain a popular financing technique in many New Jersey municipalities and counties. In addition, several municipalities and counties throughout the country have runoff management, drainage, and flood control authorities or districts to provide residents with runoff-related services.

Using utility charge financing has several advantages. By addressing only runoff needs and benefits, utility funding avoids competing with other programs and needs. Utility funding also demonstrates a direct link between the funding and the services it provides. This approach does, however, require an entirely new operating sys-

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tem and organization that needs legal authorization to exist, operate, and assess charges. The effort required to create such an entity can deter many, although the continued success of established authorities and growth of new ones have done much to allay concerns over the effort required.

In a runoff utility, the user charges are often based on the need for services rather than the benefits derived from them. While charges are based on actual costs to inspect and maintain runoff facilities and measures within the service area, the assessed rate structure should relate to site characteristics. These include property area size, extent of impervious coverage, and other factors with a direct and demonstrable effect on runoff. To be fair, the rate structure should also remain simple and understandable to the rate payer.

Permit Fees

Collecting permit fees to finance runoff inspection and maintenance is a long-standing funding procedure. Most governmental entities—local, county, and state—can establish and collect fees and other charges to obtain operating funds for programs and services. Many inspection services, most notably the construction inspection of both ESC measures and permanent drainage and runoff management facilities, are financed at least in part through fees collected by permitting agencies. Unlike taxes or some utility charges, inspection costs are borne by those who need them.

The permit fee collection program should have a demonstrable link to the runoff management or drainage systems. The public agency should demonstrate a direct link between the permit fees collected and the permitted project—one method is using dedicated accounts for individual projects and facilities. Finally, the rate structure should reflect site characteristics—such as area size or imperviousness—that directly relate to the measure or facility by affecting runoff or erosion.

Dedicated Contributions

Like permit fees, dedicated contributions require those creating the need to bear the cost. Under this system, land developers must provide the necessary funding for inspection or maintenance before receiving construction approval. Funds are deposited in a dedicated account controlled by the responsible public agency. In some New Jersey jurisdictions, developers fund construction inspection of the ESC and permanent drainage and runoff management facilities as part of the land development. The contribution is based on a cost estimate made prior to construction. Throughout construction, inspector time sheets and expense reports monitor and record actual costs; additional funds are obtained as necessary. When construction is complete, any unspent balance is returned to the developer.

Other public agencies have used developer contributions to fund long-term facility maintenance. This approach is particularly appropriate in single family residential subdivisions, where numerous individual property owners served by a single runoff facility can result in confusion over who has maintenance responsibility.

The exact funding technique depends on many factors, including community attitude and knowledge, economic and political viability, and program needs and costs. Some techniques, including permit fees and dedicated contributions, may be more appropriate for short-term activities, such as construction inspection. Others—utility charges and specialized tax revenues—may apply to all phases of an inspection and maintenance program but require considerable effort and special legal authorization to operate.

Education and Training

An important key to a successful inspection and maintenance program is the level of understanding and knowledge held by those affected. This includes the builders and inspectors who create or install the measure or facility; the planners, designers, and reviewers who use sound preconstruction techniques; and the public and its elected leaders who provide the necessary funding.

As such, a comprehensive and effective education and training effort must be part of any inspection and maintenance program. Details of such training efforts are highlighted in the following sections, which detail key elements of programs for erosion and sediment control measures at construction sites and permanent runoff management and drainage facilities.

Erosion and Sediment Control Inspection Programs

A comprehensive construction site erosion and sediment control program consists of several elements—erosion and sediment control planning, plan review, contractor education, and inspection and enforcement.

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The following sections cover ESC planning and inspection and enforcement, and provide examples of inspection guidelines for common practices.

ESC Planning

ESC planning is an absolute prerequisite for an effective program (see Chapter 12 for more details). A careful site analysis should produce a standalone plan devoted exclusively to this aspect of the project and executed with the same thoroughness and care as any other plan in the overall project.

Acquiring the familiarity with the site and proposed construction necessary to execute the ESC plan is an exercise in data collection and analysis. Information should be cataloged before laying out the ESC plan. Table 14.1 lists the data to be collected and the information to be cataloged.

An ESC plan consists of a narrative and site plans. It is the key element for implementing a comprehensive control program. Site plans are maps and engineering plans illustrating and specifying the project location, existing and modified site conditions, and BMPs. BMPs are usually spec-

Table 14.1—Preliminary information needed for ESC planning.

DATA TO BE COLLECTED	INFORMATION TO BE CATALOGED
■ Soils	■ Grading (location, amount)
■ Vegetation	■ Topographic changes
■ Topography	■ Clearing and grading limits
■ Groundwater table	■ Drainage changes
■ Neighboring waterbodies	■ Materials to be used
■ Adjacent properties	■ Locations of use and storage
■ Drainage routes and patterns (define subbasins)	■ Access points
■ Downstream channels and capacities	
■ Potential areas of serious erosion problems	
■ Existing development, utilities, and dump sites	

Table 14.2—Components of an ESC plan.

ESC PLAN NARRATIVE	SITE PLAN ELEMENTS
■ Project description	■ Data collection worksheet—shows topography, soils, and vegetation
■ Existing and modified site conditions	■ Data analysis worksheet—indicates drainage subbasins and primary drainage courses
■ Descriptions of ESC BMPs	■ Site plan development worksheet—shows existing and finished contours, roadways, and permanent runoff facilities
■ Descriptions of BMPs for pollutants other than sediments	■ Erosion control plan—shows BMP locations
■ Plans for permanent stabilization	■ Diagrams of representative BMPs—shows appropriate BMPs
■ Calculations	■ BMP operating procedures and maintenance schedules
■ Provisions for inspection and maintenance	

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ified using a system of symbols defined in a legend. Table 14.2 lists the various elements of the ESC plan narrative and site plan.

Inspection and Enforcement

The most important needs of this program are dedicated staff, specific staff training, and administrative support. A dedicated revenue source, such as a runoff utility assessment, can best provide these needs. Staff should not have unrelated and distracting duties, like inspecting other facets of construction. Training should offer a background in legal and regulatory requirements, water quality, hydrology, soils, vegetation, and other related issues. Training should also provide detailed coverage of BMP requirements (see following section). Administrators must provide strong backing to staff filling a relatively new function that is sometimes unpopular with economic interests.

During program development, some additional issues must be clarified and incorporated as formal program elements. Recommendations are drawn from experience in the Puget Sound region, especially in King County and the cities of Bellevue and Redmond in Washington State. One issue is how to respond when measures in an approved ESC plan prove to be inadequate. Strong permit review should normally limit these instances, but unforeseen circumstances can arise. The jurisdiction should retain the authority to require additional measures if needed and note this option on each ESC plan.

Another issue is handling field change orders. Plan change requests should receive careful but expeditious consideration, generally after consulting plan review personnel. Variances from code requirements should be granted only under strict and specific conditions:

- The result should at least be comparable to the expected outcome with the approved method.
- Sufficient background information and justification should be presented to adequately assess the alternative.
- The variance should retain the ability to meet safety, function, appearance, environmental protection, and maintenance objectives, based on sound engineering judgment.
- The variance should be in the public interest.

The enforcement authority and system must be obtained, defined, and clarified to the regulated parties. A three-step system is successfully used by the city of Bellevue:

- A verbal warning, with a correction deadline;
- A correction notice, with specifications of corrections, a deadline, and a warning of noncompliance consequences; and
- A stop work order, with warning of noncompliance consequences.

ESC Practices and Inspections

The numerous ESC practices can be categorized in various ways. The most basic division is between erosion control practices, which prevent or minimize erosion, and sediment control practices, which attempt to recapture soil that has been released through erosion. Several categories represent general strategies for achieving either erosion or sediment control. Construction sites can also generate many other pollutants—petroleum products, solvents, paints, sanding dusts, pesticides, and fertilizers. These materials can often be efficiently managed in concert with sediments and inspected simultaneously with ESC inspection. Therefore, these practices represent another basic division.

Table 14.3 provides a listing of the most widely recognized and used practices (Reinelt, 1991). All but the sediment trapping techniques are preventive and are thus the most cost-effective options. However, the straw bale and filter fabric fences and sedimentation ponds among the trapping techniques are most commonly seen.

The following are inspection checklists for example practices, generally the most common, in each category and subcategory. The checklists indicate checks for installation and checks for follow-up visits to determine maintenance or replacement needs.

While an inspector performs much work in the field, some background work must be done in the office before going out to inspect an installation. This work consists mainly of consulting the ESC plan to determine the specifications. The plan should be retained on the construction site so the inspector or construction personnel can reference it.

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Table 14.3—Commonly used erosion and sediment control practices.

PRACTICES	CATEGORIES	METHODS
Erosion Control	Natural vegetative cover	Phasing construction
	Temporary cover	Temporary seeding Straw mulch Wood fiber mulch Excelsior Mats and blankets
	Permanent vegetation establishment	Permanent seeding Sodding
	Stabilized construction entrance and roads	Quarry spalls
	Runoff control	Pipe slope drain Surface roughening Interceptor dikes or swales
Sediment Trapping Techniques	Sediment barriers	Filter fabric fence Straw bale fence Brush fences Gravel barriers
	Settling ponds	Sediment basin Sediment trap Permanent pond
Management of Other Construction Site Pollutants		Cement and concrete handling Material storage and handling Spill containment Waste management

A. Erosion Control

Natural Vegetative Cover

▮ ***Phasing Construction.*** Clearing operations are done in stages to take advantage of existing cover before construction.

■ **Installation checks**

1. Are areas not to be cleared set off with plainly visible fencing?
2. Is plainly visible flagging placed at the drip line of trees to be protected (Figure 14.1)?
3. Are fills and cuts near protected trees treated as shown in Figure 14.1?
4. Is final vegetation established as soon as portions of the site can be made ready?

■ **Maintenance checks**

1. Do fencing and flagging need repair or replacement so personnel can see them well?
2. Do exposed or injured roots of protected trees need covering or dressing?

Temporary Cover

Portions of most construction sites often remain unworked for months at a time. During that time large amounts of soil could erode unless the areas are stabilized by temporary seeding, various kinds of slope coverings, or both. Slope coverings include mulches and commercial mats and blankets. Applying temporary cover to different areas several times during construction is often necessary.

Mulches, mats, and blankets serve several purposes in erosion control. They cover the slope temporarily to prevent erosion by raindrop impact and runoff friction, hold water to aid grass growth, protect grass seedlings from heat, and enrich the soil. Straw, hay, wood fiber, wood chips, and other natural organic materials can serve as mulches. Mats and blankets are manufactured from both natural and synthetic materials.

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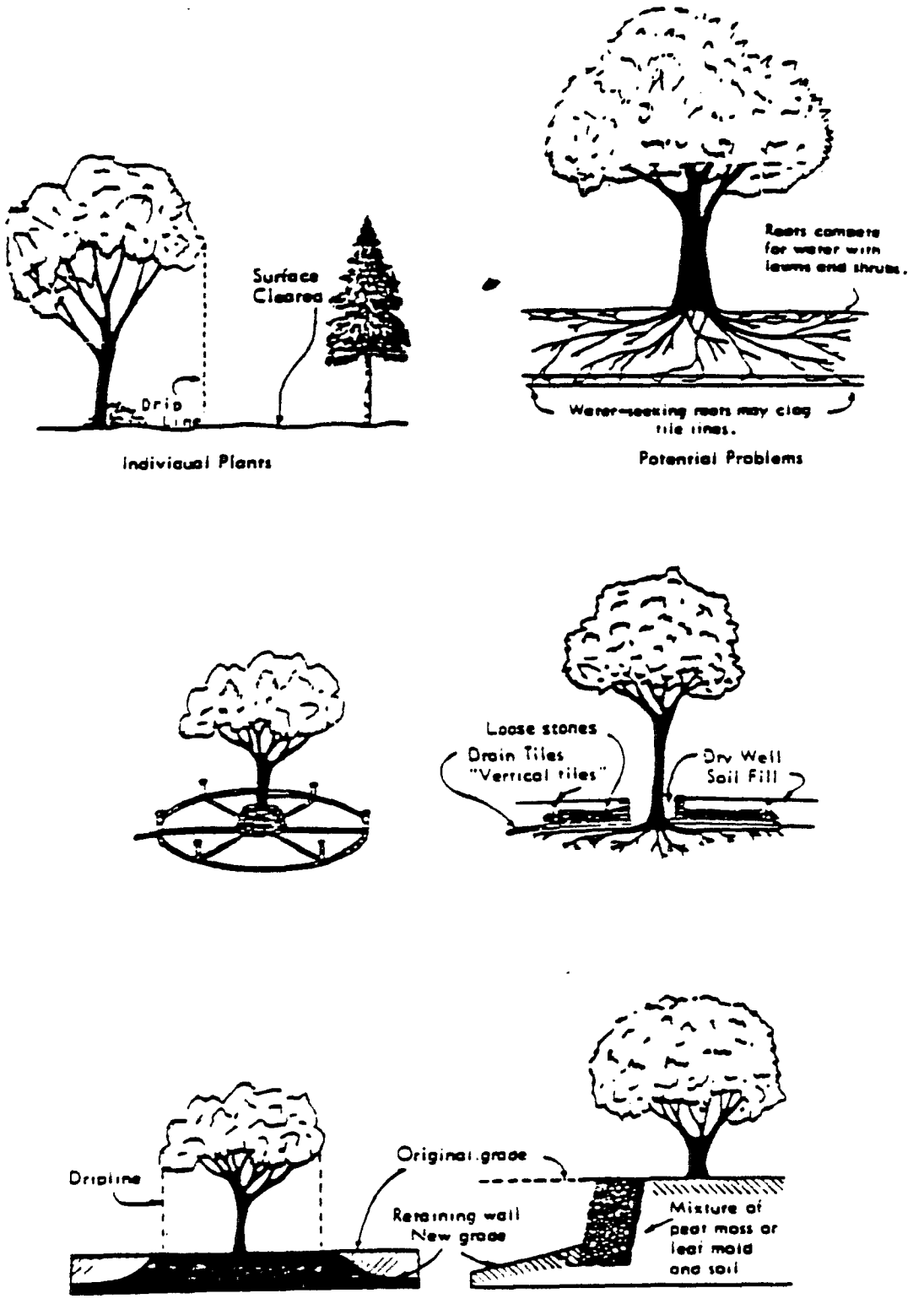
Figure 14.1—Guidelines for preserving natural vegetation.



Source: Washington Dep. Ecol. 1992.

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Temporary Seeding

Installation checks

1. Is the soil stabilized within the period specified by regulation? This period varies from place to place depending on climate patterns. In the Puget Sound area of Washington State, which receives most of its rainfall in the winter, the specified periods are within two days from October to April and within seven days from May to September.
2. If used without slope covering practices, is temporary seeding limited to slopes less than 10 percent and 100 ft (30.48 m) in length? If the slope exceeds either limit, is a mulch or mat slope covering used?
3. Has the seedbed been prepared with 2 to 4 in (5.08 to 10.16 cm) of tilled topsoil?
4. Is fertilizer use limited as much as possible? If used, is it applied in amounts limited to grass needs for the prevailing soil conditions?
5. Is mulch applied to newly seeded areas that can be subject to high temperatures and runoff before the grass is well established?
6. Is irrigation provided for seeded areas that might have insufficient rainfall for good establishment?

Maintenance checks

1. Is irrigation and/or reseeding necessary?

Straw Mulch. Straw mulch can be used without seeding or, for better erosion control, with seeding.

Installation checks

1. Is the straw spread a minimum of 2 in (5.08 cm) deep (corresponding to 2 to 3 tons [4.47 to 6.72 Mg/ha] per acre), and deeper on very steep slopes, adjacent to sensitive areas, and where concentrated flow passes over the slope?
2. Is the mulch anchored as needed by crimping, disking, rolling, or punching into soil or by moistening, tackifying, or netting?

Maintenance checks

1. Should mulch be replaced because it blew away or decomposed over time?
2. Should mulch be moistened to eliminate a fire hazard?

Wood Fiber Mulch. Wood fiber mulch should only be used with seeding and generally with a soil bonding agent.

Installation checks

1. Is extensive runoff expected before good grass growth will occur? If so, is an extra coarse grade of wood fiber mulch applied?
2. Is the mulch used with seeding and a soil bonding agent? Were the application guidelines followed?
3. Has wood fiber been applied to cover the soil completely, allowing no bare soil to show through? This amount corresponds to about 1 ton per acre (2.24 Mg/ha) and is adequate for most circumstances. Do special circumstances, such as seeding during hot weather, require increasing the amount by about 50 percent?

Maintenance checks

1. Is replacement needed as a result of loss over time?

Excelsior. Excelsior is made of fine wood shavings in a helical form. Because this form does not allow excelsior to lie in close contact with the soil, runoff drains beneath it and causes erosion. Therefore, it should be used only with seeding when needed to hold moisture and provide protection from direct sun in hot periods. Suppliers generally market several grades for sheet and channelized flow and different velocities.

Installation checks

1. Is excelsior used only with seeding?
2. Was an appropriate material selected, placed, and stapled according to manufacturer's recommendations?
3. On slopes, was excelsior placed 3 ft (0.91 m) over the crest or in an anchor ditch?
4. In ditches, was excelsior placed in the direction of water flow, with any seams offset 6 in (15.24 cm) from the ditch centerline?

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Maintenance checks

1. Is replacement needed as a result of damage or loss over time?

Mats and Blankets. Examples of materials produced in mat or blanket form are jute, woven straw, and synthetics. Mats can be used without seeding or with seeding for better erosion control. As with excelsior, suppliers generally market several grades for sheet and channelized flow and different velocities.

Installation checks

1. Was an appropriate material selected, placed, and stapled according to manufacturer's recommendations?
2. Was the material placed in the direction of water flow, in full contact with the soil but not tightly stretched?

Maintenance checks

1. Is replacement needed as a result of damage or loss over time?

Permanent Vegetation Establishment

Permanent vegetation should be established in each segment of the site as soon as possible after construction is completed. Grass can be established by seeding or sodding. Seeding is generally preferred, because of lower cost and greater flexibility in selecting grass species. Sod is often available only in limited varieties that may not be suitable for erosion control and other purposes, unless grown to order. Overseeding with preferred species can be performed in the spring, while grass establishment must be done with sod in the winter. Species should be selected based on local climate and soil conditions, using regional guides and consulting with regional experts.

Permanent Seeding

Installation checks

1. Has the seedbed been prepared by loosening with a plow if subsoils are highly compacted, spreading 2 to 6 in (5.08 to 15.24 cm) of topsoil, and lightly rolling?
2. Is fertilizer use limited? If used, is it applied in amounts no greater than needed for the prevailing soil conditions?
3. Is mulch applied for protection if areas are seeded when temperatures can be high or runoff is likely to occur before the grass is well established?
4. Is irrigation provided for seeded areas if rainfall is insufficient for good establishment?

Maintenance checks

1. Is watering and/or reseeding necessary?

Sodding

Installation checks

1. Is the sod placed beginning in the lowest area and perpendicular to water flow?
2. Are sod strips wedged tightly together and joints staggered at least 12 in (30.48 cm)?
3. On a steep slope, is the sod stapled?

Maintenance checks

1. Is overseeding needed, either to repair damage or to install a preferred grass species?

Stabilized Construction Entrance and Roads

The entrance is the most important access route to stabilize, since it is the last point at which tracking sediment off-site can be stopped. If equipment travels extensively on unstabilized roads on the site, install a tire and vehicle undercarriage wash near the entrance on crushed rock. Treat wash water in a sediment pond or trap (Figure 14.2).

Stabilized Construction Entrance

Installation checks

1. Is the entrance constructed with crushed rock 4 to 8 in (10.16 to 20.32 cm) in size and at least 12 in (30.48 cm) thick?
2. Is the stabilized entrance 50 ft (15.24 m) in length for sites up to 1 acre (0.4 ha) and 100 ft (30.48 m) for larger sites?
3. Is the stabilized entrance at least 20 ft (6.10 m) wide with enlargement to the street at a 25 ft (7.62 m) minimum radius curve?
4. If the entrance sits on a slope, is a filter fabric fence located down grade?

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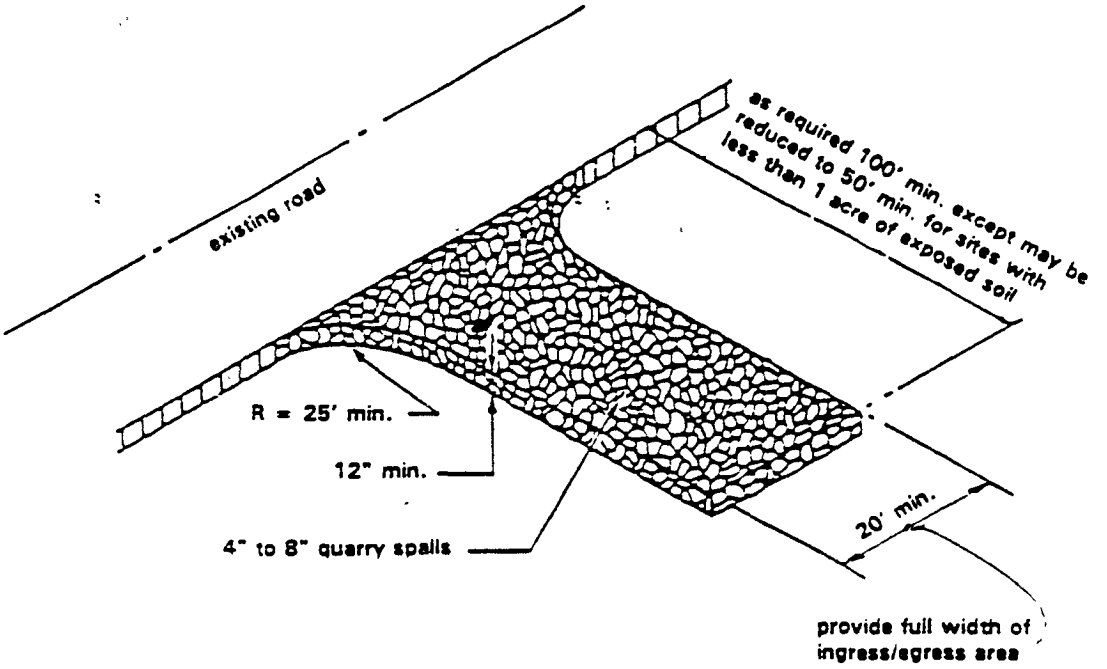
Figure 14.2—Stabilized construction entrance.



Source: Washington Dep. Ecol. 1992.

Maintenance checks

1. Is the entrance clogged with sediments, requiring top dressing the pad with 2 in (5 cm) of clean rock?
2. Must any sediments carried from the site onto the street be cleaned up?

Runoff Control

Runoff control represents various practices designed to keep water from contacting bare soil or, if so, controlling its velocity. Runoff control includes drains for surface and subsurface water, dikes and swales placed across slopes to interrupt and divert runoff, and roughness created on the surface to reduce velocity (Figures 14.3 and 14.4; see Chapter 11).

Pipe Slope Drain. A temporary pipe slope drain is effective in preventing runoff erosion on a slope from a higher elevation. Upslope runoff needs to be collected and directed into the drain and then discharged in a controlled way to prevent erosion at the slope bottom.

Installation checks

1. Are no more than 10 acres (4.05 ha) drained into a single pipe slope drain?
2. Was a minimum 6 in (15.24 cm) metal toe plate placed at the entrance to prevent undercutting?
3. Is runoff directed into the pipe with interceptor dikes at least 12 in (30.48 cm) higher at all points than the top of the pipe?
4. Is the slope toward the pipe on a grade of at least 3 percent at the inlet?
5. If the pipe is 12 in (30.48 cm) in diameter or larger, was a flared entrance section installed and connected securely to the drain with watertight connecting bands?
6. Was the soil thoroughly compacted at the entrance and under the pipe?
7. Were gasketed, watertight fittings placed between pipe sections? Were the sections securely fastened and the drain anchored to the soil?
8. Was the area below the outlet stabilized with a riprap apron?
9. If the drainage can carry sediment, is it treated in a sediment pond or trap?

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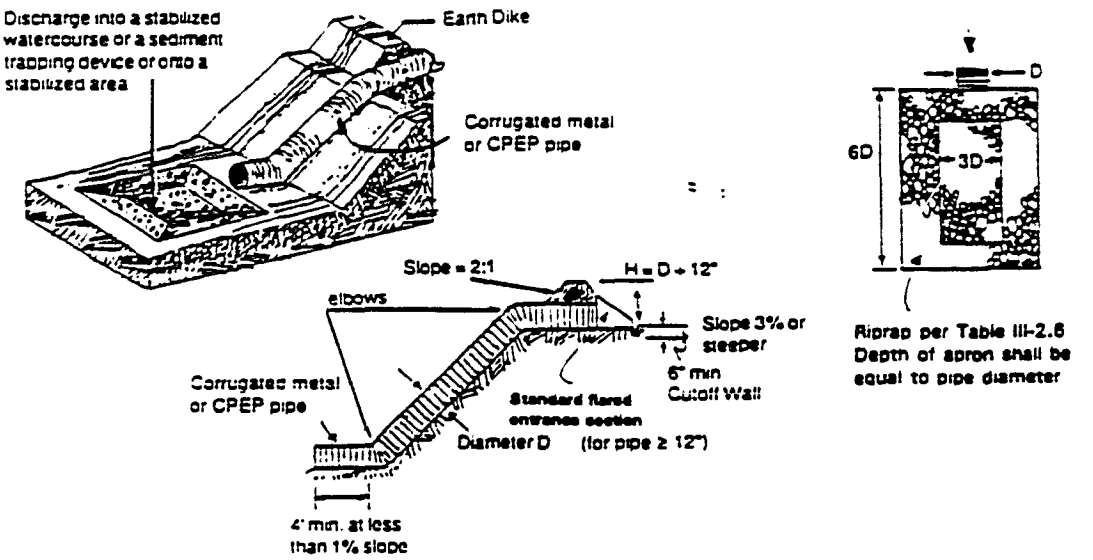
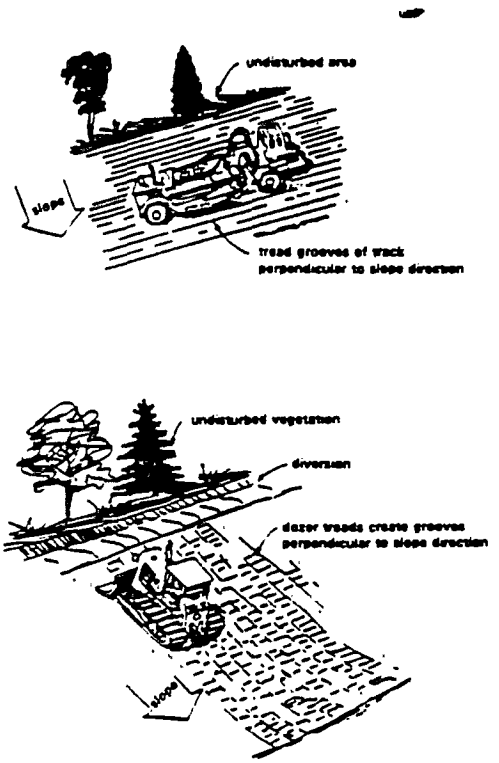
Figure 14.3—Pipe slope drain details.



Source: Washington Dep. Ecol. 1992.

Figure 14.4—Maintenance standards for catch basins.



Source: Washington Dep. Ecol. 1992.

■ Maintenance checks

1. Is runoff undercutting or bypassing the inlet, requiring reinforcing of the headwall with compacted earth or sandbags?
2. Is erosion occurring at the outlet, necessitating rebuilding the apron?

▮ *Surface Roughening.* A roughened surface is an easy and cheap way to reduce runoff velocity, establish vegetation, increase infiltration, and trap sediment. The practice is not effective enough to be used alone—diversion is often necessary—but it can reduce the load on sediment trapping practices downstream. Roughening is best used on a slope with a horizontal-to-vertical ratio steeper than 3-to-1 that does not require mowing. The methods of roughening a surface all involve forming horizontal depressions with equipment. Methods include tracking perpendicular to the slope direction, driving treaded equipment along the slope direction to get grooves perpendicular to the slope, or tilling—preferred because it avoids compaction. On slopes with a ratio steeper than 2-to-1, a stair-step pattern should be formed.

■ Installation checks

1. Have all exposed slopes with a horizontal-to-vertical ratio steeper than 3-to-1 been roughened, with 40 to 50 in

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(1.02 to 1.27 m) stair-steps on slopes steeper than 2-to-1?

2. Was the soil scarified if heavily compacted by the roughening?
3. Was the area seeded as quickly as possible?

Maintenance checks

1. Have rills, gullies, or slumps appeared that should be regraded and reseeded?

B. Sediment Trapping Techniques

Trapping sediments once they are released requires slowing the transport velocity sufficiently so soil particles can settle. This means reducing the velocity below the settling velocity of the particles. Soil particles range in size from small clays to large sands. Settling velocity is related to the square of the particle diameter—halving the diameter approximately quadruples the time needed for settlement. Therefore, as particle sizes decrease, they become increasingly difficult to remove from a runoff stream. Thus, preventive techniques, more cost-effective than sediment trapping practices, are strongly preferred.

The two basic types of sediment trapping techniques are sediment barriers and settling ponds. Sediment barriers include the commonly used filter fabric and straw bale fences, brush fences, and barriers constructed of gravel. Both types trap sediments by ponding water. Although ponding is more obvious in ponds than in barriers, barriers have little ability to filter and can only slow the water long enough for some particles to settle. Thus, they can only trap relatively large particles, generally the larger silts and sands. The trapping ability of settling ponds depends on size. While ponds can theoretically be made large enough to trap any size particle, practical sizes generally limit efficient removal to medium and larger silts.

Sediment Barriers

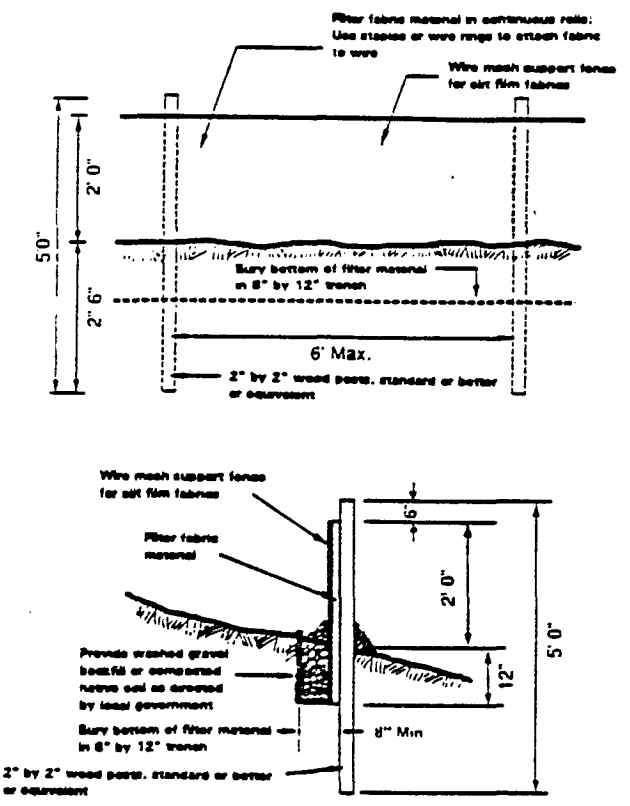
Several principles apply to the various types of sediment barriers. Maximizing a sediment barrier's ponding volume maximizes the sediment trapped. Therefore, barriers should be placed away from the immediate toe of slopes to increase the ponding area. Sediment barriers must be aligned on the contour, not up and down slopes. This alignment places them at a right angle to flow paths and increases ponding volume. Slopes draining to sediment barriers generally should not be more than 100 ft (30.48 m) long. Sediment barriers must be trenched in and staked to hold up under the pressure of the wall of water they will dam. Finally, sediment barriers do not provide effective sediment removal from concentrated flows. While straw bales are sometimes used in ditches, rock check dams are a better alternative for decreasing velocity in channels. Filter fabric and straw bale fences are illustrated in Figures 14.5 and 14.6.

Filter Fabric Fence

Installation checks

1. Are filter fabric fences used only in applications where
   - Maximum of 1 acre (0.405 ha) is served by a single fence?
   - Maximum gradient is 1-to-1 and slope length is ≤ 100 ft (30.48 m)?
   - Situation is sheet flow, never concentrated flow?

Figure 14.5—Filter fabric fence detail.



Source: Washington Dep. Ecol. 1992.

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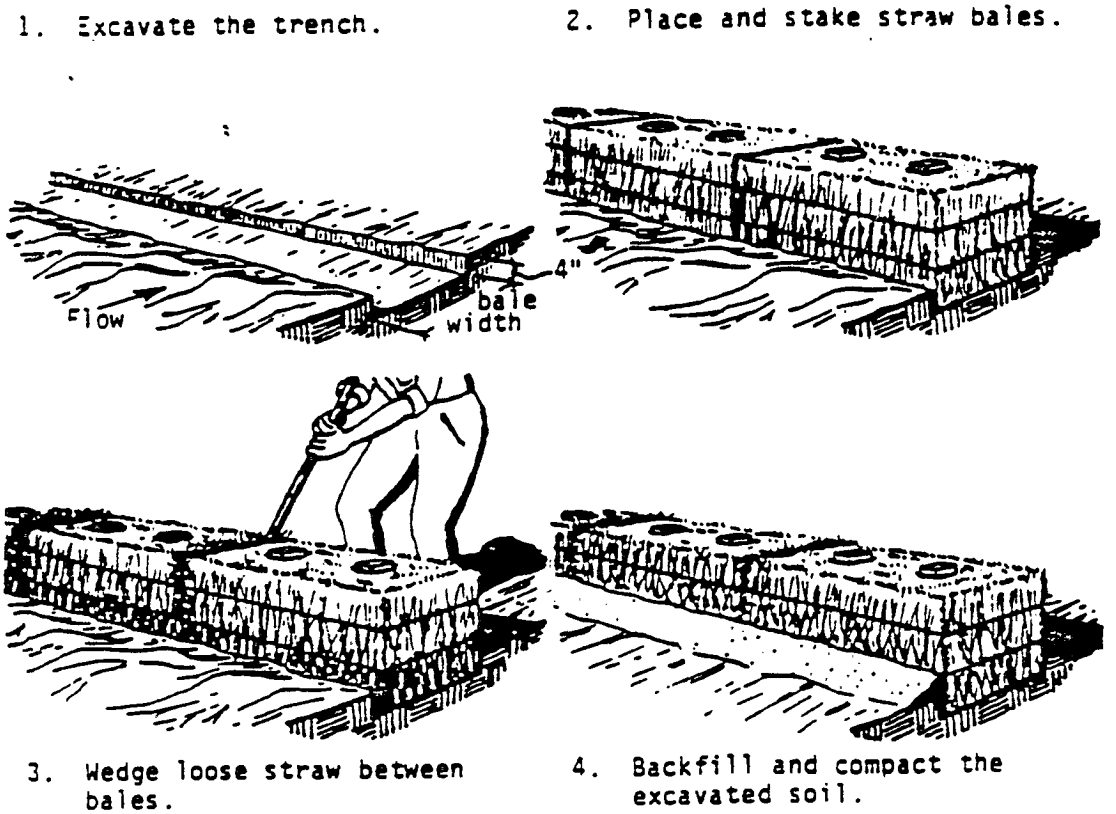
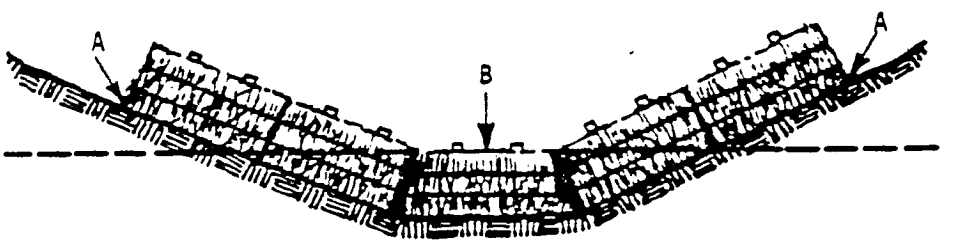
Figure 14.6—Proper installation of straw bale fences.



CONSTRUCTION OF A STRAW BALE BARRIER



Points A should be higher than point B

PROPER PLACEMENT OF STRAW BALE BARRIER IN DRAINAGE WAY

Source: Washington Dep. Ecol. 1992.

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2. Is the fence aligned as closely as possible to slope contours?
3. Is the fence height above the soil no more than 3 ft (0.91 m)?
4. Are wooden posts 2 by 4 in (5.08 by 10.16 cm), and steel posts 1.33 lb/ft (1.98 kg/m), or the equivalent?
5. Are posts buried 2.5 ft (0.76 m) deep whenever possible and spaced no more than 6 ft (1.83 m) apart?
6. Is fabric attached on the upslope side with staples of at least 1 in (2.54 cm), tie wires, or hog rings?
7. Is the end of the fabric buried in a trench sized as shown in Figure 14.5 and backfilled on both the upslope and downslope sides?
8. Is splicing avoided? If unavoidable, is splicing done only at posts and overlapped at least 6 in (15.24 cm)?
9. Woven monofilament materials have the best properties for silt fencing. If a woven slit-film fabric is used, is 14-gauge reinforcing wire mesh with openings no larger than 6 in (15.24 cm) placed on the upslope side and fastened the same as the fabric?

Maintenance checks

1. Does the fence need restaking, reattaching, or replacing to maintain all previously cited conditions?
2. Is sediment removal needed before sediment reaches one-third fence height?

Straw Bale Fence. Straw bale fences, which tend to swell when wet, require frequent maintenance. Users should gain local experience on the expected service life of bales and replace them before they become ineffective. While not highly recommended, these fences could be somewhat effective if used according to the following guidelines:

Installation checks

1. Are straw bale fences used only in applications where
   - Maximum of 1/4 acre (0.1 ha) is served per 100 ft (30.48 m) of fence length?
   - Maximum slope gradient is 2-to-1 and slope length is 100 ft (30.48 m)?
2. Is the fence aligned as closely as possible to slope contours?
3. Are the bales bound with wire or alternatively with string placed around the sides, parallel to the ground?
4. Are bales installed in a 4 in (10.16 cm) trench as in Figure 14.6 and backfilled with 4 in (10.16 cm) of soil on the upslope side?
5. Are the bales forced tightly together and anchored with at least two stakes or rebars per bale, driven toward the previous bale, and flush to the top of the bale?
6. Are gaps wedged with straw spread on the upslope side?
7. Are straw bale fences used in channels with concentrated flow only when velocities are low, placed perpendicular to flow, and extended at least one bale length above the mid-channel bale (see Figure 14.6)?

Maintenance checks

1. Must the fence be replaced to maintain all of the previously stated conditions?
2. Is removal needed before sediment reaches one-half the fence height?

Settling Ponds

Settling ponds have several advantages. They can function through all construction phases and have relatively low maintenance requirements if preventive erosion control is effective. Settling ponds can also be located to intercept runoff before and after the on-site drainage system is developed.

The three types of settling ponds differ in the their outlet structure. The term sediment basin is used for a settling pond with a pipe outlet that generally serves a drainage area of 3 to 10 acres (1.22 to 4.05 ha). A sediment trap is a settling pond with a stable spillway outlet and smaller service area. The third type is a permanent water quantity control pond used temporarily during construction. Used permanently, this pond could be designed to drain completely between storms. This operating mode is not effective for erosion and sediment control—residence time is too short for good particle trapping, and settled material

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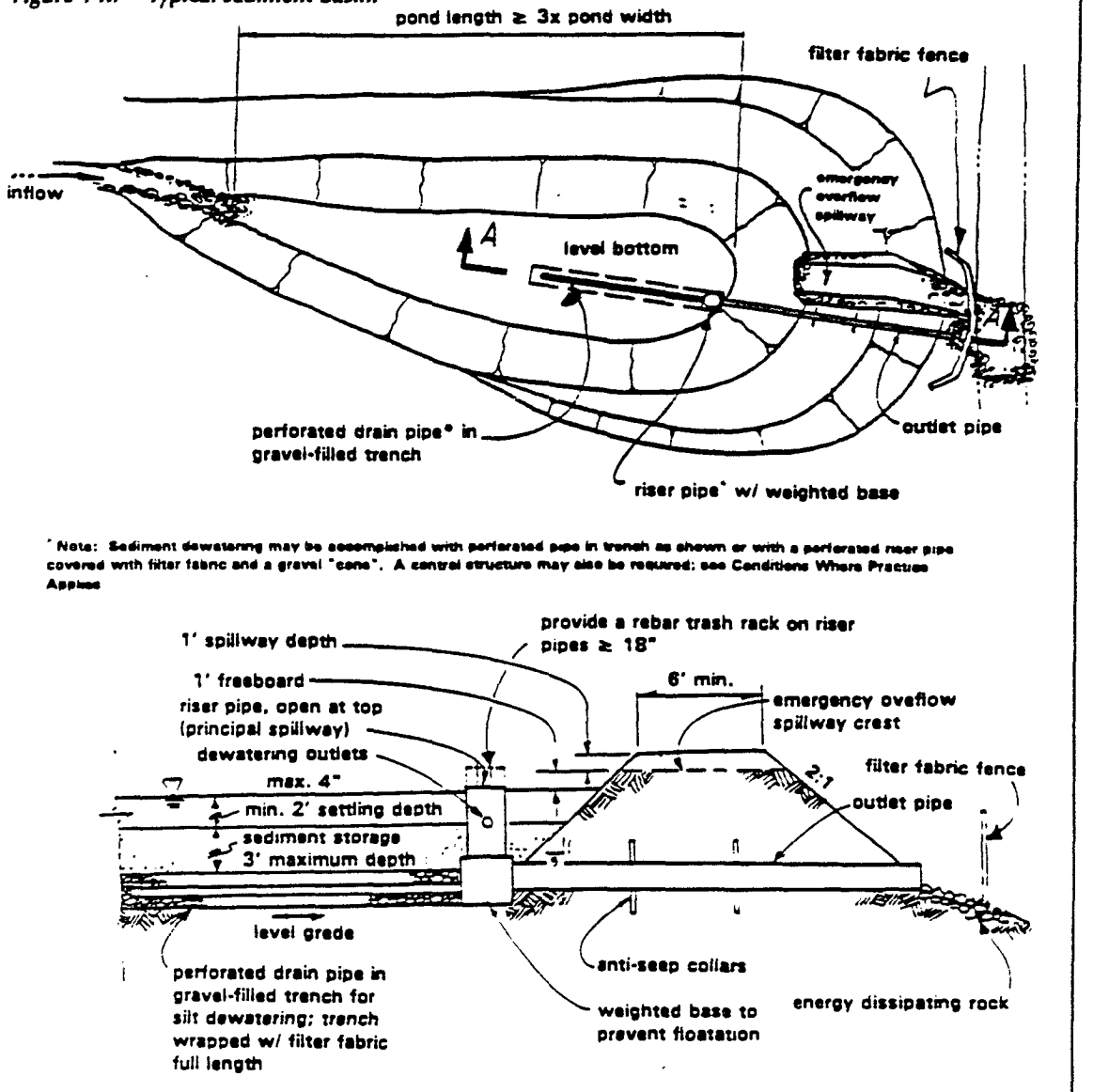
Figure 14.7—Typical sediment basin.



Source: Washington Dep. Ecol. 1992.

becomes resuspended during draining. Therefore, a temporary riser outlet must to be installed for construction use.

In designing and constructing a settling pond, avoid allowing water to short circuit. Short circuiting can cut the actual residence time far below the theoretical value and harm performance. Therefore, divide the pond into two or more cells, locate the inlet and outlet far apart, and install baffling to increase the flow path. Figure 14.7 illustrates a typical sediment basin.

Sediment Basin

Installation checks

1. Is the bottom graded level?
2. Is the pond no deeper than 7 ft (2.13 m) plus 1 ft (0.31 m) of freeboard?
3. Are side slopes no steeper than a horizontal-to-vertical ratio of 3-to-1?
4. Does the pond have an emergency spillway 1 ft (0.31 m) deep, a width two

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to three times the number of acres served by the pond, and is the pond lined with 2 to 4 in (5.1 to 10.16 cm) of rocks?

5. Does the pond discharge through a riser pipe having multiple orifices at the top of the sediment storage zone?
6. Are inlet and outlet areas protected from erosion with riprap?
7. Is baffling installed if the length-to-width ratio is less than 6 or if the entrance velocity is high?
8. A two-celled pond, preferably with cells divided by sandbags or a rock berm and connected by a riser pipe like the outlet, can prevent short circuiting of flow. A less desirable arrangement is to divide the pond with a filter fabric fence. Is the more effective feature installed if specified in the design?
9. Can the pond be easily accessed to remove sediment? Is there a plan to safely dispose of sediment or use it for fill?
10. Is the pond fenced if it presents any safety hazard to children?

Maintenance checks

1. Is sediment removal needed before 1.5 ft (0.46 m) accumulates?
2. Are any outlet orifices clogged and in need of cleaning?
3. Are any embankments damaged and in need of compaction or rebuilding?
4. Has riprap or spillway lining material been lost and need replacing?
5. Do signs of excessive drainage to the pond require rerouting or pond enlargement?
6. Do signs of excessive sediment loading to the pond require stabilizing the drainage area?
7. Is sediment being disposed of in a conscientious manner?

C. Management of Other Site Pollutants

Construction sites can create pollution problems over and above erosion and sediments through paving operations, handling and storage of various materials, spills, and waste handling. Inspectors should also be aware of the potential for runoff contamination from these sources and inspect the site according to the following guidelines:

Cement and Concrete Handling

Inspection checks

1. Do concrete trucks have a designated wash-out area with a sediment trap?
2. Is exposed-aggregate driveway wash water drained toward a collection point at the side or into a sediment trap where it cannot enter a street drainage system?

Material Storage and Handling

Inspection checks

1. Are weather-resistant enclosures used to store and handle materials like paints, coatings, wood preservatives, pesticides, fuels, lubricants, and solvents, and for potentially polluting wastes?
2. Are procedures for handling materials and wastes and washing containers designated and clearly communicated?
3. Is a chemical inventory maintained, including material safety data sheets?
4. Are containers and enclosures inspected periodically for leakage?
5. What is the fueling process? Are overflow prevention methods used?

Spill Containment

Inspection checks

1. Has a spill control plan been developed and have supplies been obtained to implement it? Does the plan include
   - Who to notify if a spill occurs?
   - Specific instructions for different products?
   - Who is in charge?
   - Spill containment procedures?
   - Easy to find and use spill clean-up kits?
   - How a spill will be prevented from getting into a drainage system—for example, valving, diversion, absorption?
   - A disposal plan?
   - A worker education program?

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▮ *Waste Management*

- **Inspection checks**

1. Have waste reduction practices been instituted—for example, reusing solvents, substituting for toxic products, minimizing quantities of materials used?
2. Have recycling practices been instituted—for example, waste separation for recycling, purchasing recycled materials?
3. Are hazardous and nonhazardous wastes separated and each disposed of properly and promptly?
4. Is there an employee education program on waste management?

Comprehensive Inspection Program for Permanent Drainage

As previously discussed, a comprehensive inspection program for permanent drainage practices and facilities should contain the following elements:

- Runoff management planning
- Plan review
- Construction inspection and enforcement
- Follow-up inspection and long-term maintenance

Runoff management planning ensures that each site entering the permit process is comprehensively analyzed. Chapter 12 contains a discussion of the extensive considerations of plan review. Inspection of completed runoff management facilities determines that they have been installed consistently with the approved plans. The next section covers programmatic aspects of follow-up inspection and long-term maintenance, which ensures that sites continue to operate properly.

Follow-Up Inspection and Long-Term Maintenance

An effective program should have the following features:

- An ordinance designating public authority and public and private responsibilities
- A tracking system
- An inspection schedule
- A maintenance schedule
- A safety program
- A citizen response program
- Proper waste disposal practices
- Maintenance contractor education

The following information principally draws on experience in King County, Bellevue, Olympia, and elsewhere in the Puget Sound region of Washington State.

▮ ***Public vs Private Responsibilities.*** While inspection is usually a public function, who is responsible for upkeep of privately owned facilities? One model establishes a multiyear bonding period, during which the developer has all responsibility. After this period and a demonstration of effective operation, the government agency responsible for runoff takes over operation and maintenance.

A second model leaves maintenance as a private function—by a commercial property owner or homeowners' association—with inspection by the public agency. If the private party does not meet the responsibility, the government assumes the responsibility and charges the costs. This strategy requires access to private maintenance contractors who are competent in performing the needed work. The frequent lack of qualified contractors requires government agencies to consider training and certifying them.

▮ ***Tracking System.*** King County offers a good tracking system model to organize long-term inspections and maintenance using a computerized information system. Each inspector is assigned an inventory of facilities to inspect for specific maintenance and receives a laptop computer for field use. The information system contains an identification number for each facility, its type (e. g., wet pond, infiltration basin), location, any special needs, and data on previous experiences. After each visit, the inspector enters a maintenance needs assessment in the computer database. The computer then generates a maintenance work order.

▮ ***Safety.*** Safety is a major consideration because of potentially harmful atmospheres in below-ground spaces, corroded supports, traffic, falling objects, sharp edges, poisonous plants and in-

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insects, and lifting. A tester should check all conditions and test all enclosed spaces before entering. The safety portion of an inspection and maintenance program should include the following:

- Testing instruments for harmful atmospheres—e.g., explosive, containing hydrogen sulfide, lacking in oxygen
- Ventilating equipment
- Checking structural soundness before entering a manhole
- Traffic warning devices
- Ladders, safety harnesses, and hard hats
- Removing poisonous plants and insect nests
- Adequate personnel
- Safety training

Waste Handling. Major maintenance on large facilities should be scheduled when the least runoff is expected. Inspectors should require ESC practices like filter-fabric fences, sandbags, grassed drainage areas, and revegetation to prevent sediment escape during maintenance.

The vactor truck—which vacuums out storm sewers, drains, and inlets—is the maintenance workhorse. A problem with vactor trucks is the mixing of relatively clean and very dirty waste. A solution, but an expensive one, is to have "clean" and "dirty" trucks. Another issue is the disposal of both solids and separated "decant" water picked up by vactor trucks.

The best solution is to discharge decant water to a special station with sediment and oil separation equipment before the water discharges to a sanitary sewer. However, oil separators should not be cleaned at the same time as sediment accumulation chambers. Few such stations exist now, and most vactor waste is discharged directly into the sanitary sewer. This practice can result in pollutants entering surface waters because of inadequate treatment at the municipal wastewater plant and in toxic materials that can upset biological processes at the treatment plant. Guidelines, while needed, generally do not exist for disposing of solids. The best programs now send solids to a lined municipal landfill, unless they fail a "looks bad and smells bad" test. In that case, they are treated as hazardous waste.

Table 14.4—Permanent drainage practices.

CATEGORIES	PRACTICES
Stormwater devices	Oil/water separators Pipes and culverts Catch basins
Detention facilities	Wet ponds Extended/detention dry ponds Vaults and tanks
Infiltration facilities	Infiltration basins Infiltration trenches Porous pavements
Biofilters	Vegetated swales Constructed wetlands Filter strips

Permanent Drainage Practices and Facilities Inspection

Table 14.4 provides a listing of practices (Reinelt, 1992). The practices include some variations on common devices, depending on their intended function as specified by the *Stormwater Management Manual for the Puget Sound Basin* (Washington Dep. Ecol. 1992). For example, detention facilities include wet ponds, which have a quantity control function, and water quality wet ponds, which are treatment devices.

The following are inspection checklists for the most common practices and facilities in each category. While brief descriptions are presented here, runoff management manuals or textbooks can provide detailed descriptions.

As previously suggested, inspectors must perform background work—consulting the design plans to determine the specifications before going out to inspect an installation. Infrequent inspection and maintenance is a main reason for poor performance by runoff facilities. The frequency of follow-up inspections varies with the type of device and the installation circumstances. Each installation should have an inspection and maintenance plan developed before it goes into service. As a general rule, surface facilities should receive a drive-by inspection at least monthly and after any rain totaling 0.5 in (1.27 cm) or more in 24 hours.

Stormwater Devices

These devices are used to collect and convey runoff and as special-purpose facilities. Within the category are catch basins, pipes and culverts, and

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oil/water separators. Inspection guidelines are provided for oil/water separators and tables of maintenance standards are included for the other types of facilities.

▮ ***Oil/Water Separators.*** Figure 14.8 illustrates the three basic types of oil/water separators. The spill control unit (14.8A) catches small spills; it is not capable of separating dispersed oil. The American Petroleum Institute (API) separator (14.8B) is a baffled tank that can separate "free" (unemulsified) oil but requires a relatively large volume for effectiveness. The coalescing plate (CP) separator (14.8C) can separate free oil in a much smaller volume because of the large surface area provided by the corrugated plate pack. The following guidelines generally apply to all types, except as noted.

■ **Installation checks**

1. Is the type appropriate for the service?
2. Is the unit sized and installed as specified in the plans?
3. Are adequate removable covers provided for observation and maintenance?
4. Is runoff excluded from roofs and other areas not likely to contain oil?
5. Is any pump being used placed downstream in order to prevent mechanical emulsification?
6. Is detergent use avoided upstream to prevent chemical emulsification?
7. For API and CP types, is a forebay provided and sized at 20 ft^2 (1.86 m^2) of surface area per 10,000 ft^2 (929 m^2) of drainage area?
8. For API and CP types, is an afterbay provided to place absorbents?
9. For the CP type, are the plates no more than 3/4 in (1.91 cm) apart and at 45 to 60 degrees from horizontal?

■ **Maintenance checks**

1. Does the owner perform weekly inspections?
2. Are oil and any solids removed frequently enough—at least just before the main runoff period and after the first major runoff event?
3. Are absorbents replaced as needed—at least at the beginning and end of the main runoff season?
4. Is the effluent shutoff valve operational for closure during cleaning?
5. Are waste oil and solids disposed of as specified by regulations?
6. Is any standing water that is removed discharged to the sanitary sewer and then replaced with clean water?

▮ ***Pipes and Culverts.*** Table 14.5 contains a summary of maintenance standards for conveyance facilities.

▮ ***Catch Basins.*** Catch basins are routinely placed between drain inlets in streets and parking lots and the conveyances that transport water away to settle large solids. Table 14.6 contains a summary of maintenance standards.

▮ ***Wet Ponds.*** A typical wet pond has a "dead storage" permanent or semipermanent pool and a "live storage" zone that fills during runoff events and then drains fairly quickly (see Figure 14.9). Designs differ depending on the purpose—quantity control, quality control, or both—but the checks made at installation and later during operation are generally the same, with the few exceptions noted.

■ **Installation checks**

1. Does construction comply with local requirements for earthwork, concrete, other masonry, reinforcing steel, pipe, water gates, metal work, and woodwork?
2. Are all dimensions as specified in the approved plan?
3. Are interior side slopes no steeper than a horizontal-to-vertical ratio of 3-to-1 and exterior side slopes no steeper than 2-to-1?
4. Is the bottom level?
5. Are the spillways—between cells, if any, and the emergency outlet spillway—sized and reinforced as specified in the approved plan?
6. Can the drain empty the dead storage zone within four hours?

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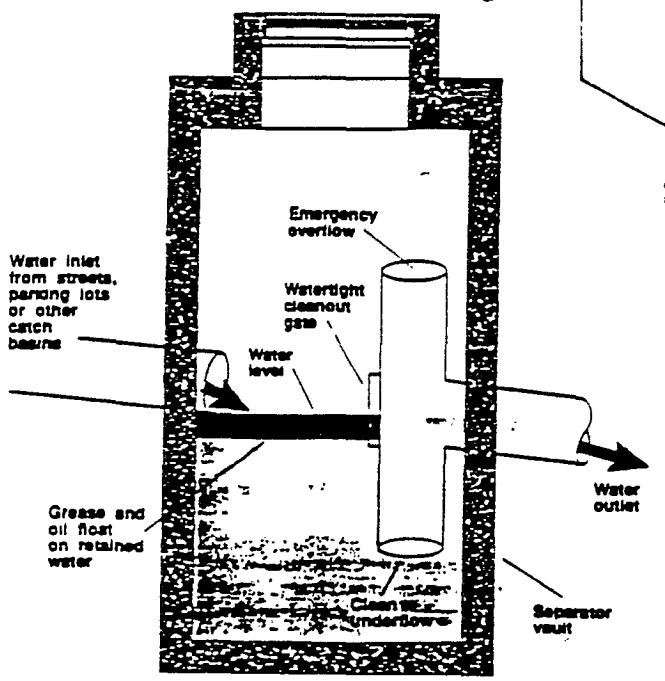
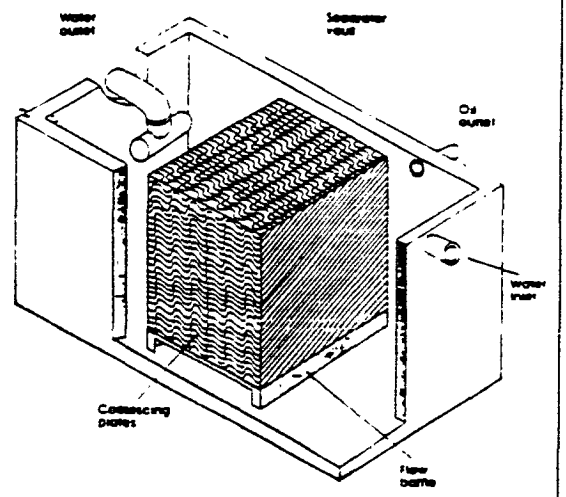
Figure 14.8—Types of oil/water separators.

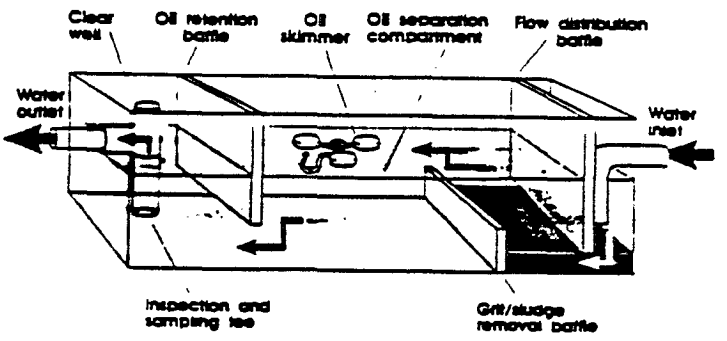


14.8A
SC-Type Separator



14.8B
CPS Separator

14.8C
API Separator



Source: Washington Dep. Ecol. 1992.

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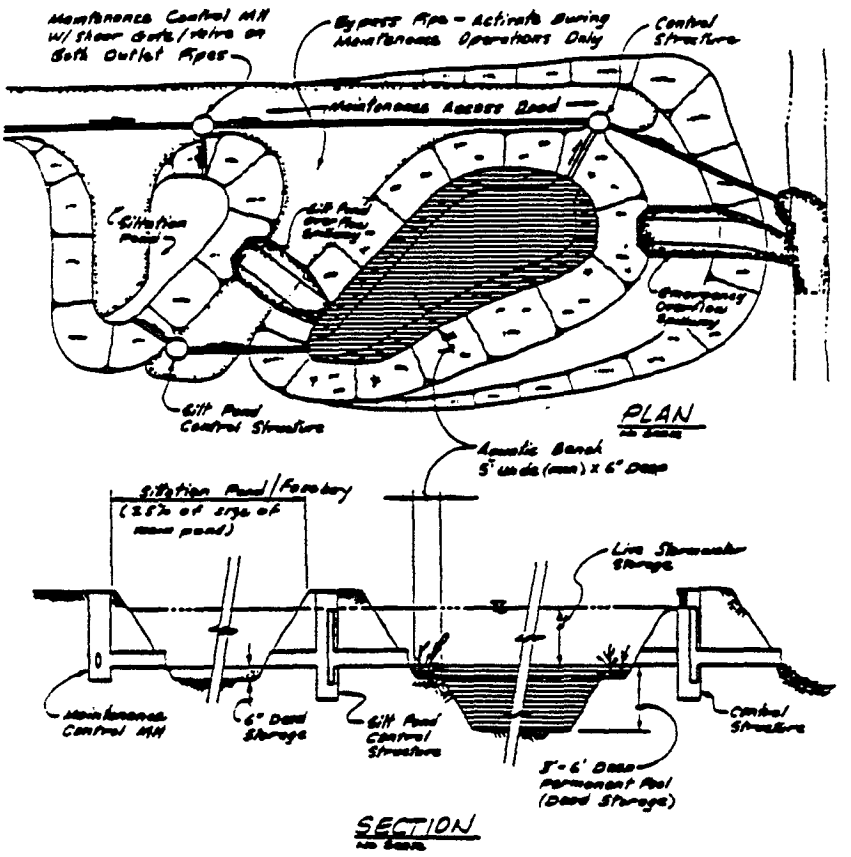
Table 14.5—Maintenance standards for pipes and culverts.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Sediment and debris	Accumulated sediment that exceeds 20 percent of the pipe diameter	Pipe cleaned of all sediment and debris
Vegetation	Vegetation that reduces free movement of water through pipes	All vegetation removed so water flows freely through pipes
Damaged	Protective coating is damaged; rust is causing more than 50 percent of deterioration to any part of pipe Any dent that decreases the end area of pipe by more than 20 percent	Pipe repaired or replaced
Debris barriers	Trash or debris plugging more than 20 percent of the barrier openings	Barrier clear to receive capacity flow
Damaged/missing bars	Bars are bent out of shape more than 3 in (7.62 cm)	Bars in place with no bends > 3/4 in (1.91 cm)
	Bars are missing or entire barrier missing	Bars in place according to design
	Bars are loose and rust is causing 50 percent deterioration to any part of barrier	Repair or replace barrier to design standards

Source: Adapted from Reinelt, 1992.

Figure 14.9—Typical wet pond.



Source: Washington Dep. Ecol. 1992.

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Table 14.6—Maintenance standards for catch basins.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Trash and debris (including sediment)	Trash or debris of more than 1/2 ft^3 (14.16 dm^3) located in front of the catch basin opening or blocking capacity of basin by > 10 percent	No trash or debris located immediately in front of catch basin opening
	Trash or debris in the basin that exceeds 1/3 to 1/2 the depth from the bottom of basin to invert of the lowest pipe into or out of the basin	No trash or debris in catch basin
	Trash or debris in any inlet or outlet pipe blocking more than 1/3 of the height	Inlet and outlet pipes free of trash or debris
	Dead animals or debris that could generate odors that would cause complaints or dangerous gases	No dead animals or vegetation present
	Deposits of garbage exceeding 1 ft^3 (28.32 dm^3) in volume	No trash or debris in catch basin
Structural damage to frame and/or top slab	Corner of frame extends more than 3/4 in (1.91 cm) past curb face into the street (if applicable)	Frame is even with curb
	Top slab has holes larger than 2 in^2 (12.9 cm^2) or cracks wider than 1/4 in (1.61 cm) (to ensure that all materials run into basin)	Top slab is free of holes and cracks
	Frame not sitting flush on top slab—i.e., separation of > 3/4 in (1.91 cm) of the frame from top of slab	Frame is sitting flush on top of slab
Cracks in basin walls or bottom	Cracks wider than 1/2 in (3.23 cm) and longer than 3 ft (0.91 m), any evidence of soil particles entering catch basin through cracks, or structure is unsound	Basin replaced or repaired to design standards
	Cracks wider than 1/2 in (3.23 cm) and longer than 1 ft (0.305 m) at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through crack	No cracks more than 1/4 in (1.61 cm) wide at joint of inlet/outlet pipe
Settlement/misalignment	Basin has settled more than 1 in (2.54 cm) or has rotated more than 2 in (5.08 cm) out of alignment	Basin replaced or repaired to design standard
Fire hazard	Presence of chemicals such as natural gas, oil, and gasoline	No flammable chemicals present
Vegetation	Vegetation growing across and blocking more than 10 percent of basin	No vegetation blocking opening to basin
	Vegetation (or roots) growing in inlet/outlet pipe joints > 6 in (15.24 cm) tall and < 6 in (15.24 cm) apart	No vegetation or root growth present
Pollution	Nonflammable chemicals of > 1/2 ft^3 (14.16 dm^3) per 3 ft (0.91 m) of basin length	No pollution present other than surface film

Source: Adapted from Reinelt, 1992.

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7. Are inlet and outlet areas stabilized to avoid erosion?
8. Are safety features provided such as a shallow bench surrounding the pond edge, barrier plantings to discourage approach by children, and/or fencing (unnecessary if sloped as recommended and other safety features provided)?
9. For a water quality pond, is the effective length-to-width ratio at least 3-to-1 and preferably 5-to-1? Are the inlet and outlet separated as widely as possible?

Maintenance checks

1. Has a maintenance plan and schedule been developed?
2. Table 14.7 contains specific checks and maintenance standards, which also apply to other types of ponds.

Vaults and Tanks. Refer to Table 14.8 for a summary of maintenance standards for closed detention systems.

Infiltration Facilities

Infiltration facilities discharge most of the entering water into the ground. They include surface basins and trenches, below-ground perforated pipes, roof drain systems, and porous pavements. Inspection guidelines are given for infiltration basins in Figure 14.10 and a table of maintenance standards is included for infiltration trenches as well (Figure 14.9).

Infiltration Basins

Installation checks

1. Does construction comply with local requirements for earthwork, concrete, other masonry, reinforcing steel, pipe, water gates, metal work, and woodwork?
2. Are all dimensions as specified in the approved plan?
3. Does the timing of basin construction avoid any runoff containing sediment from elsewhere on the site?
4. Is the basin preceded by a pretreatment device— presettling basin or biofilter—to prevent failure caused by siltation?
5. Is the basin at least 50 ft (15.24 m) from any slope greater than 15 percent and at least 100 ft (30.48 m) upslope and 20 ft (6.1 m) downslope of any building?
6. Is the outlet orifice design consistent with the facility's infiltration capacity—e. g., to avoid the collection of more water than can infiltrate in 48 hours?
7. Are the spillways—between cells, if any, and the emergency outlet spillway—sized and reinforced as specified in the approved plan?
8. Are all disturbed areas stabilized to prevent erosion?
9. After final grading, has the bed been deeply tilled to provide a well-aerated, highly porous surface texture?

Maintenance checks

1. Has a maintenance plan and schedule been developed?
2. Table 14.9 contains specific checks and maintenance standards.
3. Is tilling necessary to restore infiltration capacity (regular annual tilling is recommended)?

Infiltration Trenches. Table 14.10 contains a summary of maintenance standards for infiltration trenches.

Biofilters

Biofilters, or vegetated land treatment systems, can be vegetated swales where water flows at some measurable depth. Biofilters can also be broad surface areas where water flows in a thin sheet, sometimes called filter strips. Constructed wetlands are also sometimes put in this category. The following guidelines generally pertain to swales and filter strips, although some exceptions are noted. To inspect constructed wetlands, refer to both these guidelines and those given previously for wet ponds.

Biofiltration Swales and Filter Strips

Installation checks

1. Are the dimensions and plantings as specified in the approved plan?
2. Is the vegetation cover dense and uniform?

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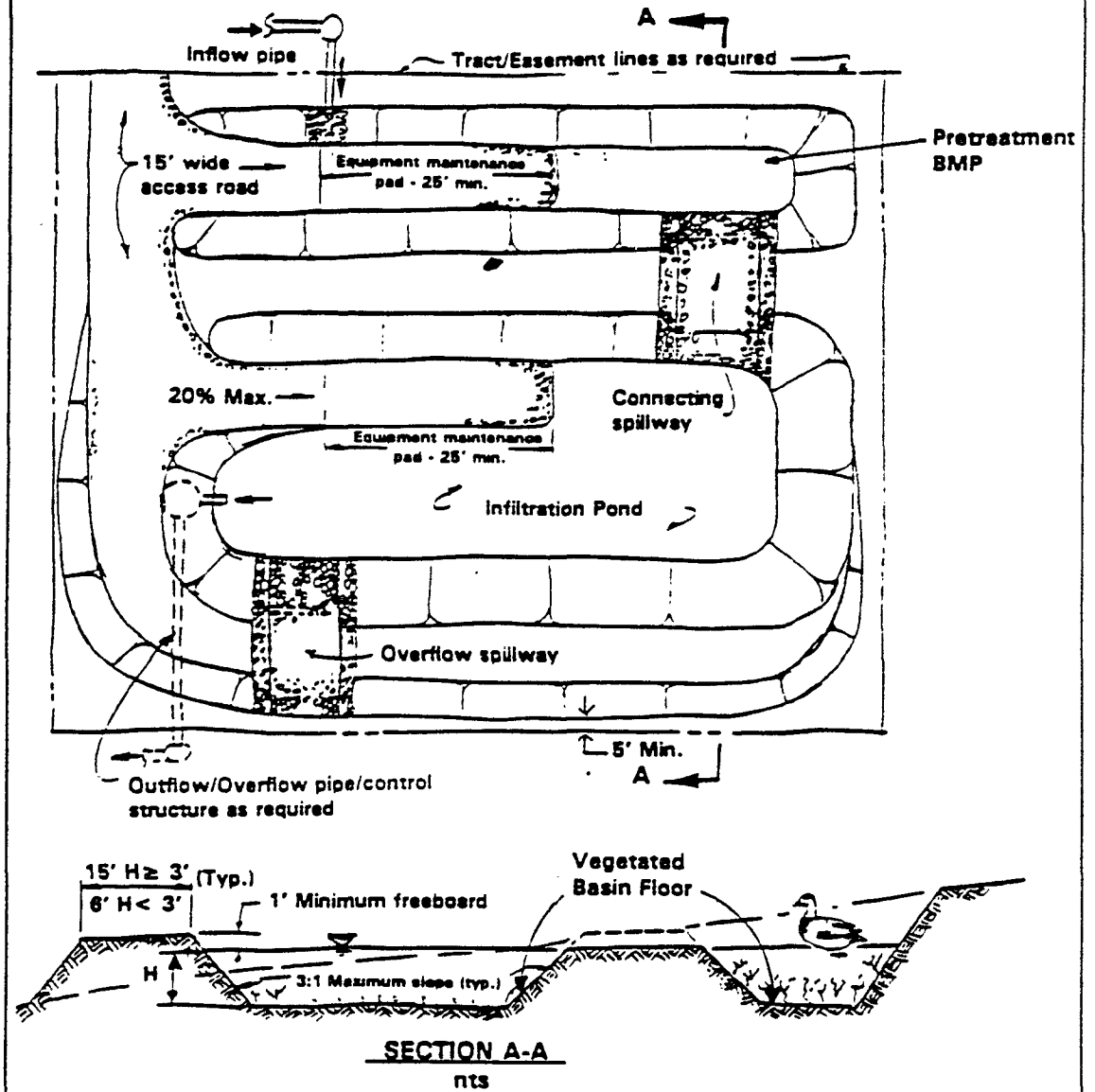
Figure 14.10—Typical infiltration basin.



Source: Washington Dep. Ecol. 1992.

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Table 14.7—Maintenance standards for detention facilities.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Trash and debris	Any trash or debris that exceeds 1 ft^3/1,000 ft^2 (28.32 dm^3/92.9 m^2); no evidence of dumping should exist	Trash and debris cleared from site
Poisonous	Presence of any poisonous vegetation that constitutes a hazard to maintenance personnel or the public (e.g., tansy, poison oak, stinging nettles, devils club)	No evidence of poisonous vegetation; coordinate with local health department
Pollution	One gallon or more of oil, gas, or contaminants, or any amount that could (1) cause damage to plant, animal, or aquatic life; (2) constitute a fire hazard; (3) be flushed downstream during storms; or (4) contaminate groundwater	No contaminants present other than a surface film; coordinate with local health department
Unmowed grass/ ground cover	In residential areas, mowing is needed when the cover exceeds 18 in (.46 m) in height; otherwise, match facility cover with adjacent ground cover and terrain as long as facility function does not decrease	Grass/ground cover should be mowed to 2 in (5.08 cm); maintain dense cover on slopes and in bottom of dry ponds
Rodent holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes	Rodents destroyed and dam or berm repaired; coordinate with local county health department
Insects	When insects such as wasps or hornets interfere with maintenance activities	Insects destroyed or removed from site; coordinate with people who remove wasps for antivenom protection
Tree growth	Does not allow maintenance access or interferes with maintenance activity; if trees are not interfering with access, leave alone	Trees do not hinder maintenance activities
Erosion of pond side slopes	Eroded damage > 2 in (5.08 cm) deep where cause of damage is still present or potential for continued erosion exists	Slopes stabilized with appropriate erosion control BMPs (e.g., seeding, mats, riprap)
Sediment accumulation in forebay/pond	Accumulated sediment that exceeds 10 percent of the design forebay/pond depth, or every 3 years	Sediment cleaned out to design depth; reseed if necessary for erosion control
Dike settling	Any part of dike that has settled more than 4 in (10.16 cm)	Dike is rebuilt to design elevation
Rocks missing from overflow spillway	Only one layer of rock above native soil in an area of 5 ft^2 (0.47 m^2) or greater, or any exposed soil	Rock replaced to design standard
Inadequate spillway size	Emergency overflow or spillway not large enough to handle flows from large storm events	Increase capacity of spillway to current design standards

continued on next page

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Table 14.7—continued

Missing, broken, or damaged fencing	Any defect in fencing that permits easy entrance to the pond	Fencing repaired to prevent entrance
	Damaged fencing including posts out of plumb by > 6 in (15.24 cm), top rails bent > 6 in (15.24 cm), missing or loose tension wire, missing or sagging barbed wire, missing or bent extension arms	Fencing parts that have a rusting or scaling condition affecting structural adequacy
	Opening in fencing that allows passage of an 8 in diameter ball	No opening in fence
Erosion under fencing	Erosion 4 in (10.16 cm) deep and 12 to 18 in (.31 to .46 cm) wide permitting an opening under fence	No opening under fence > 4 in (10.16 cm)
Missing or damaged gates	Missing or damage gate, locking device, or hinges	Gates, locking devices, and hinges repaired
	Gate is out of plumb by > 6 in (15.24 cm) and > 1 ft (.31 m) out of design alignment	Gate is aligned and vertical
	Missing stretcher bar, bands, or ties	Stretcher bar, bands, and ties in place
Blocked or damaged access roads	Debris that could damage vehicle tires	Roadway free of debris
	Obstructions that reduce clearance above road surface to < 14 ft (4.27 m) (e.g., tree branches, wires)	Roadway clear overhead to 14 ft (4.27 m)
	Any obstructions restricting access to a 10 to 12 ft (3.05 to 3.66 m) width for a distance of > 12 ft (3.66 m), or any point restricting access to a width of < 10 ft (3.05 m)	Obstructions moved to allow at least a 12 ft (3.66 m) access route
	Any road settlement, potholes, mushy spots, or ruts that prevent or hinder maintenance access	Road surface repaired and smooth
	Weeds or brush on or near road surface that hinder access, or are > 6 in (15.24 cm) tall and < 6 in (15.24 cm) apart within a 400 ft^2 (37.16 m^2) area	Weeds and brush on or near road surface cut to 2 in (5.08 cm)
	Erosion within 1 ft (.31 m) of the roadway > 8 in (20.32 cm) wide and 6 in (15.24 cm) deep	Shoulder and road free of erosion

Source: Adapted from Reinelt, 1992.

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Table 14.8—Maintenance standards for closed detention systems.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Plugged air vents	Half of the end area of a vent is blocked at any point with debris and sediment	Vents free of debris and sediment
Debris and sediment in storage area	Accumulated sediment depth is > 10 percent of the diameter of the storage area for 1/2 the length of storage vault or any point exceeds 15 percent of the diameter; for example, 72-in (1.83-m) storage tank would require cleaning when sediment reaches a depth of 7 in (17.78 cm) for more than 1/2 the tank length	All sediment and debris removed from storage area
Cracks in joints between tank/pipe sections	Any crack allowing material to be transported into the facility	All joints between tanks/pipe sections are sealed
Problems with manhole cover	Cover is missing or only partially in place; any open manhole requires maintenance	Manhole is closed and secured
	Locking mechanisms cannot be opened by one maintenance person with proper tools; bolts into frame have < 1/2 in (3.23 cm) of thread (may not apply to selflocking lids)	Mechanism is repaired or replaced so it functions properly
	Cover difficult to remove by one maintenance person applying 80 lbs (36.29 kg) of lift	Cover can be removed and reinstalled by one maintenance person
Ladder rungs of manhole unsafe	Local government safety officer or maintenance person judges that ladder is unsafe due to missing rungs, misalignment, rust, or cracks	Ladder meets design standards and allows for maintenance access
Catch basins	See Table 14.6	See Table 14.6

Source: Adapted from Reinelt, 1992.

Table 14.9—Maintenance standards for infiltration basins.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Sediment buildup in system	Soil texture test indicates facility is not functioning as designed	Sediment is removed and/or facility is cleaned so that system works according to design; a forepay or presetting basin is installed to reduce sediment transport to facility
Poor facility drainage (more than 48 hours)	Soil texture test indicates facility is not functioning as designed	Additional volume added through excavation to provide needed storage; soil aerated and rototilled to improve drainage
Sediment trapping area	Sediment and debris fill more than 10 percent of sediment trapping facility or sump	Sediment trapping facility or sump cleaned of accumulated sediment
No sediment trapping facility	Runoff enters infiltration area without pretreatment	Add a trapping facility (presettling basin, detention pond, biofilter) before infiltration facility

Source: Adapted from Reinelt, 1992.

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Table 14.10—Maintenance standards for infiltration trenches.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Sediment and debris buildup in trench	By visual inspection, little or no water flows through the trench during large storms	Debris blocking infiltration trench removed; gravel in infiltration trench replaced or cleaned
Observation well	Observation well buried, covered, or inaccessible	The observation well/cap is accessible to the inspector for opening and inspection
Water percolates up from trench	Trench water or water with dye percolating to surface	Gravel and filter fabric in infiltration trench replaced or cleaned; trench functions according to design standards
Filter fabric exposed	Filter fabric is exposed or damaged	Filter fabric is replaced or repaired and covered with proper backfill material

Source: Adapted from Reinelt, 1992.

3. If the biofilter is a swale, is it parabolic or trapezoidal in shape, with side slopes no steeper than a horizontal-to-vertical ratio of 3-to-1?
4. Is the biofilter placed near buildings and trees so that no portion will be shaded throughout the day and possibly experience poor plant growth?
5. If the longitudinal slope is less than 2 percent or if the water table can reach the root zone of vegetation, is water-resistant vegetation planted to survive a standing water condition? Is an underdrain system installed to assist drainage (underdrains may not be practical with a large filter strip)?
6. If the longitudinal slope is in the 4 to 6 percent range, are check dams provided approximately every 50 to 100 ft (15.24 to 30.48 m) to reduce velocity (check dams may not be practical on a larger filter strip)?
7. If a swale is installed on a slope that exceeds 6 percent, does it traverse the slope so that no reach slopes more than 4 percent, or 6 percent with check dams?
8. Is the lateral slope entirely uniform to avoid any tendency for the flow to channelize?
9. Is flow introduced so that entrance velocity is dissipated quickly, flow is distributed uniformly, and erosion is avoided (e. g., by using a riprap pad or some means of level spreading)?
10. Was construction-phase runoff excluded or was the biofilter reestablished after construction? Are upslope areas stabilized to avoid erosion into the biofilter?
11. Is a bypass in place for flows larger than the flow rate the biofilter was designed to treat? Is the facility sufficiently large to at least pass the 100-year, 24-hour storm without eroding (a bypass is preferred to maintain treatment and prevent resuspension of settled material)?

Maintenance checks

1. Has a maintenance plan and schedule been developed?
2. Table 14.11 contains specific checks and maintenance standards.

Recommended Reading

References Cited

New Jersey Department of Environmental Protection and Energy. 1989. Stormwater Management Facilities Maintenance Manual. Trenton, NJ.

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Table 14.11—Maintenance standards for biofilters.

DEFECT	CONDITIONS WHEN MAINTENANCE NEEDED	MAINTENANCE RESULTS
Trash and debris	Dumping of yard wastes; accumulation of nondegradable materials	Remove degradable wastes and compost; recycle other waste when possible
Sediment buildup	Accumulation exceeds 20 percent of design depth	Cleaned or flushed to match design; vegetation restored as necessary
Poor vegetation cover	Vegetation sparse and/or weedy; overgrown with woody vegetation	Aerate soil and plant; remove woody growth and replace
Erosion damage to slopes	Erosion > 2 in (5.08 cm) deep where cause still present, or potential for continued erosion	Find cause and eliminate; stabilize with appropriate erosion controls (e.g., seeding, mat, mulch)
Conversion to use incompatible with water quality control	Filled or planted inappropriately, or blocked	Discuss with nearby property owners and specify corrections to be made
Poor drainage	Water stands in swale	Determine cause; if high water table, consider rebuilding with liner or underdrain; if slope < 1 percent, use underdrain

Source: Adapted from Reinelt, 1992.

Reinelt, L.E. 1991. Construction Site Erosion and Sediment Control Inspector Training Manual. Eng. Continuing Edu., Univ. Washington, Seattle, WA.

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CHAPTER 15

Watershed Management

Runoff management and nonpoint source pollution present many complex challenges to the water resources manager. This chapter discusses how to meet these challenges by using a watershed management approach to integrate land planning and other resources within the watershed.

The challenges, quite different from those encountered when managing traditional point sources of pollution, include

- Integrating land use management, since the change in land use creates the runoff problem;
- Educating the public about how everyday activities contribute to the runoff problem and how they must be part of the solution;
- Developing a management framework given that we all live downstream and that runoff flows are not constrained by political boundary lines;
- Obtaining the cooperation and coordination of neighboring political entities within a watershed;
- Managing runoff from new development and retrofitting the existing drainage system built solely to convey runoff away from developed lands to the nearest waterbody as quickly as possible.
- Coordinating point and nonpoint source runoff strategies and activities.

Additionally, constraints imposed by current runoff treatment technology—such as treatment efficiency, land needs, and maintenance needs—and by the costs of assessing and solving existing runoff/nonpoint source pollution problems call for a cooperative regional framework. Finally, a watershed management approach includes planning efforts to prevent problems and traditional regulatory efforts to mitigate adverse effects caused by land alterations and changes in land use. This approach permits extensive use of inexpensive nonstructural management practices.

Definition and Rationale

What is a Watershed?

The term watershed refers to a geographical area in which water, sediments, and other materials drain to a common outlet such as a stream, lake, or estuary. This area is also called the drainage basin of a receiving waterbody. When a raindrop falls in this area, it flows until it reaches the downstream receiving waterbody.

Watershed dimensions depend on the waterbody. A large river's watershed may cover thousands of square miles, while each of its tributaries has a smaller watershed. The U.S. Geological Survey has segmented the nation into hydrological units, a standard way to define the many subbasins or small watersheds that combine to make up large watersheds.

What is Watershed Management?

Watershed management is a flexible framework for integrating the management of all resources—land, biological, water, infrastructure, human, economic—within a watershed. Human activities are managed so they cause the least disruption to our natural systems and native flora and fauna. The crucial factor in managing runoff and nonpoint sources is integrating land use, water/runoff,

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and infrastructure management. Watershed management includes numerous facets—planning, education, regulation, monitoring, and enforcement. These facets should be accomplished on a watershed basis and involve a diverse set of stakeholders in the process.

Selection of watershed size depends on many factors—watershed ecological systems, groundwater hydrologic influences, type and scope of resource management problems and goals, and level of available resources. The institutional framework also varies greatly, depending on the legal framework established by state laws and local ordinances.

Why Watershed Management?

Solving our nation's runoff problems, especially retrofitting existing drainage systems to reduce pollutant loads discharged to receiving waters, presents many complex challenges. Correcting these problems is expensive, technically difficult, and requires a long time period. Accordingly, we need to reevaluate our current approach to runoff management and shift the emphasis toward more comprehensive, prevention-oriented strategies such as watershed management.

The following comparison illustrates the differences between the traditional, piecemeal approach to runoff management and a comprehensive watershed approach (Camp, Dresser, McKee, 1985).

The Traditional Versus the Watershed Approach

The Piecemeal Approach

The traditional approach for existing urban development is to address local runoff problems without evaluating the potential for the control measure to adversely affect downstream areas (see Chapter 10). In new urban development, runoff management responsibilities are delegated to local land developers, with each responsible for constructing runoff management facilities on the development site. Their goal is to control runoff from the development site with little regard to how the discharges affect the system as a whole or the effects on the local government infrastructure. This is a piecemeal or individual site approach to runoff management.

While the usual approach to urban runoff management is relatively easy to administer it has several disadvantages. The risk of negative effects, particularly in watersheds that cover several jurisdictions, is greater. The failure to consider downstream impacts in selecting runoff management facilities causes ineffective runoff control throughout the watershed. This approach incurs relatively high local costs for facility maintenance. In addition, unnecessary costs are used for small-scale structural solutions rather than using large-scale nonstructural solutions, which are typically much cheaper.

Other negative effects of piecemeal runoff management are the following:

- It only partially solves major flooding problem(s).
- It solves flooding problems in the upstream jurisdiction, but may create flooding problems downstream.
- Randomly locating detention basins may actually increase downstream peak flows.
- Maintenance needs and costs associated with numerous on-site runoff controls are very high.
- Significant capital and operation/maintenance expenditures may be wasted.
- Remedial structural solutions cost more than implementing proper management programs in the first place.
- Other watershed management changes in the hydrolic regime or in stream temperature may not be considered.

The Watershed Approach

The watershed approach develops a comprehensive watershed plan—a runoff master plan—to identify the most appropriate control measures and the optimum locations to control watershed-wide activities. The watershed approach typically results in the following combinations:

- Reviewing watershed and its characteristics overall to assess problems and potential solutions.
- Using regional systems where appropriate.
- Providing runoff conveyance improvements where necessary.

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- Developing nonstructural measures throughout the watershed, such as acquiring floodplains, wetlands, and natural runoff depressional storage areas, limiting the amount of imperviousness, requiring grassed swales rather than storm sewers, and directing roof runoff to pervious areas.

- Coordinating point and nonpoint source program implementation.

Watershed master planning offers significant advantages over the piecemeal approach. It reduces capital and operation/maintenance costs and the risk of downstream flooding and erosion, particularly in multijurisdictional watersheds. It offers better opportunities to manage existing runoff problems and to consider and use nonstructural controls. Other benefits include increased opportunities for recreational uses of runoff controls, potential contributions to local land use planning, enhanced opportunities for runoff reuse, and popularity among land developers.

The major disadvantages of the watershed-level runoff master plan include

- Local governments must conduct advanced studies to locate and develop preliminary designs for integrated management facilities without fully knowing local plans.

- Local governments must develop and adhere to a future land use plan and properly design an effective mix of local and regional controls to capture runoff from present and future development and impervious surfaces.

- Local governments must often finance, design, and construct the regional runoff management facilities before most development occurs and provide for reimbursement by developers over a build-out period that can be many years long.

- In some cases, local governments may need to conduct expensive maintenance activities for regional facilities that the public views as primarily recreational.

However, another advantage of watershed management is that resource management goals can be resource oriented. This approach stresses prevention practices and programs to protect natural systems and beneficial uses of our waterbodies. These practices and programs are typically more cost-effective than trying to restore natural systems after they have been adversely affected by human activities.

Watershed management allows coordination of infrastructure improvements with point and nonpoint source management programs and, most importantly, provides a vital link between land use and water resources management.

Watershed Management Framework

Until recently, watershed management has faced many deterrents. Initially, the goal of a runoff management program was drainage—preventing flooding by quickly conveying runoff away from buildings and other developed areas, typically to the nearest waterbody. Restricting the use of private property through growth management/land use planning programs and regulations—the most cost-effective management option—has not been effective until recently. Little thought was given to the potential impacts of a land use change on the local drainage system or on the community at large. The generally accepted tenet was that development was good for the community, helped increase the tax base, and stimulated the economy—i.e., "growth pays for itself."

Other major deterrents to establishing comprehensive, integrated watershed management programs have been prevailing attitudes that foster turf wars and a lack of cooperation between state and local governments and, more important, between cities and counties. Each political entity believes it is an island unto itself. Far too little attention has been paid to intergovernmental coordination and cooperation.

Implementing watershed management programs requires a long-term commitment of time, energy, and money. Elected officials, responding to the citizens' cries to be frugal with their tax dollars, are reluctant to spend money on the planning studies required to implement watershed management programs. In only a few locations have elected officials recognized the long-term benefits and cost savings that can accrue by implementing comprehensive land use plans and runoff master plans.

Establishing a Framework

No single approach or institutional framework is available to establish a watershed management

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program. Establishing an institutional and legal framework would be easy if we could start with a clean slate. However, each state, county, and city has an existing legal framework and most differ greatly. Some states have comprehensive laws, rules, and programs. Other states do not have an adequate statutory or regulatory framework to form a foundation for watershed management programs. Therefore, a key to opening the watershed management door is flexibility. In some cases, the focus will be on enacting new laws; in other cases, the focus is on revising existing laws or ordinances to better integrate and coordinate programs and objectives.

Another key to a watershed management framework is patience. Enacting or modifying state laws or local ordinances is not an easy process. A long-term game plan must be developed and pursued with diligence. Each component of a watershed management program has its own controversies, assuring that public debate on many issues will be vociferous. Therefore, priorities must be established. Typically, priority setting depends on state resource problems and needs, public sentiment, and whether an issue becomes "sexy," thereby receiving coverage by the news media. In many cases, a particular piece of legislation will take several years to pass or revise.

To succeed, educating elected officials, state agency managers, and the public is a priority. Public participation and support are essential to build consensus. Many issues addressed by watershed management programs are complex and not easily demonstrated. Managers of runoff and other nonpoint sources of pollution, unlike the managers of traditional point sources, cannot point to pipes that continuously discharge effluents. Therefore, promoting watershed management programs requires multimedia presentations, not only to educate but also to entertain. You must *sell* the need for watershed management.

Taking advantage of opportunities that arise is another key to success. Unfortunately, opportunities often occur after a natural disaster that results in lost property or lives. After hurricanes Frederick and Andrew struck South Carolina and South Florida respectively, considerable public debate arose. Issues included building codes, land uses, and development within sensitive and susceptible coastal areas; whether to allow rebuilding in these areas; and whether public programs such as the National Flood Insurance Program should subsidize development. These debates, especially on costs and benefits, can help build support for growth management and land acquisition programs. Furthermore, flooding—and in a few locales, water quality problems—can be used to break the "hydro-illogical cycle" and gain support for runoff management programs and local runoff utilities.

In building a watershed management framework, establishing clear goals for the overall program should include

- Providing opportunities for preventive nonstructural controls, in addition to structural controls, to mitigate the impacts of human activities.
- Establishing clearly defined, holistic natural resource management goals.
- Setting priorities for a long-term legislative agenda.
- Encouraging public participation so that all parties buy in and feel a part of the solution.
- Integrating all available tools and resources into a coordinated, cost-effective, cooperative approach (i.e., integrate point and nonpoint source programs).
- Finding dedicated funding sources outside the main funding stream (general revenues) so that the watershed management programs do not compete against law enforcement, education, and other high priority societal needs.

In developing, selling, establishing, and implementing a watershed management framework and associated programs, keep in mind the following "big Cs" of watershed management:

- *Comprehensive* management of people, land use, natural resources, water resources, and infrastructure throughout a watershed.
- *Continuity* of runoff/watershed management programs over a long time period to correct existing problems and prevent future ones.
- *Cooperation* between federal, state, and local governments; cities and counties; the public and private sectors; and among all citizens.
- *Communication* to educate ourselves and elected officials about how everyone is part of the problem and must be part of the solution.
- *Coordination* of runoff retrofitting to reduce pollutant loading and other natural sys-

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tems restoration activities; includes complementary infrastructure improvements (e.g., road projects) or development/redevelopment projects to maximize benefits and cost-effectiveness.

- *Creativity* in best management practices, technology, funding sources, and approaches to solve these complex, costly problems.

- *Consistency* in implementing laws, rules, and programs nationally and statewide to assure equity and fairness.

- *Cash* in large amounts and over a long time period to correct existing problems and prevent future ones.

- *Commitment* to solve our current problems and prevent future ones to ensure that our children have a bright future—a willingness to put our money where our mouths are.

Program Components and Legislative Needs

Watershed management integrates management programs that address the many differing human activities within a watershed. The following brief discussion of components and programs that are part of watershed management is not all inclusive—other programs address specific state or regional needs. In developing or implementing programs, take advantage of information and technology transfer clearinghouses and communicate with people in other jurisdictions that have implemented similar programs.

Watershed management programs include common aspects, such as planning, holistic goals, scientific/technical support, and implementation—regulatory and nonregulatory approaches. Extensive public participation is also needed in all aspects of the program—planning, developing and adopting rules, permitting, and inspecting and enforcing. Programs must also address obtaining adequate funding and staffing; training staff and the public, especially the regulated community; assuring inspection and compliance; and assuring long-term operation and maintenance of structural controls. Finally, programs must be evaluated regularly to optimize their environmental effectiveness, cost-effectiveness, and service efficiency. This evaluation requires a commitment to monitoring programs that can actually ascertain if the program's goals are being met.

Typically, these programs are implemented after a state law is enacted and a state agency is set up to address a specific concern. A legislative mandate usually ensures that a program has adequate legal authority, staffing, and funding support. Programs have been established by a state agency using its general legislative powers to pass a rule—for example, programs for pubic education, pollution prevention, and monitoring and prioritizing target watersheds. Given the current scientific data on runoff pollutants, erosion and sediment control and even runoff treatment programs can be established using general water pollution control authorities. However, these programs are staff and resource intensive and, at a minimum, require legislative approval of budget requests.

Common watershed management programs include both planning and regulation. While the difference between comprehensive planning and permitting are important, both are needed to manage growth effectively and protect the quality of our environment and the lives of our citizens.

▮ ***Comprehensive Planning.*** Planning allows a community to make decisions about how and where growth will occur in the future. Comprehensive planning asks several questions: Is this the right location? Is this the right time? Is this the right intensity for the proposed land use? Comprehensive planning seeks to prevent problems—social, economic, environmental—before development occurs.

▮ ***Permitting.*** Permitting is site-specific and seeks only to mitigate the impacts of the land use decision. It asks: How can we do the best job with this development on this particular site? Any regulatory program has inherent limitations that comprehensive planning can help overcome. Principal among these limitations is that permitting is piecemeal and does not consider cumulative effects. Therefore, regulation and permitting cannot substitute for planning.

Watershed planning and management programs must include two equal components: the land planning framework and the water planning framework (Figure 15.1).

The Planning Framework

A watershed management framework can be divided into three categories:

- Land planning and management

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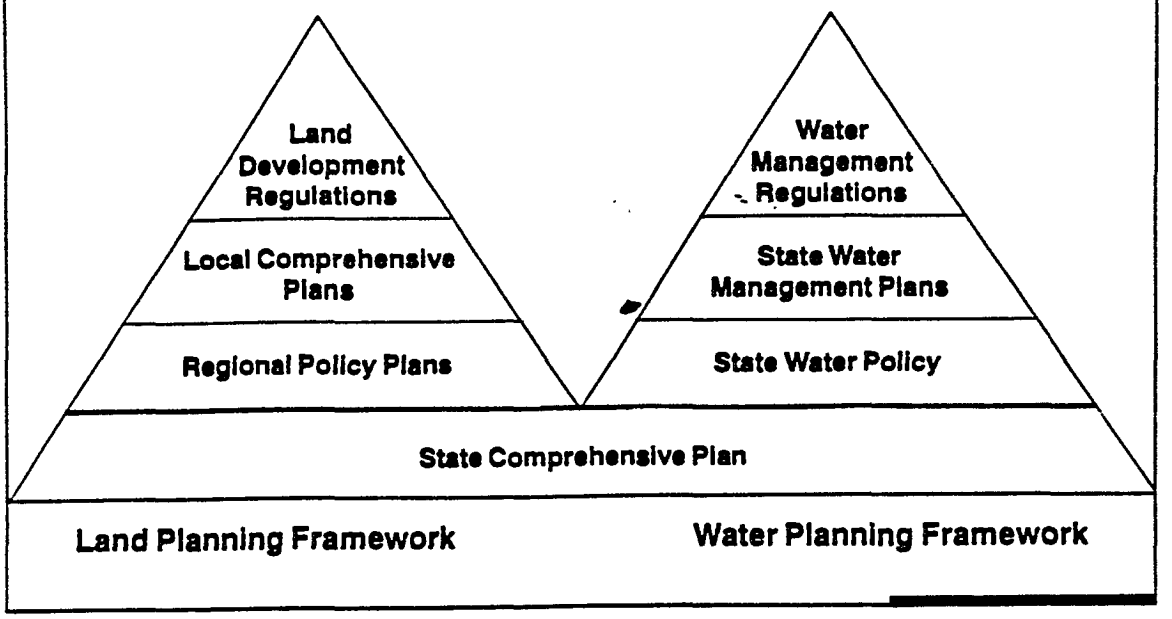
Figure 15.1.—The land planning and water planning frameworks.



- Water planning and management
- General resources planning and management

Land Planning and Management Programs

Land planning and management programs are often called growth management programs. However, growth management, comprehensive planning, and land and environmental regulations are clearly distinct.

Growth management looks at broad issues and the interrelationship of systems—natural systems, infrastructure, land use, and people. It assesses our past success in providing for citizens' needs and determines the needs of new arrivals and how to meet them. Growth management encompasses comprehensive planning, natural resource management, public facilities planning, housing, recreation, economic development, and intergovernmental coordination.

Comprehensive planning is a governmental process to inventory resources, establish priorities and a vision of where the community wants to go, and determine how to get there. It is a systematic way of looking at the different components of a community, county, region, and state.

Regulations are the specific controls applied to different types of development activities to regulate and minimize their negative impacts. Typically, regulations are administered by all levels of government—federal, state, and local. Locally, land development regulations are the ordinances that implement the local comprehensive plan.

State Comprehensive Plan

A state comprehensive plan serves as the base of the land and water planning pyramids (Figure 15.1). A state comprehensive planning act establishes goals and policies for each of the plan's elements and requires the state land planning agency to prepare a general state comprehensive plan. Elements of a plan usually include water resources, natural systems, air quality, coastal and marine resources, land and wildlife resources, waste management, public facilities (infrastructure), transportation, mining, agriculture, education, and economic development. If the state's land planning framework includes regional planning councils or council of governments, those agencies would develop a regional plan.

Both the state and regional plans should be consistent with the goals and policies stated in the state comprehensive planning act. These goals and policies, set by the legislature, provide guidance to state, regional, and local governments in developing and implementing programs, rules, or

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ordinances. The planning pyramid should be consistent from its base to its apex. To ensure consistency and integrate agency implementation programs with the law's goals and policies, the law can require state agency functional plans. These plans form the basis for agency budget requests, which are related to the goals and policies of the comprehensive plan.

Growth Management and Land Development Regulation

The Local Government Comprehensive Planning Act (LGCPA), often referred to as the growth management act, establishes the key piece of the natural resources jigsaw puzzle. It provides the direct connection between land use management and water/natural systems management. Eight states—Oregon, Florida, New Jersey, Maine, Vermont, Rhode Island, Georgia, and Washington—have implemented state growth management programs (Gale, 1992). While these programs have elements in common, each state has different implementation requirements. Some states "require" while other states "recommend" local plans, consistency, or compliance. A LGCPA should address, at a minimum, the following questions common to the existing state growth management programs:

- What is the legislative authority and intent?
- Are local comprehensive plans required or voluntary? Do they require a schedule or planning period? Do they require specific or minimum elements?
- Are plan implementation, site planning, or land development regulations required?
- Must plan be consistent with state goals and policies? Are monitoring and enforcement required?
- Are state review and approval required? From which agencies or administrative process?
- Is compliance or monitoring required? Does the plan provide incentives, disincentives, or citizen enforcement?
- Does the plan limit the number and type of amendments, the frequency, or the amendment process?
- Does the plan provide for regular updates and implementation appraisals and their frequency?

Wetlands and Floodplain Protection

Wetlands and floodplains provide storage and treatment for watersheds. They provide a wide range of irreplaceable services at no cost, including maintenance and improvement of water quality; floodwater conveyance and storage; shoreline stabilization; water recharge and supply; sediment control; aquatic productivity; spawning and nursery grounds; habitat for shellfish, fish, waterfowl, endangered species, and other wildlife; and open space and recreation.

Unfortunately, the benefits provided by wetlands and floodplains are not fully appreciated. Instead, these areas are seen as unproductive, snake invested, mosquito havens with no socially accepted redeeming value. Consequently, only about 40 percent of our nation's original 215 million acres (87 million ha) of wetlands in the 48 contiguous states remain, largely the result of the conversion of wetlands and floodplains to agricultural lands.

Section 404 of the Federal Clean Water Act established a wetlands program to maintain, protect, and restore our nation's wetlands. However, nationwide general permits to conduct activities in wetlands are easy to obtain. In addition, agricultural and silvicultural activities are largely exempt. Another problem hindering the environmental effectiveness of this federal program is a lack of national consistency. Furthermore, other federal programs (e.g., section 205 of the 1948 Flood Control Act, National Flood Insurance Program) directly conflict with wetland and water quality protection efforts by promoting alteration and development of these sensitive lands.

A state wetlands protection act can be an important addition to a state's watershed management arsenal to fill the gaps in the federal program or expand the protection of wetlands and floodplains. A state wetlands protection program should *integrate with, not duplicate,* existing federal programs. Since the current federal wetlands permitting program is administered by the Army Corps of Engineers and U.S. EPA, the state water quality/environmental management agency typically implements the program at the state level. Frequently, the wetlands protection act is simply a new section within a state's existing environmental laws.

Components that should be addressed by a state wetlands/floodplain protection act include

- Establishing wetland protection/management goals and policies as the basis for wetland regulations and permitting criteria.

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- Initiating goals and policies that foster cost-effective pollution prevention by stressing wetland avoidance rather than mitigation.

- Precisely defining a wetland. A wetland should be defined by three characteristics—the elevation and duration of flooding, the presence of certain wetland-specific plants, and hydric soil conditions. The law should clearly state that wetlands are "waters" similar to a river, lake, or estuary.

- Establishing a standard method to delineate wetlands. Wetlands represent the transitional edge between waters and uplands. Determining where a wetland and an upland begins is not easy—and is frequently controversial. Wetland scientists should be allowed to establish—through combinations of hydrologic, vegetation, and soil indicators—a process to "draw the wetland line."

- Requiring consistent statewide application of the definition and wetland jurisdictional delineation method by all government levels.

- Requiring or encouraging regional mitigation banks rather than on-site mitigation.

- Establishing a fair permitting process that assures public participation, equity, an appeals process, and decisions based on scientific and technical merit.

- Allowing, with strict pretreatment requirements, incorporation of certain wetlands into domestic wastewater and runoff management and reuse systems, provided the ecological characteristics of the wetland are protected, restored, or enhanced.

- Requiring the annual tracking of wetland losses and mitigation efforts, successes, and failures.

- Providing for state assumption of the federal section 404 wetlands program.

State and Local Land Preservation and Acquisition

Regulating and restricting the use of private property is controversial. However, the U.S. Supreme Court has ruled several times that state and local governments have that legal authority. In fact, the government is responsible for ensuring the health, safety, and welfare of the public. Restricting what can and cannot be done on a piece of property helps maintain property values and prevent contamination of air, land, water, and human resources. However, care must be exercised to avoid the taking of property. Land acquisition programs help ensure that this goal is met and that extremely crucial or sensitive lands within a watershed are preserved.

The federal government has set up several types of land acquisition programs to preserve sensitive lands, protect vital wildlife habitats, and establish recreational lands, such as national parks and wildlife refuges. However, federal budget problems and intense competition makes obtaining limited federal land acquisition funds difficult, especially for properties without national—or at least regional—significance. Additionally, federal programs generally require matching funds from state and/or local governments. Therefore, establishing state and local land acquisition programs can greatly increase the ability to purchase and protect sensitive lands and, equally importantly, capture limited federal funds.

State or local land acquisition programs require extensive citizen participation and support. They require asking individuals to tax themselves to raise money to purchase lands, preserve them, and provide recreational opportunities. Catchy phrases and acronyms are helpful to "sell" the program. Citizens must be convinced that they and their children will benefit and that funds will be spent wisely and cost-effectively. Land acquisition programs must avoid conflicts of interest and be administered with integrity and openness.

A state and local land preservation and acquisition act should contain the following components and considerations:

- Clearly defined program goals and policies. Such policies form a foundation to determine the types of properties to be purchased and how to establish purchasing priorities. The program's goals and policies should advocate preserving and restoring lands that contribute nonstructural environmental benefits. Additional resource management factors to consider in purchasing lands includes open space, recreational, and wildlife benefits.

- Integrated and coordinated federal, state, local, and private land preservation and acquisition programs. This component maxi-

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mizes the ability to leverage funds from various sources. Establishing interconnected wildlife corridors and greenways should be a priority goal.

- Extensive participation by citizens, private conservation groups, and state and local governments to establish program regulations, administrative procedures, and—most important—land buying priorities.

- Long-term ownership and active land management once the property is purchased. The act should specify which agency will be in charge—an environmental agency, a parks and recreation agency, a fisheries or wildlife agency, or a private organization (e.g., Trust for Public Land). The act should determine if a land management plan must be developed and how land management will be funded.

- Dedicated funding sources. Purchasing and managing sizable amounts of land, especially with public access and use, requires large sums of money over a long time period. To obtain sufficient funds, a state or local government might choose to sell bonds, which allow it to raise large amounts at one time and pay bonds off like a mortgage. However, this decision requires a stable and predictable funding source over the life of the bond. Fees on real estate transactions, such as documentary stamps, and local option sales taxes have been used extensively.

Water Resources Planning and Management Programs

The United States is generally blessed with an abundance of clean water resources. Water is available whenever we want it, in whatever quantity we desire, and at a very low cost. Consequently, we have placed less attention and emphasis on water resources planning and management, especially from a holistic approach. In the past, water planning and management programs were implemented to address a crisis. However, our population's continuing growth exerts ever expanding demands on our vulnerable and limited water resources. Additionally, to manage unconventional pollution sources, such as runoff and other nonpoint sources, we need to reevaluate the way we manage water. Accordingly, water resource planning and management programs are receiving increased attention and evaluation.

Watershed management programs include water quantity and quality programs to protect and manage surface and groundwaters and general environmental protection programs. These programs usually contain pollution prevention and treatment aspects.

Environmental Protection

Most states have enacted some type of state environmental protection act to control traditional point source pollution. These laws, generally patterned after the federal Clean Water Act, are frequently revised as a new state environmental crisis or concern arises or as Congress amends the Clean Water Act. The Clean Water Act shows how, over a long period, laws can be revised to establish or refine existing or new environmental requirements or programs.

While state environmental protection laws include many similar requirements and mandates, they vary considerably because states approach the same problem differently. For example, some states enact separate erosion and sediment control and runoff management acts; other states combine these important watershed management components. In some states, the law governing the siting and use of on-site wastewater disposal systems is found within a state's general health code law; in other states, the law is within the environmental law. These watershed management components are discussed separately, even though their legislative authority is often integrated into a state's environmental laws.

State environmental protection laws generally contain components and considerations that establish

- The state environmental agency, its legal authority, and its powers and responsibilities.

- An environmental regulation commission generally composed of citizens appointed by a political body (e.g., the governor) that holds public workshops and adopts environmental regulations and standards.

- Permit evaluation criteria, permit fees, and administrative procedures, which include a legal administrative hearing process to appeal permitting decisions.

- Programs—with adequate legal authority, direction, and resources (i.e., staffing and funding)—to address general environmental protection and management of air, land, and water resources such as surface and groundwater.

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- Programs—with adequate legal authority, direction, and resources—to minimize the impacts of specific pollution sources such as wastewater and industrial discharges, solid wastes, hazardous wastes, and toxic wastes.

- Pollution prevention programs such as "amnesty days" that allow citizens to safely dispose of hazardous or toxic household wastes, used-oil recycling centers, waste reduction and assistance programs for industry, adopt-a-road (stream, lake, bay, shoreline), recycling, and farmstead assistance (Farm*A*Syst).

- Programs to restore environmentally damaged lands and waters, especially critical areas such as wetlands, floodplains, steep slopes, and eroding lands.

- Programs to monitor the environmental health and assess the effectiveness of watershed management programs. Monitoring programs should include sampling the water column, sediment, and biological community. Programs must provide information concerning long-term trends in environmental health and the health of selected waterbodies or natural systems.

Water Resources Planning and Management

Many states have enacted a water resources act distinct and separate from the state environmental protection act. States are recognizing that planning and managing water resources are essential to the continued survival of life on the planet and that water is a major determinant of economic development and quality of life. Water resources planning and management must consider both water quantity (i.e., supply, allocation, flooding) and quality. An effective state water resources act must be fully integrated with the state environmental protection act. State environmental protection and state/regional water resources programs must be coordinated, consistent, and complementary.

A state water resources act creates the framework for water resources planning and management programs by state, regional, and local governments (see Figure 15.1). Using goals and policies of the state comprehensive planning act, the environmental regulation commission adopts a regulation, or state water policy. This regulation contains general policy statements addressing a myriad of water resource topics, such as water supply and conservation, surface water preservation and management, and natural systems preservation and management. It guides the implementation of all water resource programs and regulations, whether by a state, regional, or local entity. The act could establish regional watershed management districts, set up by watershed boundaries. The districts conduct regional watershed planning, coordinate water management efforts undertaken by local agencies to ensure that watershed goals are cooperatively met, and operate regulatory and research programs.

A state water resources act should include

- Establishing watershed management districts to administer special regional (watershed) water planning and management programs and providing statutory authorities and responsibilities to give them broad powers to protect, manage, and restore surface and groundwater resources.

- Setting the institutional relationships between the state environmental agency, regional water management districts, and local governments. Strong oversight of programs, especially regulatory ones, implemented downwards is essential for program consistency.

- Developing a state water policy (SWP) to guide all state water programs and regulations and adopt them as part of the state's environmental regulation code.

- Basing the SWP on the goals and policies of the state planning act and ensuring that state, regional, and local water regulations and programs are consistent. Goals and policies of the local comprehensive plan should also be consistent with SWP.

- Providing the districts with dedicated sources of revenue to ensure long-term, adequate funding of all necessary water resource management programs. Sources used include ad valorem assessments (property taxes), fees on water use, permitting fees, and special assessments.

Supplemental Surface Water and Environmental Protection Programs

Several watershed management components can be included in the state environmental protection or water resources act or established in a separate statute.

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the design and performance of OSDS (i.e., secondary treatment or nitrates less than 10 mg/L); whether surface discharges will be allowed and under what conditions; inspections during construction and throughout the use of the system; and maintenance.

- Regular inspection (every two to three years) and maintenance (e.g., pump out, drainfield) to help ensure that OSDS continue to function properly. One mechanism is to establish OSDS management districts with defined service areas, funding sources, and legal authorities.
- Another method to assure that OSDS continue to function properly is to require inspections, upgrading, and maintenance of systems when a property is sold.

General Resources Planning and Management

One complication in implementing watershed management frameworks and programs is their complex, interwoven nature. Many aspects of watershed management transcend the simple classification scheme outlined in Figure 15.1. These include the need for broad-based natural resource management programs and environmental education programs. Many states have established separate agencies responsible for management of land, fish and wildlife, agriculture, mining, and for providing parks and recreation. Often a state forestry department is responsible for acquiring and managing state forest lands. These activities and programs typically are essential to watershed management. Close coordination and cooperation between these agencies and the other primary natural resources management agencies ensure that programs do not conflict and maximize the benefits and cost-effectiveness of all programs.

Additionally, while nearly every natural resource management agency has some type of environmental education program, these programs are often narrowly focused. The growing importance of nontraditional pollution sources such as runoff and nonpoint sources requires developing and implementing a broad-based environmental curriculum that begins teaching children in kindergarten and continues all the way through senior high school. Each individual must understand the basic interrelationships of air, land, and water and how everyday activities degrade our natural systems. The best way to establish the ethic of stewardship is by educating our youth.

State Watershed Management Initiatives

Several states have developed and implemented some or many of the watershed management components previously discussed. In recent years, states have begun integrating ongoing programs into a comprehensive watershed management framework. Chapter 16 provides case histories from the states of Florida, Delaware, and New Jersey. The Puget Sound Management Program in Washington State and the Priority Watershed Program in Wisconsin are also good examples of watershed management initiatives.

North Carolina's ongoing efforts demonstrate one way that existing programs, especially planning and regulatory, can evolve into an integrated watershed approach. The North Carolina Division of Environmental Management (NCDEM) has developed a plan in which basins—not stream reaches—are the basic unit of water quality management. According to the U.S. Environmental Protection Agency (1991), the objectives of North Carolina's Basinwide Water Quality Management Initiative include

- Identifying priority problem areas and pollution sources that merit particular pollutant control, using modifications of rules (e.g., basin criteria) and increased enforcement.
- Determining the optimum water quality management strategy and distribution of assimilative capacity for each of the 17 major river basins within the state.
- Preparing, in cooperation with local governments and citizens, comprehensive basinwide management plans that set forth the rationale, approaches, and long-term management goals and strategies for each basin.
- Implementing innovative management approaches that protect the state's surface water quality, encourage the equitable distribution of assimilative capacity, and allow for sound economic planning and growth.

The whole-basin initiative is a fully integrated approach to water quality assessment and management. It integrates planning, monitoring, modeling, point source permitting and control, nonpoint source control, and enforcement within

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- A state training and certification program for plan reviewers, inspectors, and contractors is highly recommended since public agencies will not likely obtain sufficient staffing to conduct regular inspections of runoff systems during or after construction. These programs can be integrated with the similar erosion and sediment control programs.

- Integrating the state runoff management program with the erosion and sediment control program and the new federal NPDES permitting program.

- Establishing a mechanism, such as runoff operating permits, to ensure at least annual runoff management system inspections. Inspections determine maintenance needs and ensure that systems are maintained and operated properly. This system could be operated by a local runoff utility and provide the owner of a properly maintained and operated system a utility fee credit as an economic incentive.

- Providing statutory authority to establish dedicated state and local funding sources for runoff management programs. State sources could include small fees on concrete, asphalt, fertilizer, or pesticides. Communities nationwide use runoff utilities with great success.

Watershed Prioritization and Targeting Act/Program. The growing number of water resource problems and the financial constraints faced by all levels of government strongly suggest a need to establish watershed prioritization and targeting programs. Many states have set up such programs, often as part of their runoff/nonpoint source management programs.

Considerations and components of a state watershed prioritization and targeting act/program include

- Clearly identifying which state, regional, and local agencies are involved in establishing priority watersheds. Public participation is essential to ensure citizen cooperation and buy in around the state and within the targeted watershed. Cooperation and joint ventures with private land conservation groups should be encouraged.

- Providing guidance on factors to consider in the prioritization process. These factors may include requiring that waterbodies be state or regionally significant or at a certain degradation level; a specific level of local government and citizen support, especially from land owners who need to install management practices; and the availability of local matching funds. Pristine waterbodies may also be given priority.

- Providing a legal mechanism for the appropriate state, regional, or local agency to adopt the priority list; ensuring that the list is reviewed regularly and updated or refined as needed.

- Providing a dedicated source of state, regional, or local funds to develop and implement a watershed management plan within a realistic time schedule.

On-Site Wastewater Management Act/Program. The nation's rapid population growth and accompanying migration to the suburbs and beyond has led to a tremendous proliferation in on-site wastewater disposal systems (OSDS). Often considered an inexpensive alternative to centralized wastewater collection and treatment systems, OSDS can cause or contribute to health and environmental resource problems that are difficult and expensive to solve. Like many areas of nonpoint source management, OSDS programs should stress prevention and correct problems caused by past use and misuse. Traditionally, state, county, and local health departments, rather than environmental or water resources agencies, have administered OSDS programs. However, OSDS are increasingly considered major contributors to impairment of aquatic systems.

A state on-site wastewater management act/program should include the following components and considerations:

- Clearly defined legal authority, goals and performance standards, and responsibilities of the state, regional, or local entities charged with implementing the program.

- Goals and performance standards that address traditional health concerns and consider the potential environmental effects of OSDS.

- Provisions to adopt regulations that govern the types of OSDS systems (i.e., drainfields, mound systems, aerobic units); the siting of systems (i.e., water table elevation, soil types, setbacks from wetlands/waters);

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CHAPTER 16

Runoff/Watershed Management Case Histories

This chapter presents several case histories that include important components of watershed management programs.

Florida's Watershed Management Program

Florida is blessed with a multitude of natural systems—longleaf pine-wiregrass hills of the panhandle, sinkhole and sand ridge lakes of the central ridge, the Everglades "River of Grass," and the coral reefs of the keys. Abundant surface water resources include over 20 major rivers and estuaries and nearly 8,000 lakes. Plentiful groundwater aquifers provide over 90 percent of the state's residents with drinking water. This, along with the state's favorable climate, explains why many consider the Sunshine State a favored vacation destination and why Florida has experienced phenomenal growth since the 1970s. Today, Florida is the fourth most populous state and still growing rapidly, although not at the rate of 900 people per day (300,000 per year) that occurred throughout the 1970s and 1980s.

However, Florida's natural systems—especially its surface and groundwater resources—are extremely vulnerable and easily damaged. This is partially the result of the state's sandy porous soils, karst geology, and abundant rainfall. Florida experienced the negative impacts of unplanned growth as early as the 1930s. The southeast coastal water supply was threatened by saltwater intruding into the fragile freshwater aquifer that supplied most of the potable water for a rapidly expanding population. By the 1970s, unplanned land use, development, and water use decisions were clearly altering the state. If left unchecked, this development could have led to profound, irretrievable loss of the very natural beauty that brought residents and tourists to Florida. Extensive destruction of wetlands, bulldozing of beach and dune systems, continued saltwater intrusion into freshwater aquifers, and extensive pollution of the state's rivers, lakes, and estuaries were only some of the negative impacts of this rapid growth.

Fortunately, Florida's citizens and elected officials educated themselves and began developing programs to protect and manage the state's natural resources. Florida's serious and comprehensive efforts to manage its land, water resources, and growth coincided with the increasing strength of the national environmental movement of the early 1970s. Florida's natural resources management programs, consisting of 25 individual laws and programs enacted over a 20-year period, make up Florida's watershed management program. In many cases, these laws have been integrated into existing laws or adopted as regulations by various state, regional, or local agencies.

The evolution of Florida's watershed management program has followed a typical sequence. Concern about a specific pollutant or problem creates a resource/environmental management program that usually begins by focusing on new sources (site basis). Over time, as new sources are controlled and the program administration and effectiveness increase, the focus shifts to cleaning up older sources (watershed or regional basis). The focus then shifts to integrating the program with similar ones to eliminate any duplication and improve efficiency and effectiveness. Figure 16.1 provides an overview of the interrelationships among the various programs and regulations outlined in the next section.

Following is a chronology of how Florida statutes and programs, the cornerstones of its overall watershed management efforts, were established and revised.

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a basin. NCDEM has rescheduled its NPDES permit activities to occur simultaneously with permit renewals, which are repeated at five-year intervals within a given basin.

Difficulties in implementing a basinwide approach include setting priorities, establishing a rotating schedule among the basins, and correlating management needs (e.g., monitoring, planning, permitting, and enforcement) with staff and resource allocations. North Carolina prioritized and scheduled its 17 basins by considering the nature and extent of known problems, the basin's important human use, data availability, and balancing staff workload.

North Carolina will perform a 15-step process for each basin as follows:

1. Compile all existing relevant information on basin characteristics and water quality.
2. Define the water quality goals and objectives for waterbodies within the basin; revise as more data are obtained.
3. Identify the critical issues (e.g., water supply protection, shellfish harvesting) and current water quality problems within the basin; determine the major factors and sources (i.e., point, nonpoint, habitat degradation) that contribute to the problems.
4. Prioritize the basin's water quality concerns and critical issues; ensure public participation and input from other government agencies and nongovernment groups.
5. Define the subbasin management units using basin hydrology, physiographic boundaries, problem areas, and critical issues.
6. Identify the need for additional information.
7. Collect additional information.
8. Analyze, integrate, and interpret the information collected; revisit steps 2 through 5 in light of new information.
9. Determine and evaluate the management options for each management unit in the basin.
10. Select final management approaches for the basin and targeted subbasins.
11. Complete the draft Whole-Basin Management Plan; perform additional modeling and other analyses to finalize wasteload allocations.
12. Distribute the draft plan for review and comment and conduct public hearings.
13. Revise the plan as appropriate in response to comments; facilitate adoption by the Environmental Management Commission.
14. Implement the management approaches, including point and nonpoint source controls.
15. Monitor the program's success, and update the plan every five years.

Recommended Reading

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1973

■ Chapter 403, F.S. The Florida Environmental Protection Act renamed the Department of Pollution Control as the Department of Environmental Regulation (DER) and broadened its powers, duties, and programs. This law, the state's general environmental protection act, is amended almost annually as new environmental concerns and needs arise and existing programs evolve.

1975

■ Chapter 163, F.S. The Local Government Comprehensive Planning Act (LGCPA), the state's first growth management legislation, was recommended by the first Environmental Land Management Study Committee (ELMS I). The law required all cities and counties to prepare a comprehensive plan and submit it to the state's land planning agency, the Department of Community Affairs, for review. This agency sends the plans to other state agencies for review and comment. However, the LGCPA contains no teeth—local governments are under no statutory requirement to revise their plans by incorporating comments and recommendations made by reviewing agencies. Furthermore, localities are not required to pass land development regulations to implement their plans.

1976

■ Implementation by EPA of section 208 of the 1972 Clean Water Act required development of areawide water quality management plans. This was the first national program to assess and control nonpoint sources of pollution. In Florida, millions of federal grant dollars allow the DER and 12 designated area agencies to undertake extensive research on nonpoint source impacts, sources, controls, control effectiveness, and costs This data provided the scientific basis to develop and implement a statewide rule in 1982 that requires runoff treatment for new development and redevelopment projects.

1978

■ Chapter 380, F.S. This added Part II to the Florida Coastal Management Act, which required establishing a program based on existing statutes and rules to receive federal approval under the federal Coastal Zone Management Act of 1972. After approval of the program, NOAA-Office of Coastal Zone Management federal grants funded many initiatives to better protect and manage coastal resources. One established an estuarine watershed management program that emphasized sediment mapping. This led to the development of innovative, reliable coastal sediment sampling, analytical, and assessment techniques.

1979

■ First components of the state's areawide water quality management plan, the agriculture nonpoint source plan, and the silviculture nonpoint source plan were submitted to and approved by U.S. EPA. These called for a nonregulatory approach, with a regulatory backstop, if best management practices required by farm conservation plans were not implemented or if the forestry BMPs required by the state's adopted silvicuiture BMP manual were not followed.

■ Chapter 17-4.248, Florida Administrative Code (FAC). The state's first stormwater rule, adopted by the state Environmental Regulation Commission (ERC) as a rule of the DER, was a temporary regulation until ongoing research on BMP design and effectiveness was completed. The rule's adoption was controversial, but data collected during section 208 program studies conclusively showed that runoff, especially from urban land uses and highways, is a pollutant and therefore should be controlled. Florida's continuing rapid growth made treatment of runoff imperative, with BMPs required for new runoff discharges that would be "a significant source of pollution."

■ Chapter 253, F.S. This was amended to establish the Conservation and Recreation Land (CARL) Trust Fund, which provided additional funding to purchase environmentally endangered lands and other lands deemed appropriate and in the public interest by the governor and cabinet.

1981

■ Through action taken by the governor and cabinet, the Save Our Coasts land acquisition program was established. The program proposed spending $200 million over 10 years to purchase coastal lands such as beaches, shorelines, and sensitive areas. Funding was provided by the sale of state bonds backed by documentary stamps as authorized in Chapter 375, F.S., which sets policy on how the Land Acquisition Trust Fund was to be administered.

■ Chapter 373, F.S. This was amended with the creation of the Save Our Rivers land acquisition program. Administered by the WMDs, this pro-

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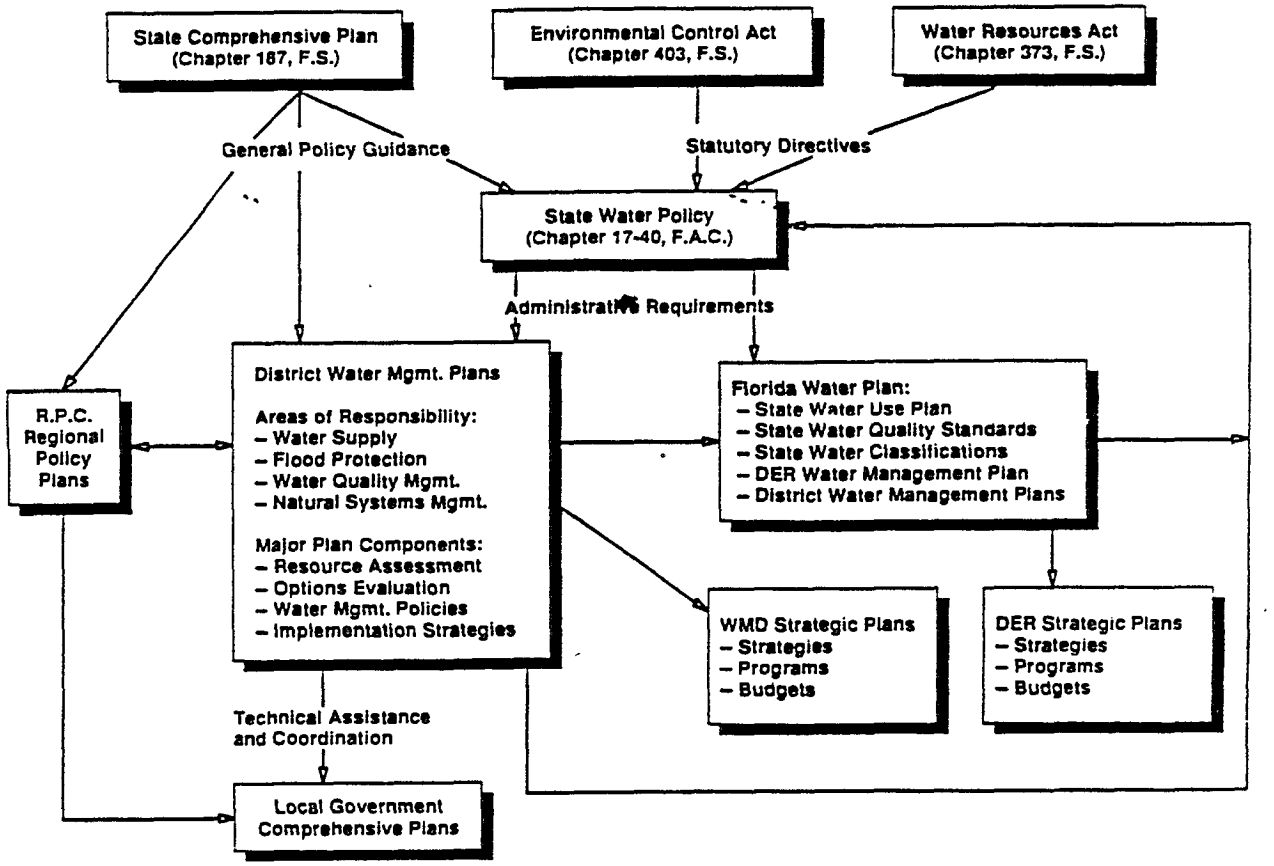
Figure 16.1—Functional relationships of Florida water planning programs.



Source: By author.

Evolution of Florida's Watershed Management Program

1970

■ Chapter 370, Florida Statutes (F.S.). Created the Coastal Coordinating Council, the first state effort at integrating state and regional programs in protecting and using coastal resources. Initial efforts from 1970 to 1975 focused on a comprehensive resource-based coastal protection program.

1972

■ Package of land and water planning, regulation, and acquisition programs.

- Chapter 380, F.S. Created the Developments of Regional Impact (DRI) and Areas of Critical State Concern (ACSC) land planning and management programs.
- Chapter 373, F.S. The Florida Water Resources Act established five regional water management districts (WMD); designated the Department of Pollution Control as the oversight agency for the WMDs; required the development of a state water plan; and allowed for the regulation of the water resource. WMDs, financed by ad valorem property taxing authority of up to 1 mil ($1/$1,000 value), set in the Florida constitution. The Northwest Florida WMD millage capped at .05 mil.
- Chapter 259, F.S. The Land Conservation Act established a program, commonly known as the Environmentally Endangered Lands Program, which authorizes the state to purchase critical and sensitive lands. It was envisioned as a 10-year program, investing $200 million, and funded by the sale of state bonds.

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Important minimum treatment performance standards included

- 80 percent average annual load reduction for new runoff discharges to most waterbodies.
- 95 percent average annual load reduction for new stormwater discharges to "outstanding Florida waters," a special class of exceptionally high quality waterbodies.
- Reducing, on a watershed basis, the pollutant loading from older runoff systems to protect, maintain, or restore the beneficial uses of the receiving waterbody, according to the pollutant load reduction goal.

■ Chapter 375, F.S. This section was amended with the creation of Preservation 2000, a 10-year land acquisition program with a goal of spending $300 million per year. The legislation divided available annual funding among seven programs: CARL, Save Our Rivers, Florida Communities Trust, State Parks, State Forests, State Wildlife Areas, and Rails to Trails. Although the program was funded the first year by state bonds backed by an increase in the documentary stamp fee, the provision did not identify a long-term dedicated funding source. It made the program subject to annual legislative appropriations. Between 1972 and 1991, the state's land acquisition programs invested more than $1.5 billion to buy over 1.2 million acres (485,640 ha). Equally important, as a result of the state land acquisition programs, 14 Florida counties have created programs that currently commit up to $600 million for land conservation. Revenue sources for these local land acquisition programs include local option sales tax, impact fees, added property taxes, and local bonds.

1991

■ Chapter 40C-42, FAC. The St. Johns River WMD completely revised this provision to modify the design criteria for runoff treatment BMPs so they will achieve the minimum treatment levels set in the state water policy. Runoff reuse became essential for developments discharging to outstanding Florida waters.

■ Chapter 40C-44, FAC. The St. Johns River WMD adopted this provision to regulate certain agricultural pumped discharges (formerly regulated as industrial wastewater) and established design and performance criteria for these agricultural runoff management systems.

■ The Southwest Florida WMD initiated development of an agricultural runoff management program for certain types of agricultural activities, including row crops and citrus. The program included regulatory incentives to obtain technical assistance from USDA SCS or other qualified individuals to prepare and implement a farm-specific resource management plan that contains certain required BMPs.

1992

■ DER and the WMDs, in response to increasing demands on state waters and the increasing number of water quantity and quality problems, began developing district water management plans. Collectively, these district plans, together with the DER's plan, will create the state water management plan. These plans are based on the goals and policies set in state water policy and in the state comprehensive plan. For each of four major areas—water supply, water quality, flood protection, and natural systems protection—four key planning steps should occur: assess resources to identify current or anticipated problems, examine options, declare policy, and designate implementation strategies.

■ Section 314, Federal Clean Lake Program Lake Assessment Grant. This grant was obtained to delineate lake ecoregions, select lake ecoregion reference sites, and test/validate lake bioassessment sampling protocols and metrics.

1993

■ Chapters 373 and 403, F.S. These chapters were revised extensively and merge the Department of Environmental Regulation and Department of Natural Resources to create the Department of Environmental Protection (DEP), as a part of the Environmental Permit Streamlining bill. The goals of the streamlining bill were to eliminate duplication, especially in permitting; increase administrative and environmental effectiveness by increasing delegation of programs from DEP to the WMDs; and ensure greater program consistency and integration.

Key specific actions of the bill included

- Moving the Wetlands Protection Act from Chapter 403 to Chapter 373, F.S.

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gram proposed spending $320 million over 10 years to purchase wetlands, floodplains, and other lands necessary for water management, water supply, and the conservation and protection of water resources.

1982

■ Chapter 17-25, FAC. This policy was adopted by the ERC after two years of rule adoption workshops and 29 official rule drafts. The rule was technology rather than water-quality based, although the state's water quality standards remain as a backstop, should a runoff discharge cause violations. A performance standard of 80 percent average annual load reduction is recommended based on BMP effectiveness and cost data and to establish equity with the minimum treatment levels for point source discharges. The rule created design criteria for various types of BMPs, including retention, detention with filtration, and wet detention. The rule also created general permits for certain types of BMPs (e.g., retention, detention with filtration) built to the design criteria. The South Florida WMD implemented the rule allowing runoff treatment requirements to be merged with runoff quantity (flood control) requirements in one permit.

1984

■ Chapter 403, F.S. Revised to create section IX, known as the Henderson Wetlands Protection Act. This legislation expanded the authority of the DER to protect wetlands; established administrative procedures to allow landowners to obtain legally binding "wetland lines"; allowed DER to consider fish and wildlife habitat, endangered species, historic and archaeological resource, and other relevant concerns in wetland permitting; allowed certain wetlands to be incorporated into domestic wastewater and runoff management systems; transferred wetland regulation for agriculture and forestry activities to the WMDs; and required the WMDs to protect isolated wetlands and consider fish and wildlife habitat requirements.

■ The Southwest Florida WMD receives delegation of the stormwater quality permitting program from DER, thereby integrating these permits into the district's existing stormwater quality permitting program.

■ In the late 1970s and early 1980s, an extensive appraisal of Florida's growth management system concluded that the existing system was not working. Shaped by the Final Report of the Governor's Task Force on Resource Management (1980) and the second Environmental Land Management Study Committee (ELMS II), a totally new blueprint for managing growth emerged. The ELMS II Committee recommended a package of integrated state, regional, and local comprehensive planning; reforms to the Developments of Regional Impact law; and coastal protection improvements. The legislature responded by enacting several laws between 1984 and 1986.

■ Chapter 186, F.S. The State and Regional Planning Act mandated the governor's office to prepare and present a state comprehensive plan to the 1985 legislature. It also required the state's 11 regional planning councils to prepare regional plans and provided $500,000 for plan preparation.

1985

■ Chapter 187, F.S. The State Comprehensive Plan was envisioned to be a leadership document —the foundation of the entire planning process— with strong, measurable, strategic goals that would set the course for Florida's growth over the next 10 years. Each state agency was to prepare a functional plan, based on the state plan, upon which its budget appropriations would be made. Unfortunately, one of the most important elements of the state plan, the development and adoption of a capital plan and budget, was never prepared. However, the plan contained important goals and policies in 25 different areas, including water resources, coastal and marine resources, natural systems and recreation, air quality, waste management, land use, mining, agriculture, public facilities, and transportation.

Important and relevant goals included

- Ensuring the availability of adequate water supply;
- Maintaining functions of natural systems, and
- Maintaining/enhancing present surface and groundwater quality.

Important and relevant policies included

- Eliminating the discharge of inadequately treated wastewater and runoff;

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This move delegated the wetland resource permits to the WMDs, except for certain projects that require other types of DEP permits.

- Merging the existing surface water/runoff management permit with the wetland resource permit to create an environmental resource permit.
- Redefining wetlands based on their hydrology, vegetation, and soils, and requiring the development of a single wetland delineation method to be used by DEP, WMDs, and local governments.

■ Recommendations of the third Environmental Lands Management Study Committee (ELMS III) were enacted into law, thereby amending several state laws. The act strengthens the state planning process by

- Requiring the governor to biannually review and analyze the state comprehensive plan and recommend any necessary revisions.
- Requiring the governor to prepare a new growth management portion of the state comprehensive plan. It will provide a more detailed and strategic state policy guidance for state, regional, and local governments to identify urban growth centers, set strategies to protect identified areas of state and regional environmental importance, and provide guidelines to determine where urban growth is appropriate and should be encouraged.

The governor's growth management document must be adopted by the legislature. However, to what extent local comprehensive plans, state agency strategic plans, and regional policy plans must be consistent with the state plan is unknown. The document is to be recommended by the governor and adopted as law by the 1994 legislature.

The act also provided greater flexibility and less requirements in local comprehensive plans for small cities and counties (less than 50,000); streamlined the plan amendment process by limiting the types of revisions requiring state review and approval; strengthened the local plan evaluation and appraisal process; terminated or made optional the DRI process in certain areas and revised the DRI process in other areas; and authorized a local option gas tax of up to 5 cents.

Recommendations

Florida has established a wide variety of laws, regulations, and programs at the state, regional, and local level. These are designed to protect, manage, and restore the state's incredibly valuable yet vulnerable natural resources, especially its water resources. Although these programs have helped reduce adverse impacts on natural resources resulting from the state's rapid and continuing growth over the past 20 years, many of Florida's natural resources have still been strained or degraded.

Some adverse effects were caused by activities that occurred before modern watershed management programs began, such as the channelization of the Kissimmee River and the creation of the vast drainage canal network south of Lake Okeechobee. Both of these conditions are contributing to the decline of Lake Okeechobee, the Everglades, and Florida Bay. Other adverse impacts directly related to 20 years of rapid growth and development are water supply and quality problems, declining habitat, and impacts on endangered species such as the manatee and the Florida panther.

Why are these adverse impacts still occurring, given the wide range of watershed management programs implemented in Florida? What can be done to reduce these effects and possibly restore already degraded areas? Following is a list of program deficiencies and recommendations to correct them:

1. While the statutes enacted by the legislature may be sound, governmental entities have insufficient resources to implement programs. The state's reliance on sales tax as a primary means to raise general revenues means that state revenues are tied closely to economic conditions. Relying on such sources during a recession, especially when the population is still growing, means that the state budget is nearly always in crisis. To compete for limited state resources and have adequate resources to achieve intended benefits, watershed management programs need dedicated sources of funding.

2. The statutes and programs are not fully integrated, leaving gaps in both land and water planning programs. In particular,

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plans to assure some consistency, and establishing administrative processes to develop and adopt SWIM plans by the WMDs and submitting them to DER for review and approval.

■ The State Nonpoint Source Assessment and Management Plan, prepared under section 319 of the Clean Water Act, was submitted to EPA and approved. This qualified the state for section 319 nonpoint source implementation grants for BMP demonstration projects and to refine existing nonpoint source management programs. This plan delineates the state's ecoregions based on river systems, selects ecoregion reference sites, and modifies EPA's Rapid Bioassessment Protocols and metrics for use in Florida.

1989

■ Chapters 373 and 403, F.S. These provisions, revised as part of the 1989 stormwater legislation, accomplished the following:

- Clarified the stormwater program's multiple goals and objectives;
- Set forth the institutional framework that involves a partnership among DER, the WMDs, and local governments;
- Defined the responsibilities of each entity;
- Addressed the need to treat agricultural runoff by amending Chapter 187, F.S., to add a policy in the agriculture element to "eliminate the discharge of inadequately treated agricultural wastewater and stormwater";
- Further promoted the watershed approach being used by the SWIM program;
- Unsuccessfully attempted to integrate the runoff program, SWIM program, and local comprehensive planning program;
- Established State Water Policy, an existing but little used DER rule, as the primary implementation guidance document for stormwater and all water resources management programs; and
- Created the State Stormwater Demonstration Grant Fund and provided $2 million as an incentive to local governments to implement runoff utilities.

1990

■ Chapter 17-40, FAC. State Water Policy underwent a total revision and reorganization to be used as a guide by all entities implementing water resource management programs and regulations. Section 17-40.420 included the goals, policies, and institutional framework for the state's runoff management program.

■ DER was designated as the lead agency with responsibility for setting program goals, providing overall program guidance, overseeing implementation of the program by the WMDs, and coordinating with EPA, especially the new NPDES runoff permitting program.

■ WMDs were named the chief administrators of the runoff regulatory program (i.e., quantity and quality). They prepare SWIM watershed management plans, which include establishing runoff pollutant load reduction goals, and provide technical assistance to local governments, especially in basin planning and developing runoff master plans.

■ Local governments were designated the front lines in the watershed management program since they determine land use and provide runoff facilities and other infrastructure. Under the policy, they are encouraged, but not required, to set up runoff utilities to provide a dedicated funding source for their programs. Their runoff responsibilities include preparing a runoff master plan to address needs imposed by existing land uses and needs created by future growth; operation and maintenance activities; capital improvements of infrastructure; and public education. They are encouraged to set up an operating permit system to annually inspect runoff systems to ensure that needed maintenance is performed.

Important goals included

- Preventing stormwater problems from new land use changes and restoring degraded waterbodies by reducing the pollution contributions from older runoff systems.
- Retaining sediment on-site during construction.
- Trying to assure that the runoff peak discharge rate, volume, and pollutant loading are no greater after a site is developed than before.

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water and land planning and regulatory programs need better integration. The local government growth management program needs a close connection to state and regional water management programs. The requirements set forth in the state water policy and the district/state water management plans need to be incorporated by local governments in their land use planning programs. Local plans need to be consistent among all levels.

3. Greater emphasis must be placed on the long-term maintenance and operation of runoff management systems. Since these systems are part of the local infrastructure, local government must take a more active role. Establishing runoff operation permits as part of a runoff utility funded program is an excellent way of providing an economic incentive to a land owner to properly maintain and operate an on-site management system.

4. Greater emphasis must be placed on erosion and sediment control for construction sites and utility installation projects. Assuring the regular inspection of erosion prevention and sediment control practices is a major deficiency. A training and certification program for inspectors and contractor supervisors, similar to the Certified Construction Reviewer Program in Delaware, is needed.

5. Retrofitting existing drainage systems to reduce their pollutant loading is one of the biggest, most difficult, and most expensive challenges the state has faced. The state must develop new runoff treatment techniques that are not land intensive and fund demonstration projects to research new techniques.

6. While Floridians are among the nation's most educated citizens in water resources and runoff management issues, they need more education to provide support for watershed management programs. The state's environmental education program should establish a comprehensive natural resources management curriculum, beginning in kindergarten and continuing through high school. Additionally, because of the large number of people—especially retirees—moving to Florida, citizens need continuous education programs about the vulnerability and importance of Florida's natural resources.

Delaware's Sediment Control and Runoff Management Program

Prior to submitting any proposed legislation regarding runoff management or sediment control, representatives of the Delaware Department of Natural Resources and Environmental Control (DNREC) conducted an extensive educational program to document the serious nature of statewide water quantity and quality problems. This educational program was successful in that elected officials, impacted industries, and the general public acknowledged the need for a comprehensive approach to sediment control and runoff management. Statewide legislation was unanimously approved in four legislative committees and on the floor of both the state senate and house of representatives, due somewhat to its support by local conservation districts. In addition, the regulations providing the program details were approved with the assistance of a regulatory advisory committee after an extensive process and a public hearing with no negative comments.

The program's basic premise is that sediment control during construction and postconstruction, runoff quantity, and water quality control are components of an overall runoff management program that functions from the time that construction begins through the project's lifespan. The initial emphasis of the program, which began on July 1, 1991, was to prevent existing flooding or water quality from worsening. The intent is to limit further degradation until more comprehensive watershed approaches, as detailed in the state legislation and regulations, are adopted.

Program Structure

The structure of the sediment and runoff management program is based on the premise that ultimate program responsibility must rest with the state. In Delaware, DNREC is responsible for program implementation and is the ultimate approval authority. A local conservation district or other agency, such as a public works department, may request delegation of various program components, depending on its ability to implement them.

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Four program components may be delegated:

- Sediment control and runoff management plan approval
- Inspection during construction
- Postconstruction inspection of permanent runoff facilities
- Education and training

Individual conservation districts receive preference for program components because of their historic involvement in conservation. Essential program components must be in place before any agency is awarded delegation. Delegation is awarded for a maximum of three years. During that time, the state formally reviews the program to determine whether to award delegation for another three years.

Before a local building or grading permit is issued, the sediment control and runoff management plan review and approval process must be completed. State regulations contain criteria for plan review and approval, and DNREC has developed or approved design aids and handbooks. The delegated local agency handles day-to-day inspection responsibilities. If projects do not comply with the plan, responsibility is transferred to the state, which carries out progressive aggressive enforcement. Enforcement options include civil and criminal penalties.

Control Practices

Site control practices are grouped into two categories—temporary practices during construction and permanent practices for postconstruction runoff. Sediment control practices designed for temporary site control must comply with the Delaware Erosion and Sediment Control Handbook. This handbook details numerous practices available, depending on their applicability. The plan review process ensures that the sediment control practices are appropriately located.

In addition to the traditional structural controls, several requirements in the handbook are important in providing overall site control. Sites must be stabilized if the disturbed areas are not actively worked for more than 14 days. To facilitate project phasing, no more than 20 acres may be disturbed at any one time. This provision can be modified for a specific type of project.

Water quality regulations require that 80 percent of suspended solids be removed. Permanent runoff management control requires a pond with a permanent pool of water. Wet ponds also have an extended detention requirement—the first inch of runoff to be released over a 24-hour period—in addition to controlling peak flows from larger storms. Ponds with a normal pool are preferred over either normally dry extended detention ponds or infiltration practices because they have documented performance records and can better reduce downstream nutrient loadings. If properly designed, wet ponds can also be a community amenity. Constructed wetlands are also considered a primary runoff treatment system in upland areas. However, Delaware does not encourage using existing natural wetlands for runoff treatment.

Another site control option is using infiltration practices. These practices are allowed but not encouraged because of their potential to clog and pollute groundwater. On sites that use infiltration practices, upslope and downslope impacts must be carefully considered during the plan review process. Because it has many benefits, runoff infiltration is a necessary component of a runoff management program. However, the design must include critical safeguards for filtering runoff to prevent groundwater pollution.

Runoff filtration must also be a program component, either as a single practice or combined with other practices, primarily infiltration. Common filtration generally consists of vegetative filtering over filter strips or through swale systems. On highly impervious sites, vegetative filters are often impossible. In these situations, a sand filter can provide initial water quality treatment. A number of sand filter design variations may be applicable from site to site, but the design must adhere to specific criteria for the system to effectively remove pollutants.

Unique Features

The Delaware program has a number of unique features compared to other state and local programs. The regulations require that, after development, runoff management practices must reduce the suspended solid load by 80 percent. Florida is the only other state to require a similar performance criteria. Delaware defined this reduction criteria after reviewing nationwide performance practice. While that performance level can be achieved with present technology application, long-term removal rates that exceed 80 percent may require extraordinary measures, such as water reuse. This measure could be required locally, but it is not practical statewide.

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The concept of delegating program components is fairly unusual. Delaware can delegate each aspect of program implementation, with DNREC acting as a safety net in case a conservation district or a local government fails to adequately implement its part of the program. The initial delegation concept was developed in Maryland to inspect sediment control. Delaware law and regulations expanded that concept to encompass all aspects of program implementation. The state interaction with local programs has quickly become a partnership, with the state providing technical expertise and educational training and the conservation districts and local governments managing the program.

The Delaware program is unique in its use of private inspectors. Land developers are required to provide inspections on projects over 50 acres or as required by the state or delegated inspection agency to assist the governmental inspection agency. Inspectors must attend and pass an inspection course, inspect active construction sites at least weekly, and submit a report of findings and recommendations to the developer/contractor and the inspection agency. Approximately 170 individuals had been approved as of March 1993. The inspection agency must still inspect the site periodically to ensure the adequacy of site controls, but private inspectors reduce the need for frequent oversight. If the private inspector fails to accurately record site conditions or notify the contractor/developer or inspection agency of deficiencies, the inspector's certification could be jeopardized and enforcement action taken against the contractor/developer.

Another increasingly popular requirement in state sediment control programs is that contractors must have one or more responsible individuals certified as having attended a sediment control and runoff management course. The four-hour Delaware course acquaints contractors with the importance of good site erosion and sediment control and runoff management and their legal responsibilities. The certification program is extremely popular with contractors and reduces the "we-they" problems of many regulatory programs. Over 2,000 individuals had been certified in Delaware as of December 1993.

Evolution

The next phase of the Delaware program addresses runoff management from a watershed perspective. The regulation's designated watershed concept, when coupled with land use planning, wetland restoration, and other nonstructural practices, reduces existing flooding problems and improves water quality. Under the concept, one watershed in each county is designated as a model. Various aspects of this watershed are studied, including hydrology, water quality, and stream habitat and diversity. The study also considers alternative land uses and runoff controls and their impact on water quality. From this watershed study, the state and local government recommend a watershed protection approach—a blueprint for future resource protection—in designated watersheds. As of 1993, one Delaware watershed had been designated for additional resource protection efforts.

To expand the initial program, funding must also be addressed. The Delaware law and regulations provide a framework to expand traditional mechanisms with more innovative funding. The regulations contain significant information on using runoff utilities (user fees) as an alternative to permit fees or general funding. The runoff utility complements the designated watershed concept as a way to fund watershed studies; plan, design, and implement practices; and maintain completed structures.

While maintaining commercial structures is not a significant problem, since one entity is generally responsible for overall site maintenance, the maintenance of residential structures has not been satisfactorily addressed. Residential maintenance is generally the responsibility of a community association; however, the responsibility must become public to ensure proper maintenance. Shifting that responsibility requires implementing a dedicated funding source, such as a runoff utility.

To ensure resource protection, the issue of land use and its relationship to water quantity and quality must evolve. Significant effort must be expended to educate local government officials about the importance of wetlands, open space, greenways, cluster development, and other options to conventional "cookie cutter" zoning. The designated watershed approach provides specific details on the benefits of alternative land use approaches and their impacts on water quality and aquatic resources.

An effective runoff management program must have a multifaceted approach and implementation. It must also dispel the erroneous assumption that total resource protection is achieved through structural controls implemented after the entire site has been developed.

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Land use limitations, dedicated open space, vegetated buffer areas, and reduced impervious areas are all components of an overall resource protection strategy—a structural control strategy alone will only reduce the rate of resource decline. Structural controls should be implemented as a first step, but continued evolution is vital to achieve true resource protection.

New Jersey's Runoff Management and Soil Erosion/Sediment Control

One of the most densely populated states, New Jersey has developed its runoff management and soil erosion/sediment control programs over several decades. These programs, which are some of the most comprehensive in the country, are the result of a continuing effort by the state government to address a range of flooding and other runoff problems. Due to the state's density, these problems have occurred earlier and with greater severity than in other less developed states. The programs' development has come mainly from in-state concerns and interests.

Programs are administered by the New Jersey Department of Environmental Protection (NJDEP), formerly the New Jersey Department of Environmental Protection and Energy. An active program of public education and information, which the NJDEP recognizes as key to developing a successful program, is included.

Much of New Jersey's dense development lies within a broad corridor between the New York City and Philadelphia metropolitan areas. Outside this corridor, particularly in the state's northwest and extreme southern portions, development levels are significantly less. Much undisturbed land remains. Other extensive areas are devoted to agriculture, the source of the state's designation as the Garden State. However, intensive development pressures are caused by the state's attempt to produce housing and jobs for a growing population.

New Jersey is composed of 567 municipalities—grouped into 21 counties—which exercise land use planning authority. This municipal authority has evolved gradually since World War II and was formalized in the 1975 Municipal Land Use Law (MLUL). This state law requires each municipality to develop a land use master plan to be implemented, in part, through its planning board and zoning board of adjustment. These two boards, following municipal zoning and land development ordinances, review and approve virtually all land development activity within the municipality. The MLUL requires that all municipal master plans be updated and readopted every six years. County governments also exercise some degree of approval authority over land development through state enabling legislation that predates the MLUL by some 20 years. This legislation grants counties the power to regulate proposed land development that affects county roads or drainage facilities.

In recent years, the state has attained some land use authority, either directly or through regional agencies created by the state legislature. These agencies include the Hackensack Meadowlands Development Commission in the northeast, the Pinelands commission in the southeast, and the Delaware and Raritan Canal Commission in central New Jersey. Other state laws, including the Coastal Area Facility Review Act (CAFRA), the Wetlands Act of 1970 (pertaining to coastal wetlands), the Waterfront Development Law, the Flood Hazard Area Control Act (described as follows), and the Freshwater Wetlands Protection Act have also allowed state government to regulate either the extent or details of land development along the coast and within floodplains, coastal and inland wetlands, and other environmentally sensitive areas.

Floodplain Management Programs

One of the earliest efforts by the state government to address runoff quantity problems was a 1929 law that prohibited the construction of any bridge, culvert, wall, building, or similar structure within "the natural and ordinary high water mark of any stream" without receiving prior state approval. By "preserving the channel and providing for the flow of waters," this legislation would "safeguard the public against danger from the waters impounded or affected by such structure." The state expanded its authority over the years by passing additional laws, including chapter 19, Public Law 1962, which authorized the state to delineate and otherwise identify floodplains and flood hazard areas to minimize flood damage through improper development. The state gained more authority in 1972 when it was empowered to regulate virtually all land development activity within the delineated floodways of streams and assist municipalities with similar efforts within contiguous flood fringe areas.

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The 1978 Flood Hazard Area Control Act granted further review authority to the state and municipalities, while also coordinating the state's floodplain management activities with those of the federal Flood Insurance Program. This law, applied through the state's Flood Hazard Area Regulations, requires strict environmental constraints regarding site discharges, ground disturbance, and loss of floodplain storage through the NJDEP's Stream Encroachment Permit process. A direct effect of the restrictions on filling floodplains is that natural stream corridors and even entire floodplains have been increasingly preserved. This preservation, further enhanced by the 1987 Freshwater Wetlands Protection Act, maintains flood storage capabilities, habitats, and other environmental benefits. The Stream Encroachment Permit process has given the NJDEP procedural and technical expertise in runoff regulations and, indirectly, is an effective public information and education program.

Soil Erosion and Sediment Control Programs

New Jersey's soil erosion and sediment control program has been in effect since the 1970s. The 1975 Soil Erosion and Sediment Control Act (c. 251, P.L. 1975) was based on the legislative finding that "sediment is a source of pollution and that soil erosion continues to be a serious problem throughout the state." The legislation also noted that "rapid shifts in land use from agricultural and rural to nonagricultural and urbanizing uses, construction of housing, industrial and commercial developments, and other land disturbing activities have accelerated the process of soil erosion and sediment deposition, resulting in pollution of the waters of the State and damage to domestic, agricultural, industrial, recreational, fish and wildlife, and other resource uses."

In response to these problems, the act required the state Soil Conservation Committee—a division of the New Jersey Department of Agriculture—and the state's 16 soil conservation districts (SCDs) to develop and implement a "statewide comprehensive and coordinated erosion and sediment control program to reduce the danger from stormwater runoff, to retard nonpoint pollution from sediment, and to conserve and protect the land, water, air and other environmental resources of the State." The program requires virtually all proposed land developments that disturb more than 5,000 sq ft (0.046 ha) of land to prepare and submit a Soil Erosion and Sediment Control Plan to the SCD for review and certification. Regulated land development activities include

- Any construction that requires a construction permit under the State's Uniform Construction Code (excluding the construction of a single residence not part of a larger subdivision);
- Demolition of one or more structures;
- Construction of a parking lot;
- Construction of a public facility;
- Operation of any mining or quarrying facility; and
- Clearing or grading land for other than agricultural or horticultural purposes.

The Soil Erosion and Sediment Control plans must be developed as required in the *Standards for Soil Erosion and Sediment Control in New Jersey*, a detailed technical manual published by the State Soil Conservation Committee (New Jersey Dep. Agric. 1987). Following certification of the plan, the SCD is further empowered to conduct necessary field inspections during site construction to ensure that all erosion and sediment control measures are properly installed and adequately maintained.

If the site fails to comply with the plan during construction, the SCD municipality can issue a stop-work order. After construction is complete, a certificate of occupancy can be withheld until the project achieves full compliance. Separate state legislation specifies that the "Attorney General, on his own initiative or the respective county counsel, with the approval of the [county] board of chosen freeholders, may provide any and all legal services to any district" (NJSA 4:24-17.7) The act also authorizes SCDs to "adopt a fee schedule and collect fees from applicants for the certification of plans and for on-site inspections of the execution of certified plans" provided that such fees "bear a reasonable relationship to the cost of rendering such services."

The soil erosion and sediment control program has been highly successful. The 20-year-old program has enabled New Jersey to fully comply with the NPDES requirements of the 1987 Clean Water Act pertaining to construction and mining activities with little if any modification. The program's success is due, in part, to the original enabling legislation, which established a highly effective regulatory threshold (i.e., 5,000 sq ft [0.046 ha] of disturbance). It also provided the local SCDs with sufficient technical support

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through the Soil Erosion and Sediment Control Standards, legal support through the stop-work order and certificate-of-occupancy authority, and financial support through the fee schedule authorization. Including construction inspection costs in the fee schedule has been particularly effective in insuring that necessary soil erosion and sediment control measures are properly installed and maintained.

Runoff Management Programs

While its development began more recently, New Jersey's program to address the quantitative and qualitative aspects of runoff has built upon the success of the state's earlier floodplain management and soil erosion/sediment control efforts. The program began with the 1981 Storm Water Management Act (c. 32, P.L. 1981). This act and subsequent regulations directed municipalities, counties, and the NJDEP to address runoff impacts in several ways.

The legislation requires the state's municipalities to develop comprehensive runoff management plans for new land development within their borders. Such plans are to be designed to

- Reduce artificially induced flood damage;
- Minimize increased runoff from any new land development where such runoff will increase flood damage;
- Maintain existing and proposed culverts, bridges, dams, and other structures;
- Induce water recharge, where practical, where natural storage and geologically favorable conditions exist;
- Prevent, to the greatest extent feasible, an increase in nonpoint source pollution that would otherwise degrade water quality and render it unfit for human consumption and detrimental to stream biota;
- Maintain the integrity of stream channels for their biological, drainage, and other functions;
- Reduce the impact of land development on stream erosion;
- Reduce soil erosion from construction sites; and
- Preserve and protect water supply facilities and other water resources.

This comprehensive plan is to be developed in two phases. The municipality should incorporate a Phase I Stormwater Management Plan into its overall land use master plan. It should be implemented through municipal ordinances applied to new land developments by the Planning Board and Zoning Board of Adjustment approval process according to the Municipal Land Use Law. A Phase I plan must be based, in part, on an assessment of the municipality's environmental, technical, and institutional needs and be consistent with existing county, regional, and state plans and requirements. It must address the runoff impacts of major developments within the municipality by requiring, with certain exceptions, that the following performance standards be met:

- **Runoff quantity.** Reduction of the peak 2, 10, and 100-year discharge rates from the site after development to predevelopment levels.
- **Runoff quality.** Extended detention of the runoff from either a 1.25 inch (3.175 cm)/2-hour or 1-year/24-hour storm event so that at least 10 percent of the total runoff volume from the site still remains in the extended detention basin after 18 hours for single family residential developments or 36 hours for all others.

According to the regulations, the following are considered to be major developments and, therefore, subject to the previously stated performance standards:

- Any site plan or subdivision that will ultimately create at least 1 acre (0.41 ha) of impervious surface.
- Feeding and holding areas for specified numbers of farm animals.
- Petroleum or chemical pipelines, storage, or distribution facilities.
- Solid waste storage, disposition, incineration, or landfill.
- Storage, distribution, or treatment of liquid or radioactive wastes.
- Quarries, mines, and borrow pits.
- Land application of sewage sludge effluents.

The NJDEP is currently developing technical revisions to the Phase I plan requirements, in part to better match current Clean Water and Coastal Zone Management Acts. Phase I plans

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address the runoff impacts of new or future developments. Under Phase II, both existing and future developments and impacts are to be addressed through "a detailed analysis of alternative stormwater management approaches on an integrated or regional basis. The plan will consist of a system of nonstructural and/or structural stormwater management programs to mitigate flooding and nonpoint source pollution." Unlike Phase I, Phase II plans are to be developed by counties and municipalities at their own discretion based on needs and resources. As of 1993, seven Phase II plans had been or were being completed by various counties and funded, in part, by grants from the NJDEP. Two additional Phase II plans have been developed cooperatively by the NJDEP and USDA SCS.

Another important aspect of the Storm Water Management Act regulations is the attention to runoff facility inspection and maintenance. According to the regulations, all municipal runoff management plans should provide for facility inspection and maintenance, either privately or publicly. In the case of private responsibility, the plans must provide the means for public agencies to perform emergency maintenance in case the owner defaults or chronically neglects the site. To help municipalities address inspection and maintenance, the NJDEP prepared and published the *Stormwater Management Facilities Maintenance Manual* (1989). This manual, as previously discussed, was developed as part of a demonstration study with Ocean County, New Jersey, and contains detailed information on ownership, planning and design, regulatory, and financial aspects of runoff management facility maintenance.

In addition, the NJDEP and the New Jersey Department of Agriculture are publishing a new best management practices manual for stormwater management and nonpoint source pollution control (in prep.). This manual provides more comprehensive guidance than has been practiced statewide in the past. The manual is based on the importance of addressing stormwater and nonpoint source control at the start of the land development process to develop the most effective and efficient solutions. The manual stresses integrating preventative practices—such as land use planning, density controls, innovative site design, pollutant source controls, and waste minimization—with more traditional structural measures in a systems approach. In addition, the manual emphasizes the need for this integrated management system to be applied on a regional or watershed basis, and not merely site by site.

The NJDEP is also developing a stormwater management and nonpoint source guidance document for local governments. It is intended to introduce citizens and local officials to the scientific, technical, and legal aspects of stormwater, nonpoint source, and sediment control to increase their knowledge and ability to develop more effective local programs.

In recent years, the NJDEP has expanded the scope of the state's programs in response to internal concerns, citizen interest, and federal laws and regulations. In particular, the state developed the Industrial Stormwater Permitting Program to address the permitting requirements for such activities in the 1987 Clean Water Act. At the present time, a general stormwater discharge permit is available to eligible industries in addition to individual permits.

In August 1988, the New Jersey legislature adopted the Sewage Infrastructure Improvement Act (NJSA 58:25-23, et seq.), an initiative designed to further address stormwater and nonpoint source pollution problems. The act provides the means for municipalities and other public entities to survey, locate, and eliminate sources of pollutants entering storm sewers, waterways, and waterbodies. Under the act, 94 municipalities in four counties along and near the Atlantic coast are required to map their stormwater and sanitary sewer systems, locate and correct any interconnections, perform quarterly monitoring of outfalls to saltwater bodies, and abate nonpoint source pollution. Approximately $10 million has been allocated by the legislature to assist municipalities in meeting the act's goals.

Finally, the NJDEP has undertaken numerous demonstration and public outreach projects throughout the state, primarily through the Clean Water Act's section 319 program. These projects include the following:

- Barnegat Bay Watershed Management Plan
- New Jersey Water Watch Program
- Musconetcong Watershed Nonpoint Source Demonstration Project
- Barnegat Bay Watershed Intensive Monitoring Project
- Whippany River Watershed Management Plan
- Clean Water Information Series

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New Jersey Department of Agriculture, 1987. Standards for Soil Erosion and Sediment Control in New Jersey. State Soil Conserv. Comm., Trenton, NJ.

New Jersey Departments of Environmental Protection and Agriculture. In prep. Stormwater and Nonpoint Source Pollution Control Best Management Practices, Trenton, NJ.

New Jersey Department of Environmental Protection and Energy. 1989. Stormwater Management Facilities Maintenance Manual. Trenton, NJ.

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PART III

APPENDIXES

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APPENDIX A

Delaware's Erosion and Sedimentation Control and Stormwater Management Law

Chapter 40, Title 7, Delaware Code

§4001. LEGISLATIVE FINDINGS AND STATEMENT OF POLICY

(a) Legislative Findings. The General Assembly finds that erosion and sedimentation continue to present serious problems throughout the State, and that the removal of a stable ground cover in conjunction with the decrease in the infiltration capability of soils resulting from the creation of additional impervious areas such as roads and parking lots has accelerated the process of soil erosion and sediment deposition resulting in pollution of the waters of the State. This loss damages domestic, agricultural, industrial, recreational, fish and wildlife and other resource uses. The General Assembly further finds that accelerated stormwater runoff increases flood flows and velocities, contributes to erosion, sedimentation, and degradation of water quality, overtaxes the carrying capacity of streams and storm sewers, greatly increases the costs of public facilities in carrying and controlling stormwater, undermines flood plain management and flood control efforts in downstream communities, reduces groundwater recharge, and threatens public health, welfare, and safety.

(b) Statement of Policy. In consideration of these legislative findings, it is declared to be the policy of this Chapter to strengthen and extend the present erosion and sediment control activities and programs of this State for both rural and urban lands and to provide for the control and management of stormwater runoff consistent with sound water and land use practices. These activities will reduce to the extent possible any adverse effects of stormwater runoff on the water and lands of the State. This policy, to be carried out by establishing and implementing through the Department of Natural Resources and Environmental Control, hereinafter referred to as the "Department," in cooperation with conservation districts, counties, municipalities and other local governments and subdivisions of this State, and other public and private entities, a statewide comprehensive and coordinated erosion and sediment control and stormwater management program to conserve and protect land, water, air and other resources of the State. This program shall be consistent with, and coordinated with other environmental programs implemented by the Department such as wetlands protection and groundwater protection.

§4002. DEFINITIONS

The following words, terms and phrases, when used in this Chapter, shall have the meaning ascribed to them in this Section, except where the context clearly indicates a different meaning:

(1) "Certified Construction Reviewer" means an individual who has passed a departmental sponsored or approved training course and who provides on-site construction review for sediment control and stormwater management in accordance with regulations promulgated under this Chapter.

(2) "Designated Watershed or Subwatershed" means a watershed or subwatershed proposed by a conservation district, county, municipality, or State agency and approved by

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the Department. The Department may establish additional requirements due to existing water quantity or water quality problems. These requirements shall be implemented on an overall watershed or subwatershed master plan developed for water quality and/or water quantity protection.

(3) "Land Disturbing Activity" means any land change or construction activity for residential, commercial, silvicultural, industrial, and institutional land use which may result in soil erosion from water or wind or movement of sediments or pollutants into State waters or onto lands in the State, or which may result in accelerated stormwater runoff, including, but not limited to, clearing, grading, excavating, transporting and filling of land.

(4) "Person" means any State or federal agency, individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission board, public or private institution, utility, cooperative, municipality or other political subdivision of this State, any interstate body, or any other legal entity.

(5) "Responsible Personnel" means any foreman or superintendent who is in charge of on-site clearing and land disturbing activities for sediment and stormwater control associated with a construction project.

(6) "Sediment and Stormwater Management Plan" or "plan" means a plan for the control of soil erosion, sedimentation, stormwater quantity, and water quality impacts which may result from any land disturbing activity.

(7) "State Waters" means any and all waters, public or private, on the surface of the earth which are contained within, flow through or border upon the State of Delaware or any portion thereof.

(8) "Stormwater" means the runoff of water from the surface of the land resulting from any form of precipitation and including snow or ice melt.

(9) "Stormwater Management" means:

(a) for water quantity control, a system of vegetative, structural, and other measures that controls the volume and rate of stormwater runoff which may be caused by land disturbing activities or activities upon the land; and

(b) for water quality control, a system of vegetative, structural and other measures that controls adverse effects on water quality that may be caused by land disturbing activities or activities upon the land.

(10) "Stormwater Utility" means the establishment of an administrative organization that has been created for the purposes of funding sediment control, stormwater management or flood control planning, design, construction, maintenance, and overall resource needs by authorized and imposed charges.

§4003. DUTIES OF PERSONS ENGAGED IN LAND DISTURBING ACTIVITIES

(a) After July 1, 1991, unless exempted, no person shall engage in land disturbing activities without submitting a sediment and stormwater management plan to the appropriate plan approval authority and obtaining a permit to proceed.

(b) Projects which do not alter stormwater runoff characteristics may be required to provide water quality enhancement even if the predevelopment runoff characteristics are unchanged. Criteria will be detailed in the regulations regarding level of water quality control and variance procedures.

(c) Each land developer shall certify, on the sediment and stormwater management plan submitted for approval, that all land clearing, construction, development, and drainage will be done according to the approved plan.

(d) All approved land disturbing activities shall have associated therein at least one individual who functions as responsible personnel.

§4004. APPLICABILITY

(a) The provisions of this Chapter shall not apply to agricultural land management practices unless the conservation district or the Department determines that the land requires a new or updated soil and water conservation plan, and the owner or operator of the land has refused either to apply to a conservation district for the development of such a plan, or to implement a plan developed by a conservation district.

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(b) Unless a waiver is granted the construction of agricultural structures such as broiler houses, machine sheds, repair shops, and other major buildings shall require approval of a sediment and stormwater management plan, by the appropriate plan approval agency, prior to the initiation of construction.

(c) Utility projects that disturb less than 5,000 square feet are not subject to the provisions of this Chapter.

§4005. PROGRAM FUNDING AND FINANCIAL ASSISTANCE

(a) The Department, conservation districts, counties, or municipalities are authorized to receive from federal, State, or other public or private sources financial, technical or other assistance for use in accomplishing the purposes of this Chapter. The Department may allocate, as necessary or desirable, any funds received to conservation districts, counties, or municipalities for the purpose of effectuating this Chapter.

(b) The conservation districts, counties, and municipalities shall have authority to adopt a fee system to help fund program implementation. That fee system shall be implemented by the designated plan approval agency to fund overall program management, plan review, construction review, enforcement needs, and maintenance responsibilities. In those situations where the Department becomes the designated plan approval agency, the Department may assess a plan review and inspection fee. That fee shall not exceed $80.00 per disturbed acre per project. There shall be no duplication of fees by the various implementing agencies for an individual land disturbing activity and the fee schedule shall be based upon the costs to the Department, conservation districts, counties, or municipalities to implement and administer the program.

(c) Authority is also granted to the Department, conservation districts, counties or municipalities to establish a stormwater utility as an alternative to total funding under the fee system. The stormwater utility shall be developed for the designated watersheds and may fund such activities as long range watershed master planning, watershed retrofitting, and facility maintenance. This fee system shall be reasonable and equitable so that each contributor of runoff to the system, including State agencies, shall pay to the extent to which runoff is contributed. Criteria for the implementation of the stormwater utility shall be established in regulations promulgated under this Chapter. The implementation of a stormwater utility will necessitate the development of a local utility ordinance prior to its implementation.

§4006. STATE MANAGEMENT PROGRAM

(a) The Department shall, in cooperation with appropriate State and federal agencies, conservation districts, other governmental subdivisions of the State, and the regulated community develop a State Stormwater Management Program. This program shall take into consideration both quantity and quality of water, and shall be integrated with, and made a part of the amended State Erosion and Sediment Control Program to create a Sediment and Stormwater Program.

(b) In carrying out this Act, the Department shall have the authority to

(1) Provide technical and other assistance to districts, counties, municipalities, and State agencies in implementing this Chapter;

(2) Develop and publish, as regulation components, minimum standards, guidelines and criteria for delegation of sediment and stormwater program components, and model sediment and stormwater ordinances for use by districts, counties, and municipalities;

(3) Review the implementation of all components of the statewide sediment and stormwater program that have been delegated to either the conservation districts, counties, municipalities, or other State agencies in reviews to be accomplished at least once every three (3) years;

(4) Require that appropriate sediment and stormwater management provisions be included in all new erosion and sediment control plans developed pursuant to this Chapter;

(5) Cooperate with appropriate agencies of the United States or other states or any interstate agency with respect to sediment control and stormwater management;

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(6) Conduct studies and research regarding the causes, effects and hazards of stormwater and methods to control stormwater runoff;

(7) Conduct and supervise educational programs with respect to sediment control and stormwater management;

(8) Require the submission to the Department of records and periodic reports by conservation districts, tax ditch organizations, county and municipal agencies as may be necessary to carry out this Act;

(9) Review and approve designated watersheds for the purpose of this Act;

(10) Establish a maximum life of three years for the validation of approved plans. The regulations shall specify variances which expand this time limitation in specific situations; and

(11) Establish a means of communication, such as a newsletter, so that information regarding program development and implementation can be distributed to interested individuals.

(c) The Department shall develop such regulations in conjunction with and with substantial concurrence of a regulatory advisory committee, appointed by the Secretary, which shall include representatives of the regulated community and others affected by this Act. The recommendations of this committee shall be presented at all public workshops and hearings related to the adoption of the regulations implementing this Act. Prior to final promulgation of regulations under this Act, the Secretary shall explain, in writing, any differences between the advisory committee recommendations and the final regulations. The regulations may include, but are not limited to, the following items:

(1) Criteria for the delegation of program elements;

(2) Types of activities that require a sediment and stormwater management permit;

(3) Waivers, exemptions, and variances;

(4) Sediment and stormwater plan approval fees and performance bonds;

(5) Criteria for distribution of funds collected by sediment and stormwater plan approval fees;

(6) Criteria for implementation of a stormwater runoff utility;

(7) Specific design criteria and minimum standards and specifications;

(8) Permit application and approval requirements;

(9) Criteria for approval of designated watersheds;

(10) Criteria regarding attendance and completion of departmental sponsored or approved training courses in sediment and stormwater control that will be required of certified construction reviewers and responsible personnel;

(11) Construction review; and

(12) Maintenance requirements for sediment control during construction and stormwater management structures after construction is completed.

(d) The Department may adopt, amend, modify, or repeal rules or regulations after public hearing to effectuate the policy and purposes of this Chapter. The conduct of all hearings conducted pursuant to this Chapter and the promulgation process shall be in accordance with the relevant provisions of Chapter 60 of this Title.

§4007. LOCAL SEDIMENT AND STORMWATER PROGRAMS

(a) Pursuant to regulations promulgated by the Department, each conservation district, county, municipality, or State agency may adopt, and submit to the Department for approval, one or more components of a sediment and stormwater program for the area within its jurisdiction.

(b) Requests for delegation of program elements shall be submitted within six months of the promulgation of State regulations, and by January 1 of subsequent years if delegation is desired at a future date. The Secretary shall grant or deny such a request on or before April 1 of the year for which delegation is sought.

(c) Delegation, once applied for, shall become effective on July 1 and shall not exceed three (3) years, at which time delegation renewal is required.

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(d) A district, county, municipality, or State agency may develop the program in cooperation with any other governmental subdivisions.

(e) Initial consideration regarding delegation of program elements shall be given to the conservation districts, since the conservation districts, having unique capabilities and areawide responsibilities, are in an ideal position to coordinate and implement local sediment and stormwater programs.

§4008. INTERIM PROGRAM

(a) Prior to July 1, 1991, requirements for sediment control shall be as provided in existing erosion and sediment control regulations promulgated September 26, 1980. Also, until July 1, 1991, any State or locally developed regulation or criterion for stormwater management shall remain in effect at the discretion of the implementing authority.

(b) Projects approved prior to July 1, 1991, but which are under construction after July 1, 1991, shall be subject to the penalty provisions contained in Section 4015 of this Chapter.

§4009. FAILURE OF CONSERVATION DISTRICTS, COUNTIES, MUNICIPALITIES, OR STATE AGENCIES TO IMPLEMENT DELEGATED PROGRAM ELEMENTS

(a) If, at any time, the Department finds that a conservation district, county, municipality, or State agency has failed to implement program elements that the Department has delegated, the Department shall provide written notice of violation to the conservation district, county, municipality or State agency.

(b) Within 60 days of receipt of the notice of violation, the conservation district, county, municipality or State agency shall report to the Department the action which it has taken to comply with the requirements set forth in the violation notice.

(c) If after 120 days of receipt of the notice of violation, the conservation district, county, municipality, or State agency has failed to comply satisfactorily with the requirements set forth in the notice of violation, the Department may suspend or revoke the delegated authority.

(d) If at any time, a program element delegation is being considered for suspension or revocation, an opportunity for a hearing before the Secretary or his designee shall be provided prior to such suspension or revocation.

§4010. STATE AND FEDERAL PROJECTS

After July 1, 1991, a State or federal agency may not undertake any land clearing, soil movement, or construction activity unless the agency has submitted a sediment and stormwater management plan to the Department and received its approval. The only variation to this requirement shall be when delegation of the plan approval process has been granted by the Department to a specific State or federal agency.

§4011. DESIGNATED WATERSHEDS OR SUBWATERSHEDS

(a) Watersheds or subwatersheds approved as designated watersheds or subwatersheds by the Department shall have the regulatory requirements clearly specified through a watershed approach to nonpoint pollution control or flood control. The watershed approach shall result in a specific plan, developed or approved by the Department, for the designated watershed or subwatershed that contains the following information:

(1) Stormwater quantity or quality problem identification;

(2) The overall needs of the watershed, not just the additional impacts of new development activities;

(3) Alternative approaches to address the existing and future problems;

(4) A defined approach which includes the overall costs and benefits;

(5) A schedule for implementation;

(6) Funding sources and amounts; and

(7) A public hearing process prior to Departmental approval.

(b) Upon approval of the designated watershed or subwatershed plan, all projects undertaken in that watershed or subwatershed shall have

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stormwater requirements placed upon them that are consistent with the designated watershed or subwatershed plan.

§4012. CONSTRUCTION REVIEW AND ENFORCEMENT

(a) With respect to approved sediment and stormwater plans, the agency responsible for construction review during and after construction completion shall ensure that periodic reviews are undertaken, implementation is accomplished in accordance with the approved plans, and the required measures are functioning in an effective manner. Notice of such right of construction review shall be included in the sediment and stormwater management plan certification. The agency responsible for construction review may, in addition to local enforcement options, refer a site violation to the Department for additional action.

(b) Referral of a site violation to the Department may initiate a departmental construction review of the site to verify site conditions. That construction review may result in the following actions:

(1) Notification through appropriate means to the person engaged in a land disturbing activity and the contractor to comply with the approved plan within a specified time frame.

(2) Notification of plan inadequacy, with a time frame for the person engaged in a land disturbing activity to submit a revised sediment and stormwater plan to the appropriate plan approval agency and to receive its approval with respect thereto.

(c) Failure of the person engaged in the land disturbing activity or the contractor to comply with departmental requirements may result in the following actions in addition to other penalties as provided in this Chapter.

(1) The Department shall have the power to issue a cease and desist order to any person violating any provision of this Chapter by ordering such person to cease and desist from any site work activity other than those actions necessary to achieve compliance with any administrative order.

(2) The Department may request that the appropriate plan approval agency refrain from issuing any further building or grading permits to the person having outstanding violations until those violations have been remedied.

§4013. APPROVAL OF CERTIFIED CONSTRUCTION REVIEWERS

(a) Based on criteria established by the Department through regulation and any additional criteria established by the agency implementing the plan review and construction elements of the sediment and stormwater program, the person engaged in a land disturbing activity may be required to provide for construction review by a certified construction reviewer.

(b) Individuals functioning as certified construction reviewers must attend and pass a departmental sponsored or approved construction review training course. The Department will establish, through regulation, the length of time for which the certification will last and procedures for renewal. The construction reviewers shall also function under the direction of a registered professional engineer licensed to practice engineering in the State of Delaware.

(c) The responsibility of the certified construction reviewer will be to ensure the adequacy of construction pursuant to the approved sediment and stormwater management plan.

(d) The certified construction reviewer shall be responsible for the following items:

(1) Provision of a construction review of active construction sites on at least a weekly basis, as determined on a case-by-case basis by the plan review and construction review agencies, or as required by regulations promulgated pursuant to this Chapter;

(2) Within five calendar days, informing the person engaged in the land disturbing activity, and the contractor, by a written construction review report of any violations of the approved plan or inadequacies of the plan. The plan approval agency shall be informed, if the approved plan is inadequate, within five working days. In addition, the appropriate construction review agency shall receive

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copies of all construction review reports; and

(3) Referral of the project to the Department for appropriate enforcement action if the person engaged in the land disturbing activity fails to address the items contained in the written construction review report. Verbal notice shall be made to the Department within two working days and written notice shall be provided to the Department within five working days.

(e) If the Secretary or his designee determines that a certified construction reviewer is not providing adequate site control or is not referring problem situations to the Department, the Secretary or his designee may suspend or revoke the certification of the construction reviewer.

(f) In any situation where a certified construction reviewer's approval is being suspended or revoked, an opportunity for hearing before the Secretary or his designee shall be provided. During any suspension or revocation, the certified construction reviewer shall not be allowed to provide construction reviews pursuant to this Chapter.

(g) The failure to assign a Departmental approved certified construction reviewer to a land disturbing activity, when required by the approved plan, will place that project in violation of this Chapter and result in appropriate administrative and/or enforcement action.

§4014. TRAINING OF RESPONSIBLE PERSONNEL

After July 1, 1991, any applicant seeking sediment and stormwater plan approval shall certify to the appropriate approval agency that all responsible personnel involved in the construction project will have a certificate of attendance at a departmentally sponsored or approved training course for the control of sediment and stormwater before initiation of any land disturbing activity. The certificate of attendance shall be valid until the Department notifies the individual or announces in local newspapers that recertification is required due to a change in course content.

§4015. PENALTIES

(a) Any person who violates any rule, regulation, order, condition imposed in an approved plan or other provision of this Chapter shall be fined not less than $200 or more than $2,000 for each offense. Each day that the violation continues shall constitute a separate offense. The Justice of the Peace Courts shall have jurisdiction of offenses brought under this subsection.

(b) Any person who intentionally, knowingly, and after written notice to comply, violates or refuses to comply with any notice issued pursuant to Section 4013(2) of this Chapter shall be fined not less than $500 or more than $10,000 for each offense. Each day the violation continues shall constitute a separate offense. The Superior Court shall have jurisdiction of offenses brought under this subsection.

§4016. INJUNCTIONS

The Court of Chancery shall have jurisdiction to enjoin violations of this Chapter. The appropriate program element authority, the Department, or any aggrieved person who suffers damage or is likely to suffer damage because of a violation or threatened violation of this Chapter may apply to the Chancery Court for injunctive relief. Among any other appropriate forms of relief, the Chancery Court may direct the violator to restore the affected land or water impacted area to its original condition.

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APPENDIX B

Delaware Sediment and Stormwater Regulations

Department of Natural Resources and Environmental Control
Effective Date January 23, 1991 — Amended March 11, 1993

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Section 1 — Scope

1. Stormwater runoff may reasonably be expected to be a source of pollution to waters of the State, and may add to existing flooding problems. The implementation of a statewide sediment and stormwater program will prevent existing water quantity and water quality problems from becoming worse, and in some cases, reduce existing problems.

2. Sediment and stormwater approvals are required for land changes or construction activities for residential, commercial, silvicultural, industrial, or institutional land use which are not exempted or waived by these Regulations. Requirements under these Regulations do not apply to agricultural land management practices unless the Conservation District or the Department determines that the land requires a soil and water conservation plan, and the owner or operator of the land has refused either to apply to a Conservation District for the development of such a plan, or to implement a plan developed by a Conservation District.

3. The Department intends that, to the extent possible, the provisions of these Regulations be delegated to either the Conservation Districts, local governments, or other State agencies. Those program provisions which are subject to delegation include sediment and stormwater management plan approval, inspection during construction, post-construction inspection, and education and training. Initial consideration regarding delegation of program components shall be given to the Conservation Districts.

4. The implementation of a stormwater utility represents a comprehensive approach to program funding and implementation. The activities which may be undertaken by a stormwater utility include not only assessment, collection, and funding activities, but also carrying out provisions of adopted stormwater management plans. These provisions may include contracting for such services as project construction, project maintenance, project inspection, and enforcement of installation and maintenance requirements imposed with respect to approved land disturbing activities.

Section 2 — Definitions

As used in these regulations, the following terms shall have the meanings indicated below:

1. "Adverse Impact" means a negative impact to land or waters resulting from a construction or development activity. The negative impact includes increased risk of flooding; degradation of water quality; increased sedimentation; reduced groundwater recharge; negative impacts on aquatic organisms; negative impacts on wildlife and other resources, and threatened public health.

2. "Agricultural Land Management Practices" means those methods and procedures generally accepted by the Conservation Districts and used in the cultivation of land in order to further crop and livestock production and conservation of related soil and water resources.

3. "Applicant" means a person, firm, or governmental agency who executes the necessary forms to obtain approval or a permit for a land disturbing activity.

4. "Appropriate Plan Approval Agency" means the Department, Conservation District, county, municipality, or State agency that is responsible in a jurisdiction for review and approval of sediment and stormwater management plans.

5. "As-Built Plans or Record Documents" means a set of engineering or site drawings that delineate the specific permitted stormwater management facility as actually constructed.

6. "Certified Construction Reviewer" means those individuals, having passed a Departmental sponsored or approved training course, who provide on-site inspection for sediment control and stormwater management in accordance with these regulations.

7. "Delegation" means the acceptance of responsibility by a Conservation District, county, municipality, or State agency for the implementation of one or more elements of the statewide sediment and stormwater management program.

8. "Department" means the Department of Natural Resources and Environmental Control.

9. "Designated Watershed or Subwatershed" means a watershed or subwatershed proposed by a Conservation District, county, municipality, or State agency and approved by the Department. The Department may establish additional requirements in these watersheds and subwatersheds due to existing

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water quantity or water quality problems. These requirements shall be implemented on an overall watershed or subwatershed master plan that is developed for water quality and/or water quantity protection.

10. "Detention Structure" means a permanent stormwater management structure whose primary purpose is to temporarily store stormwater runoff and release the stored runoff at controlled rates.

11. "Develop Land" means to change the runoff characteristics of a parcel of land in conjunction with residential, commercial, industrial, or institutional construction or alteration.

12. "Developer" means a person undertaking, or for whose benefit, activities covered by these regulations are commenced and/or carried out.

13. "Drainage Area" means that area contributing runoff to a single point measured in a horizontal plane, which is enclosed by a ridge line.

14. "Easement" means a grant or reservation by the owner of land for the use of such land by others for a specific purpose or purposes, and which must be included in the conveyance of land affected by such easement.

15. "Erosion and Sediment Control" means the control of solid material, both mineral and organic, during a land disturbing activity, to prevent its transport out of the disturbed area by means of air, water, gravity, or ice.

16. "Exemption" means those land development activities that are not subject to the sediment and stormwater requirements contained in these regulations.

17. "Grading" means excavating, filling (including hydraulic fill) or stockpiling of earth materials, or any combination thereof, including the land in its excavated or filled condition.

18. "Infiltration" means the passage or movement of water through the soil profile.

19. "Land Disturbing Activity" means a land change or construction activity for residential, commercial, silvicultural, industrial, and institutional land use that can result in soil erosion from water or wind or movement of sediments or pollutants into State waters or onto lands in the State, or in accelerated stormwater runoff. These activities include but are not limited to clearing, grading, excavating, transporting and filling of land.

20. "Off-site Stormwater Management" means the design and construction of a stormwater management facility that is necessary to control stormwater from more than one land disturbing activity.

21. "On-site Stormwater Management" means the design and construction of stormwater management practices that are required for a specific land disturbing activity.

22. "Person" means any State or federal agency, individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, utility, cooperative, municipality or other political subdivision of this State, any interstate body or any other legal entity.

23. "Redevelopment" means a land disturbance activity that alters the use of land but does not necessarily alter the predevelopment runoff characteristics.

24. "Responsible Personnel" means a foreman or superintendent who is in charge of on-site clearing and land disturbing activities for sediment and stormwater control associated with a construction project.

25. "Sediment" means soils or other superficial materials transported and/or deposited by the action of wind, water, ice or gravity as a product of erosion.

26. "Sediment and Stormwater Management Plan" means a plan for the control of soil erosion, sedimentation, stormwater quantity, and water quality impacts resulting from any land disturbing activity.

27. "Stabilization" means the prevention of soil erosion by surface runoff or wind through the establishment of a soil cover through the implementation of vegetative or structural measures. Examples include, but are not limited to, straw mulch with temporary or permanent vegetation, wood chips, and stone or gravel ground cover.

28. "State Waters" means any and all waters, public or private, on the surface of the earth which are contained within, flow through or border upon the State or any portion thereof.

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28. "Stormwater" means the runoff of water from the surface of the land resulting from precipitation or snow or ice melt.

29. "Stormwater Management" means:

    A. for water quantity control, a system of vegetative, structural, and other measures that may control the volume and rate of stormwater runoff which may be caused by land disturbing activities or activities upon the land; and

    B. for water quality control, a system of vegetative, structural, and other measures that control adverse effects on water quality that may be caused by land disturbing activities or activities upon the land.

30. "Stormwater Utility" means an administrative organization that has been established for the purposes of funding sediment control, stormwater management or flood control planning, design, construction, maintenance, and overall resource needs by authorized and imposed charges.

31. "Tidewater" means water that alternately rises and falls due to the gravitational attraction of the moon and sun and is under the regulatory authority of Delaware Code, Title 7, Chapter 72. Examples of tidewaters include the Atlantic Ocean, the Delaware Bay, and the Delaware Inland Bays.

32. "Variance" means the modification of the minimum sediment and stormwater management requirements for specific circumstances where strict adherence of the requirements would result in unnecessary hardship and not fulfill the intent of these regulations.

33. "Waiver" means the relinquishment from sediment and stormwater management requirements by the appropriate plan approval authority for a specific development on a case-by-case review basis.

34. "Water Quality" means those characteristics of stormwater runoff from a land disturbing activity that relate to the chemical, physical, biological, or radiological integrity of water.

35. "Water Quantity" means those characteristics of stormwater runoff that relate to the rate and volume of the stormwater runoff to downstream areas resulting from land disturbing activities.

36. "Watershed" means the total or partial drainage area contributing stormwater runoff to a single point.

Section 3 — Exemptions, Waivers, and Variances

1. The following activities are exempt from both sediment control and stormwater management requirements established by these regulations:

    A. Agricultural land management practices, unless the local Conservation District or the Department determines that the land requires a new or updated soil and water conservation plan, and the owner or operator of the land has refused either to apply to a Conservation District for the development of such a plan, or to implement a plan developed by a Conservation District;

    B. Developments or construction that disturb less than 5,000 square feet;

    C. Land development activities which are regulated under specific State or federal laws which provide for managing sediment control and stormwater runoff. An example of this exemption would be specific permits required under the National Pollutant Discharge Elimination System when discharges are a combination of stormwater and industrial or domestic wastewater or which must comply with Parts 122, 123, and 124 of Title 40 of the Code of Federal Regulations. The Department shall ensure that all land developments which are regulated under specific State or federal laws are coordinated with delegated plan approval agencies to ensure compatibility of requirements;

    D. Projects that are emergency in nature and necessary to protect life or property such as bridge, culvert, or pipe repairs and aboveground or underground electric and gas utilities or public utility restoration. The emergency nature of a project may preclude prior plan review and approval, but subsequent inspection may necessitate sediment control or site stabilization in accordance with the provisions of this Chapter. The appropriate plan approval agency shall be notified orally

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or in writing within 48 hours of the initiation of such emergency activity.

The appropriate plan approval agency shall determine and approve of the emergency nature of a project. If the nature of the emergency will require more than 120 days to accomplish construction, formal approval shall be obtained for sediment control and stormwater management. These activities must still comply with other State, federal, and local requirements.

2. Appropriate Plan Approval Agencies may grant waivers from the stormwater management requirements of these regulations for individual developments provided that a written request is submitted by the applicant containing descriptions, drawings, and any other information that is necessary to evaluate the proposed development. A separate written waiver request shall be required if there are subsequent additions, extensions, or modifications that would alter the approved stormwater runoff characteristics to a development receiving a waiver.

   A. A project may be eligible for a waiver of stormwater management for both quantitative and qualitative control if the applicant can demonstrate that

      (1) The proposed project will return the disturbed area to a predevelopment runoff condition and the predevelopment land use is unchanged at the conclusion of the project; or

      (2) The proposed project consists of a linear disturbance of less than six (6) feet in width; or

      (3) The project is for an individual residential detached unit or agricultural structure, and the total disturbed area of the site is less than one acre; or

      (4) The proposed project is for agricultural structures in locations included in current soil and water conservation plans that have been approved by the appropriate Conservation District.

   B. A project may be eligible for a waiver or variance of stormwater management for water quantity control if the applicant can demonstrate that

      (1) The proposed project will not generate an increase in the 2-year post-development peak discharge rate of more than ten (10) percent above the 2-year predevelopment peak discharge rate and will have no adverse impact on the receiving wetland, watercourse, or waterway; or

      (2) Provisions will be made or exist for a nonerosive conveyance system to tidewater by either a closed drainage system or by open channel flow that has adequate capacity to contain the runoff events being considered as a requirement of these regulations; or

      (3) The location of a project within a watershed would aggravate downstream flooding by the imposition of peak control requirements.

      (4) The plan approval agency may grant a written variance from any requirement of these regulations if there are exceptional circumstances applicable to the site such that strict adherence to the provisions of these regulations will result in unnecessary hardship and not fulfill the intent of these regulations. A written request for variance shall be provided to the plan approval agency and shall state the specific variances sought and the reasons for their granting. The plan approval agency shall not grant a variance unless and until sufficient specific reasons justifying the variance are provided by the applicant.

Section 4 — Departmental Responsibilities

1. The Department is responsible for the implementation and supervision of the sediment and stormwater program established by Chapter 40, Title 7, Delaware Code. This responsibility shall include, but not be limited to, authority for the following actions:

   A. Provide technical and other assistance to Conservation Districts, counties, municipalities, federal, and State agencies in implementing this Chapter;

   B. Develop and publish, as regulation components, minimum standards, guidelines and criteria for delegation of sediment

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and stormwater program components, and model sediment and stormwater ordinances for use by Conservation Districts, counties, State agencies, and municipalities;

C. Review the implementation of all components of the statewide sediment and stormwater management program that have been delegated to either the Conservation Districts, counties, municipalities, or other State agencies in reviews to be accomplished at least once every three years;

D. Require that appropriate sediment and stormwater management provisions be included in all new erosion and sediment control plans developed pursuant to these regulations;

E. Cooperate with appropriate agencies of the United States or other states or any interstate agency with respect to sediment control and stormwater management;

F. Conduct studies and research regarding the causes, effects, and hazards of stormwater and methods to control stormwater runoff;

G. Conduct and supervise educational programs with respect to sediment control and stormwater management;

H. Require the submission to the Department of records and periodic reports by Conservation Districts, tax ditch organizations, county, and municipal agencies as may be necessary to carry out these regulations;

I. Review and approve designated watersheds;

J. Establish a maximum life of three years for the validation of approved plans. These regulations shall specify variances which expand this time limitation in specific situations; and

K. Establish a means of communication, such as a newsletter, so that information regarding program development and implementation can be distributed to interested individuals.

2. Matters of policy, procedures, standards, criteria, approvals, inspection, or enforcement relating to the Sediment and Stormwater Chapter shall be established by the Department subject to the jurisdiction of the Secretary of the Department. Sediment and stormwater programs or portions of programs which are delegated to the Conservation Districts, counties, municipalities, or State agencies shall include sediment and stormwater criteria consistent with the standards, procedures, and regulations of the Department.

   A variation of requirements by the delegated agency on a specific watershed will not be valid unless approved by the Department. All State and federal development in the watershed shall be reviewed subject to the same variations and requirements by the delegated State agency or Department as appropriate.

3. In situations where public notification and comment are required before an action is taken by the Department, the Regulatory Advisory Committee shall have an opportunity to review the proposed Departmental action and provide input to the Department regarding the action.

Section 5 — Criteria for Delegation of Program Elements

1. Conservation Districts, counties, municipalities, and State agencies may seek delegation of four program elements relating to the implementation of the statewide sediment and stormwater program. Delegation may be granted by the Secretary for review and approval of sediment and stormwater management plans, inspection during construction, subsequent maintenance inspection, and education and training. Program elements that are delegated shall be implemented according to Chapter 40 and these regulations.

2. The Secretary, or his designee, shall grant delegation of one or more program elements to any Conservation District, county, municipality, or State agency seeking delegation that is found capable of providing compliance with Chapter 40 and these regulations. The final decision regarding delegation shall be made only after an opportunity has been provided for public review and comment. Initial consideration regarding delegation of program elements shall be given to the Conservation Districts. The Conservation Districts, having unique capabilities and areawide responsibilities are in ideal positions to coordinate and implement local sediment and stormwater programs.

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3. Requests for delegation of more than one program element may be accomplished by the submission of one request for all the elements requested. A concern by the Department over one element will not jeopardize delegation of other requested program elements.

4. To be considered capable of providing compliance with Chapter 40 and these regulations, applications for delegation of program elements shall contain the following requisite items.

   A. Requests for delegation of plan approval responsibility shall include the following information:

      (1) Ordinance or program information detailing the plan approval process,

      (2) Plan review check lists and plan submission requirements,

      (3) Sediment and stormwater criteria, including waiver and variance procedures, that meet minimum standards established by these regulations,

      (4) Adequate personnel allocations and expected time frames for plan review which meet the requirements of Section 8(9), and

      (5) Assurance that plan reviewers will attend Departmental training programs in related fields such as wetlands identification, subaqueous permits requirements, etc.

   B. Requests for delegation of inspection during construction shall include the following information:

      (1) Inspection and referral procedures,

      (2) Time frames for inspection of active land disturbing activities,

      (3) Inspection forms,

      (4) Assurance of adequate personnel allocations or a timetable to obtain adequate personnel,

      (5) Criteria for the Certified Construction Reviewer if utilized, and

      (6) Procedures and time frames for processing complaints.

   C. Requests for delegation of maintenance inspection responsibility shall include the following information:

      (1) Inspection and referral procedures,

      (2) Inspection forms,

      (3) Time frames, not exceeding one year, for inspection of completed stormwater management structures, and

      (4) Assurance of adequate personnel allocation or a timetable to obtain adequate personnel.

   D. Requests for delegation of education and training responsibility shall include the following information:

      (1) Types of educational and training activities to be accomplished,

      (2) Frequency of activities,

      (3) Names and backgrounds of those individuals conducting the training, and

      (4) Procedures and timetables to notify the Department of educational programs.

5. A Conservation District, county, municipality, or State agency which has been granted delegation of one or more program elements may establish alternative requirements which are compatible with or are more stringent than Departmental requirements. These alternative requirements may be implemented only when prior Departmental approval has been granted. These alternative requirements shall apply in lieu of the provisions of these regulations in the specific program element that has been delegated. Alternative requirements shall be implemented only after public notice has been provided which would allow for public review and comment prior to Departmental approval.

6. Delegation of authority for one or more program elements may be granted for a maximum time frame of three years. After three years a new application to the Department must be made. Over the time frame for which delegation has been granted, the Department will evaluate delegation implementation, coordinate review findings with the delegated authority, and determine if the new delegation should be granted.

7. A Conservation District, county, municipality, or State agency requesting or renewing delegation shall submit a written request to the Secretary on or before January 1 of the year immediately preceding the fiscal year for which delegation or renewal of delegation is sought.

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8. The Secretary shall, in writing, grant or deny delegation on or before April 1 of the year during which delegation is sought. The Secretary may not deny a requested delegation unless opportunity has been afforded to the appropriate officials to present arguments. Delegation shall be effective July 1 of that year and extend no more than three years, unless renewed. In the event that the Department does not act on the renewal request by April 1, the delegated authority submitting the request would be entitled to continue operating for a subsequent three year time period unless action is taken by the Department to suspend the program.

9. If the Secretary determines that a delegated program falls below acceptable standards established by these regulations, delegation may be suspended after opportunity is afforded for a hearing. During a period of suspension, the program element shall revert to the Department for implementation. Funds set aside by a delegated agency, that were collected through fees established by the plan approval agency, shall be transferred to the Department for use if delegation is suspended.

10. A delegated authority may subdelegate program elements, with Departmental concurrence, to a stormwater utility or other responsible entity or agency.

11. The Department shall maintain, and make available upon request, a listing of the current status of delegation for all jurisdictions within the State.

Section 6 — Permit Fees, Maintenance Fees, and Performance Bonds

1. The establishment of permit fees, not involving stormwater utilities, shall be in accordance with the following items:

   A. Delegation of program elements will depend, to a large extent, on funding and personnel commitments. If the delegated jurisdiction has a source of funding that is provided through State General or local revenues, then the implementation of the delegated component will not necessitate the imposition of a permit fee to cover the cost of the delegated program component.

   B. In the event that one component of an overall sediment and stormwater management program is not funded through the use of general or special funds, a nonrefundable permit fee will be collected at the time that the sediment and stormwater management plan or application for waiver or variance is submitted or approved. The permit fee will provide for the unfunded costs of plan review, administration and management of the permitting office, construction review, maintenance inspection, and education and training. The plan review or permit approval agency, whether delegated or the Department, shall be responsible for the collection of the permit fee.

      Unless all program elements in a county or municipality have been delegated to a single agency, the funds collected not supporting the plan review function shall be distributed to the appropriate agencies.

   C. The number of needed personnel and the direct and indirect expenses associated with those personnel shall be developed by the agencies requesting delegation in a specific jurisdiction in conjunction with and with the concurrence of the Department. Those expenses will then form the basis for determining unit plan approval costs.

   D. Prior to plan approval, a fee may be assessed by the appropriate plan approval agency for those activities approved prior to July 1, 1991, for which construction will initiate after July 1, 1991.

   E. Where the Department becomes the designated plan approval agency, the Department may assess a plan review and construction review fee. That fee shall not exceed $80.00 per disturbed acre per project.

   F The use of Certified Construction Reviewers for sediment control and the submission of "As Built or Record Document" certification regarding stormwater management construction may reduce the inspection requirements for the delegated agency but may not eliminate that inspection requirement. Periodic overview inspections will still be necessary to ensure construction management.

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2. The imposition of a financial guarantee, based on existing local authority, may be required by the plan approval agency to ensure that construction of the stormwater management practices was accomplished according to the approved sediment and stormwater management plan. The developer, when required, shall submit to the plan approval agency a surety or cash bond, or irrevocable letter of credit prior to the issuance of any building or grading permit for construction of any land disturbing activity that requires a stormwater management facility. The amount of the security shall not exceed 150 percent of the total estimated construction cost of the stormwater management facility. The financial guarantee so required shall include provisions relative to forfeiture for failure to complete work specified in the approved stormwater management plan, compliance with all the provisions of these regulations, and other applicable laws and regulations, and any time limitations. The financial guarantee, fully or partially, shall not be released without a final inspection of the completed work and, when required, after submission of "As Built or Record Document" plans, and after written confirmation by the design engineer that construction was accomplished according to the approved plans. A partial release of the financial guarantee shall be allowed only to the extent that the work already accomplished would warrant such release.

3. A maintenance fee may be required on approvals granted for stormwater management structures that will be maintained by a Conservation District, county, or municipality. A fee mechanism shall be established prior to the final release of any required financial guarantee or final approval of the completed stormwater management structure by the designated construction review agency.

Section 7—Criteria for Implementation of a Stormwater Utility

The implementation of a stormwater utility will necessitate the development of a local utility ordinance prior to its implementation. There are essential components that an ordinance must contain to function as a funding mechanism for stormwater management and those components shall include, but not be limited to, the following items:

1. The financing of a stormwater utility with a user charge system must be reasonable and equitable so that each user of the stormwater system pays to the extent to which the user contributes to the need for the stormwater system, and that the charges bear a substantial relationship to the cost of the service. The use of county and municipal taxpayer rolls and accounting systems are allowed for the assessment and collection of fees.

2. The intent of the utility must be clearly defined regarding program components that are to be funded through the utility. Those components may include but not be limited to the following activities:

   A. Preparation of long range watershed master plans for stormwater management,

   B. Annual inspections of all stormwater management facilities, both public and private,

   C. Undertaking regular maintenance, through contracting or other means, of stormwater management structures that have been accepted for maintenance,

   D. Plan review and inspection of sediment control and stormwater management plans and practices, and

   E. Retrofitting designated watersheds, through contracting or other means, to reduce existing flooding problems or to improve water quality.

3. The authority for the creation of the stormwater utility and the imposition of charges to finance sediment and stormwater activities is conferred in Chapter 40, Title 7, Delaware Code. The application of a stormwater utility by means of a local ordinance shall not be deemed a limitation or repeal of any other powers granted by State statute.

4. The creation of a stormwater utility shall include the following components:

   A. The boundaries of the utility, such as watersheds or jurisdictional boundaries as identified by the local governing body,

   B. The creation of a management entity,

   C. Identification of stormwater problems,

   D. Method for determining utility charges,

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E. Procedures for investment and reinvestment of funds collected, and

F. An appeals or petition process.

5. As established by local ordinance, the local governing agency shall have responsibility for implementing all aspects of the utility including long range planning, plan implementation, capital improvements, maintenance of stormwater facilities, determination of charges, billing, and hearing of appeals and petitions. The local agency also will have responsibility for providing staff support for utility implementation.

   In the event that an agency or department other than the one in which the utility is located is best equipped to undertake a particular task, the local governing agency shall ensure that appropriate interagency charges are determined such that all costs of stormwater management are reflected in the utility budget and that utility charges finance all aspects of stormwater management.

6. With respect to new stormwater management facilities constructed by private developers, the local governing agency shall develop criteria for use in determining whether these will be maintained by the utility or by the facility owner. Such criteria may include whether the facility has been designed primarily to serve residential users and whether it has been designed primarily for purposes of stormwater management. In situations where it is determined that public maintenance is not preferable, standards shall be developed to ensure that inspection of facilities occurs annually and that facilities are maintained as needed.

7. The use of charges is limited to those purposes for which the utility has been established, including but not limited to: planning; acquisition of interests in land including easements; design and construction of facilities; maintenance of the stormwater system; billing and administration; and water quantity and water quality management, including monitoring, surveillance, private maintenance inspection, construction inspection, and other activities which are reasonably required.

Section 8 — Permit Application and Approval Process

1. After July 1, 1991, unless a particular activity is exempted by these regulations, a person may not disturb land without an approved sediment and stormwater management plan from the appropriate plan approval agency. A grading or building permit may not be issued for a property unless a sediment and stormwater management plan has been approved that is consistent with the following items:

   A. Chapter 40, Title 7, Delaware Code, relating to erosion and sediment control and stormwater management, and

   B. These regulations, or duly adopted county or municipal ordinances that are adopted as a part of the delegation process and relate to the intent of these regulations.

2. A sediment and stormwater management plan or an application for a waiver shall be submitted to the appropriate plan approval agency by the developer for review and approval for a land disturbing activity, unless otherwise exempted. The sediment and stormwater management plan shall contain supporting computations, drawings, and sufficient information describing the manner, location, and type of measures in which stormwater runoff will be managed from the entire development. The appropriate plan approval agency shall review the plan to determine compliance with the requirements of these regulations prior to approval. The approved sediment and stormwater management plan shall serve as the basis for water quantity and water quality control on all subsequent construction.

3. The sediment and stormwater management plan shall not be considered approved without the inclusion of an approval stamp with signature and date, on the plans by the appropriate plan approval agency.

4. All sediment and stormwater management plans submitted for approval shall contain certification by the owner or developer that clearing, grading, construction, or development will be accomplished pursuant to the plan and that responsible personnel involved in the land disturbance will have a Certification of Training at a Departmental sponsored or approved training program for the control of erosion and sediment control before initiation of the project. The Certification of Training for responsible personnel requirement may be waived by the appropriate plan ap-

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proval agency on any project involving silviculture or fewer than four residential homes.

5. All sediment and stormwater management plans shall contain certification by the owner or developer of the right of the Department or delegated inspection agency to conduct on-site inspections.

6. A grading or building permit issued by a local jurisdiction may be suspended or revoked after written notice is given to the permittee by the responsible delegated agency or the Department for any of the following reasons:

   A. Violations of the conditions of the sediment and stormwater management plan approval;

   B. Changes in site runoff characteristics upon which a waiver was granted;

   C. Construction not in accordance with the approved plans;

   D. Noncompliance with correction notice or stop work order issued for the construction of the sediment control practices or the stormwater management facilities;

   E. An immediate danger exists in a downstream area in the opinion of the appropriate plan approval or inspection agency, or the Department; or

   F. Failure to submit stormwater management "As Built or Record Document" plans, when required, at the completion of the project.

7. Approved plans remain valid for 3 years from the date of an approval, unless specifically extended or renewed by the appropriate plan approval agency. The basis for extension or renewal may include, but not limited to, the following items:

   A. Failure to initiate the approved project for reasons acceptable to the appropriate plan approval agency such as funding or other agency permit delays; or

   B. Time duration for a type of activity that typically exceeds three years.

8. Projects which have been approved prior to July 1, 1991, and where site clearing has not been initiated on the project within two years, shall be resubmitted to the appropriate plan approval agency for review and approval subject to the requirements of these regulations.

9. Upon receipt of a completed application for sediment and stormwater management, the appropriate plan approval agency shall accomplish its review within 30 calendar days, and have either the approval or review comments transmitted to the applicant. If that 30 day time frame cannot be met, the appropriate plan approval agency shall notify the applicant of the reasons for delay, and an expected time frame not to exceed an additional 30 days, when that review will be accomplished.

Section 9 — Criteria for Designated Watersheds

The concept of designated watersheds is intended, not only to prevent existing water quantity and water quality problems from getting worse, but also to reduce existing flooding problems and to improve existing water quality or meet State Water Quality Standards in selected watersheds. Criteria is established for designated watersheds and that criteria will depend on whether the specific problems of the watershed are water quantity or water quality oriented. Water quantity and water quality concerns will be considered in all designated watersheds, but the overall emphasis for each designated watershed will depend on its existing and anticipated problems.

1. To initiate consideration of a watershed for Designated Watershed or Subwatershed status, a watershed shall be recommended by a Conservation District, county, municipality, or State agency, to the Department. Upon recommendation to the Department, all involved agencies at the local level will be contacted and their input received prior to any watershed study being initiated.

2. Included with the recommendation of a watershed for Designated Watershed or Subwatershed status to the Department shall be an identification of the specific problems that exist in the watershed so that the pursuit of a watershed study is warranted. Inclusion in these regulations as a Designated Watershed or Subwatershed requires approval by the Department that a significant water quantity or water quality problem exists that would necessitate this joint State, District, and local government involvement. Also, inclusion of a watershed as a Designated Watershed or Subwatershed will necessitate a public hearing

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process. The process of problem identification shall be based on the following information:

A. To initiate a watershed study based on water quality considerations the following information must be submitted:

(1) Existing water quality data that has been collected as a result of the overall statewide water quality inventory process, or

(2) Other water quality data collected through specific sampling that was accomplished in the watershed, or

(3) Submission of a water quality assessment that was accomplished using a qualitative collection method of benthic macroinvertebrates.

B. To initiate a watershed study based on flooding or water quantity considerations the following information must be submitted:

(1) Estimated annual flood damage to either private, residential, commercial, industrial, or public properties, or

(2) Number of residences or industries in the floodplain, or

(3) The history of flooding in the watershed, or

(4) Measures already taken to minimize or reduce flooding, or

(5) Dangers to public health and welfare.

3. Upon modification of these regulations to include a watershed as a Designated Watershed or Subwatershed an advisory group will be established that will guide the overall watershed study. The advisory group will be appointed by the Secretary and will include State, District, and local representatives in addition to representatives of the regulated community and others affected by the results of the study.

4. The general components contained in the actual watershed studies shall be the following items:

A. Stormwater quantity or water quality problem identification,

B. The overall needs of the watershed including the additional impacts of new development activities,

C. Alternative approaches to address the existing and future problems,

D. A selected approach that includes the overall costs and benefits,

E. Schedule for implementation,

F. Funding sources that are available for the actual implementation of study recommendations, and

G. A public hearing process prior to final Departmental approval.

5. The following goals are to be obtained through the implementation of the Designated Watershed or Subwatershed program:

A. Reduction of existing flooding or water quality impacts,

B. Prevention of future flooding or water quality impacts, and

C. Minimization of economic and social losses.

6. Specific plan components of a water quality watershed study shall include, but not be limited to, the following items:

A. The limits of the watershed,

B. An inventory of existing water quality data,

C. An inventory of areas having significant natural resource value as defined in existing State or local studies as they may be impacted by the construction or location of stormwater control structures,

D. An inventory of areas of historical and archaeological value identified in existing State or local studies as they may be impacted by the construction or location of stormwater control structures,

E. A map or series of maps of the watershed showing the following information:

(1) Watershed topography,

(2) Significant geologic formations,

(3) Soils information,

(4) Existing land use based on existing zoning,

(5) Proposed land use based on expected zoning or comprehensive plans,

(6) Location of tidal and nontidal wetlands, and

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(7) Locations where water quality data were obtained.

F. An evaluation of water quantity concerns so that flooding does not become a problem in the watershed.

7. Specific components of a water quantity based study shall include, but not be limited to, the following items:

A. The limits of the watershed,

B. An inventory of historic flood damage sites, including frequency and damage estimates,

C. An inventory of areas of significant natural resource value as noted in existing State and local studies as they may be impacted by the construction or location of stormwater control structures,

D. An inventory of areas of historical and archaeological value identified in existing State and local studies as they may be impacted by the construction or location of stormwater control structures,

E. A map or series of maps of the watershed showing the following information:

(1) Watershed topography,

(2) Soils information,

(3) Existing land use based on existing zoning,

(4) Proposed land use based on expected zoning or comprehensive plans,

(5) Locations of tidal and nontidal wetlands,

(6) Locations of existing flooding problems including floor and corner elevations of structures already impacted, and

(7) 100-year floodplain delineations, water surface profiles, and storm hydrographs at selected watershed location.

F. An evaluation of water quality concerns so that water quality degradation does not become a problem in the watershed.

8. The initiation of studies for Designated Watersheds or Subwatersheds depends on the availability of funding for the study. Once a watershed has been designated, the Department will make every effort to secure funding through federal, State, or local means.

9. The Department is designated as the agency responsible for administering designated watershed or subwatershed studies with the advice of the advisory group appointed by the Secretary. Recommendations based on the results of the watershed study will only be made with the overall consent of the advisory group.

10. The formal results of the Designated Watershed or Subwatershed study will require formal acceptance by the local Conservation District Board of Supervisors and the local governing body of the appropriate county or municipality.

11. Implementation of the results of the Designated Watershed or Subwatershed study will necessitate the development and implementation of a dedicated funding source such as a stormwater utility to ensure design, construction, and maintenance of needed structures is accomplished.

12. Those watersheds or subwatersheds designated due to existing water quantity or water quality problems include the following:

A. Dover/Silver Lake/St. Jones River and all drainage areas upstream of the Silver Lake dam.

Section 10 — Specific Design Criteria and Minimum Standards and Specifications

1. General submission requirements for all projects requiring sediment and stormwater management approval include the following information:

A. A standard application form,

B. A vicinity map indicating north arrow, scale, and other information necessary to locate the property or tax parcel,

C. A plan at an appropriate scale accompanied by a design report and indicating at least:

(1) Name and address of

(a) The owner of the property where the project is proposed;

(b) The land developer; and

(c) The applicant.

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(2) The existing and proposed topography, as required on a case-by-case basis.

(3) The proposed grading and earth disturbance including:

(a) Surface area involved; and

(b) Limits of grading including limitation of mass clearing and grading whenever possible.

(4) Stormwater management and stormwater drainage computations, including:

(a) Pre- and postdevelopment velocities, peak rates of discharge, and inflow and outflow hydrographs of stormwater runoff at all existing and proposed points of discharge from the site,

(b) Site conditions around points of all surface water discharge including vegetation and method of flow conveyance from the land disturbing activity, and

(c) Design details for structural controls.

(5) Erosion, sediment control, and stormwater management provisions including:

(a) Provisions to preserve top soil and limit disturbance;

(b) Details of site grading, and;

(c) Design details for structural controls which includes diversions and swales.

D. Federal Emergency Management Agency flood maps and federal and State protected wetlands, where appropriate.

E. The appropriate plan approval agency shall require that plans and design reports be sealed by a qualified design professional that the plans have been designed in accordance with approved sediment and stormwater ordinances, regulations, standards and criteria. The appropriate plan approval agency may waive this requirement on a case-by-case basis.

F. Additional information necessary for a complete project review may be required by the appropriate plan approval agency as deemed appropriate. This additional information may include items such as public sewers, water lines, septic fields, wells, etc.

2. Specific requirements for the erosion and sediment control portion of the sediment and stormwater management plan approval process include, but are not limited to, the following items. The appropriate plan approval agency may modify the following items for a specific project or type of project. Modification for a specific type of project will require the concurrence of the Department before that modification may be applied and that modification shall be subject to public review and comment prior to adoption.

A. All plans shall include details of temporary and permanent stabilization measures including placement of the following statement on all plans submitted for approval. Following soil disturbance or redisturbance, permanent or temporary stabilization shall be completed within 14 calendar days as to the surface of all perimeter sediment controls, topsoil stockpiles, and all other disturbed or graded areas on the project site.

These requirements do not apply to those areas which are shown on the plan and are currently being used for material storage, or for those areas on which actual earth moving activities are currently being performed.

B. All erosion and sediment control plans shall comply with the Delaware Erosion and Sediment Control Handbook, dated 1989 and approved supplements. The supplements shall be subject to public review and comment prior to their incorporation in the Erosion and Sediment Control Handbook.

C. A sequence of construction shall be contained on all plans describing the relationship between the implementation and maintenance of sediment controls, including permanent and temporary stabilization and the various stages or phases of earth disturbance and construction. The sequence of construction shall, at a minimum, include the following activities:

(1) Clearing and grubbing for those areas necessary for installation of perimeter controls;

(2) Construction of perimeter controls;

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(3) Remaining clearing and grubbing;

(4) Road grading;

(5) Grading for the remainder of the site;

(6) Utility installation and whether storm drains will be used or blocked until after completion of construction;

(7) Final grading, landscaping, or stabilization; and

(8) Removal of sediment controls.

D. The plans shall contain a description of the predominant soil types on the site, as described by the appropriate soil survey information available through the local Conservation District.

E. Unless an exception is approved on a case-by-case basis or an exception is approved for a specific type of activity by the appropriate plan approval agency, not more than 20 acres may be cleared at any one time. Once grading is initiated in one 20-acre section, a second 20-acre section may have stumps, roots, brush, and organic material removed. This will necessitate the phasing of construction on sites in excess of 20 acres to minimize areas exposed of ground cover and reduce erosion rates. Grading of the second 20-acre section may not proceed until temporary or permanent stabilization of the first 20-acre section is accomplished.

3. Specific requirements for the permanent stormwater management portion of the sediment and stormwater management plan approval process include, but are not limited to, the following items. The appropriate plan approval agency may modify the following items for a specific project or type of project. Modification for a specific type of project will require the concurrence of the Department before the modification may be applied and the modification for a type of project shall be subject to public review and comment.

A. It is the overall goal of the Department to address stormwater management on a watershed by watershed basis to provide a cost effective water quantity and water quality solution to the specific watershed problems. These regulations will provide general design requirements that must be adhered to in the absence of Designated Watershed or Subwatershed specific criteria.

B. All hydrologic computations shall be accomplished using the most recent USDA Soil Conservation Service Technical Releases 20 or 55. The storm duration for computational purposes shall be the 24-hour rainfall event. For projects south of the Chesapeake and Delaware Canal, the Delmarva Unit Hydrograph shall be incorporated into the design procedure.

C. Stormwater management requirements for a specific project shall be based on the entire area to be developed, or if phased, the initial submittal shall control that area proposed in the initial phase and establish a procedure and obligation for total site control.

D. Water quantity control is an integral component of overall stormwater management. Control of peak discharges will, to some extent, prevent increases in flooding. The following design criteria for peak flow control is established for water quantity control purposes, unless a waiver is granted based on a case-by-case basis:

(1) Projects in New Castle County that are located north of the Chesapeake and Delaware Canal shall not exceed the post-development peak discharge for the 2, 10, and 100-year frequency storm events at the predevelopment peak discharge rates for the 2, 10, and 100-year frequency storm events.

(2) Projects in New Castle County that are located south of the Chesapeake and Delaware Canal, Kent County, and Sussex County shall not exceed the postdevelopment peak discharge for the 2 and 10-year frequency storm events at the predevelopment peak discharge rates for the 2 and 10-year frequency storm events.

(3) Watersheds, other than Designated Watersheds or Subwatersheds, that have well documented water quantity problems may have more stringent, or modified, design criteria that is responsive to the specific needs of that watershed. Modified criteria for that watershed must receive Departmental approval, and all projects reviewed and approved by the appropriate plan approval agency shall

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meet or exceed the modified criteria. Proposed modification of criteria for a watershed shall be subject to public review and comment prior to implementation.

E. Water quality control is also an integral component of stormwater management. Control of water quality on-site will prevent further degradation of downstream water quality. The following design criteria are established for water quality protection unless a waiver or variance is granted on a case-by-case basis.

(1) In general, the preferred option for water quality protection shall be ponds. Ponds having a permanent pool of water must be considered before a pond having no permanent pool. Infiltration practices shall be considered only after ponds have been eliminated for engineering or hardship reasons as approved by the appropriate plan approval agency.

(2) Water quality ponds having a permanent pool shall be designed to release the first 1/2 inch of runoff from the site over a 24-hour period. The storage volume of the normal pool shall be designed to accommodate, at least, 1/2 inch of runoff from the entire site.

(3) Water quality ponds, not having a normal pool, shall be designed to release the first inch of runoff from the site over a 24-hour period.

(4) Infiltration practices, when used, shall be designed to accept, at least, the first inch of runoff from all streets, roadways, and parking lots.

(5) Other practices may be acceptable to the appropriate plan approval agency if they achieve an equivalent removal efficiency of 80 percent for suspended solids.

F. All ponds that are constructed for stormwater management shall be designed and constructed in accordance with the USDA Soil Conservation Service Small Pond Code 378, dated September 1990, as approved for use in Delaware.

G. Any pond utilized for water supply purposes, or for irrigation, must obtain approval from the Department for that use pursuant to Chapter 60.

H. Where ponds are the proposed method of control, the developer shall submit to the approving agency, when required, an analysis of the impacts of stormwater flows downstream in the watershed for the 100-year frequency storm event.

The analysis shall include hydrologic and hydraulic calculations necessary to determine the impact of hydrograph timing modifications of the proposed development, with and without the pond, on downstream dams, highways, structures, or natural points of constricted streamflows past which the timing effects would be considered negligible. The results of the analysis will determine the need to modify the pond design or to eliminate the pond requirement. Lacking a clearly defined downstream point of constriction, the downstream impacts shall be established, with the concurrence of the approving agency, downstream of a tributary of the following size:

(1) The first downstream tributary whose drainage area equals or exceeds the contributing area to the pond; or

(2) The first downstream tributary whose peak discharge exceeds the largest designed release rate of the pond.

I. Where existing wetlands are intended as a component of an overall stormwater management system, the following criteria shall apply:

(1) The only disturbance to the wetland, for the purposes of these regulations, shall be that disturbance caused by the stormwater management pond embankment placement and construction; or

(2) The applicant can demonstrate that the intended or functional aspects of the stormwater management facility and wetlands are maintained or enhanced, or the construction in the wetland for stormwater management is the only reasonable alternative.

(3) All other necessary State and federal permits can be obtained.

J. Designs shall be in accordance with standards developed or approved by the

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Department, which are subject to public review and comment.

K. Ease of maintenance must be considered as a site design component. Access to the stormwater management structure must be provided for in the design, and land area adjacent to the structure must be set aside for disposal of sediments removed from the structure when maintenance is performed. The land set aside for pond maintenance shall be sized as follows:

(1) The set aside area shall accommodate at least 2 percent of the stormwater management basin volume to the elevation of the 2-year storage volume elevation;

(2) The maximum depth of the set aside volume shall be one foot;

(3) The slope of the set aside area shall not exceed 5 percent; and

(4) The area and slope of the set aside area may be modified if an alternative area or method of disposal is approved by the appropriate plan approval agency.

L. A clear statement of defined maintenance responsibility shall be established during the plan review and approval process.

M. All ponds shall have a forebay or other design feature to act as a sediment trap. A reverse slope bench must be provided one foot above the normal pool elevation for safety purposes and all embankment ponds, having a normal pool, shall have a drain installed to facilitate maintenance.

N. The use of infiltration practices for the disposal of stormwater runoff is classified by the U.S. EPA as an underground injection control practice, class V injection well. The appropriate plan approval agency shall forward a copy of all such approvals and the results of all construction inspections to the Department's Underground Injection Control program manager.

O. Infiltration practices have certain limitations on their use on certain sites. These limitations include the following items:

(1) Areas draining to these practices must be stabilized and vegetative filters established prior to runoff entering the system. Infiltration practices shall not be used if a suspended solids filter system does not accompany the practice. If vegetation is the intended filter, there shall be, at least, a 20-foot length of vegetative filter prior to stormwater runoff entering the infiltration practice;

(2) The bottom of the infiltration practice shall be at least three feet above the seasonal high water table, whether perched or regional, determined by direct piezometer measurements which can be demonstrated to be representative of the maximum height of the water table on an annual basis during years of normal precipitation, or by the depth in the soil at which mottling first occurs;

(3) The infiltration practice shall be designed to completely drain of water within 48 hours.

(4) Soils must have adequate permeability to allow water to infiltrate. Infiltration practices are limited to soils having an infiltration rate of at least 1.02 inches per hour.

Initial consideration will be based on a review of the appropriate soil survey, and the survey may serve as a basis for rejection. On-site soil borings and textural classifications must be accomplished to verify the actual site and seasonal high water table conditions when infiltration is to be utilized.

(5) Infiltration practices greater than three feet deep shall be located at least 20 feet from basement walls;

(6) Infiltration practices designed to handle runoff from impervious parking lots or driveways shall be a minimum of 150 feet from any public or private water supply well;

(7) The design of an infiltration practice shall provide an overflow system with measures to provide a nonerosive velocity of flow along its length and at the outfall; and

(8) The slope of the bottom of the infiltration practice shall not exceed 5 percent. Also, the practice shall not be installed in fill material as piping

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along the fill/natural ground interface may cause slope failure.

(9) Unless allowed on a specific project, infiltration practices will be used primarily for water quality enhancement only.

(10) An infiltration practice shall not be installed on or atop a slope whose natural angle of incline exceeds 20 percent.

P. A regional approach to stormwater management is an acceptable alternative to site specific requirements. As a substitute control practice, regional stormwater management structures shall be required to meet the following items:

(1) They shall have a contributory drainage area not in excess of 400 acres unless, on a case-by-case basis, a larger drainage area is approved by the appropriate plan approval agency;

(2) They shall have a permanent pool of water and provide for 24-hour detention of the first inch of stormwater runoff from the entire upstream watershed; and

(3) All other necessary approvals have been obtained that could be cause for site rejection.

Q. The predevelopment peak discharge rate shall be computed assuming that all land uses in the site to be developed are in good hydrologic condition.

Section 11 — General Permit Criteria

1. A general permit involves completion and submission of a form by a land owner, developer, or agent to the appropriate plan approval agency for signature. The minimum criteria for the form will be developed by the Department, and may be expanded upon by the appropriate plan approval agency. The form will contain standard conditions for erosion and sediment control that must be implemented on sites where a specific control plan is not required. The appropriate plan approval agency shall approve general permit requests within 5 calendar days of receipt.

2. The inclusion of an activity into the general permit classification does not relinquish that activity from the requirements of Chapter 40. Rather, the general permit precludes that activity from the necessity of a specific plan review for each individual project.

3. Approval of a general permit does not relieve the applicant from the conditions that are a part of the general permit approval regarding the implementation of control practices as required by the general permit. Failure to implement control practices pursuant to conditions included in the general permit may necessitate appropriate enforcement action as provided in Chapter 40 and these regulations.

4. Those activities eligible for general permits include the following:

A. Individual detached residential home or agricultural structure construction where the disturbed area for construction will be less than one acre in size. Two or more contiguous lots being developed concurrently by the same land developer will not be eligible for the general permit.

B. Forest harvest operations.

C. Highway shoulder and side swale maintenance.

D. The repair, maintenance, and installation of above and underground utilities.

E. Commercial and industrial projects for erosion and sediment control only when the total disturbed area of the project is less than 1/2 acre in size.

F. Modification or reconstruction of a tax ditch by a tax ditch organization when that tax ditch is not intended to serve new development, and which will not increase water quantity or adversely impact water quality, or change points of discharge so as to adversely affect the waters of the State.

5. The appropriate plan approval agency may place more restrictive conditions upon the general permits approval including the requirement for site specific plans for any general permits category. The imposition of more specific requirements for categories of projects shall be approved by the Department, and shall be subject to public review and comment prior to their imposition.

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Section 12 — Certified Construction Reviewer Requirements

1. Projects reviewed and approved by the Department for sediment control and stormwater management, in general, shall have a certified construction reviewer when the disturbed area of the project is in excess of 50 acres. In addition any project, regardless of its size, may be required by the Department, or the appropriate plan approval agency, to have a certified construction reviewer on a case-by-case basis.
2. The Department or the appropriate inspection agency may require that any project, already under construction, have on site a certified construction reviewer if, on that project, significant sediment control or stormwater management problems necessitate more frequent inspections.
3. The certified construction reviewer shall function under the direction of a registered professional engineer licensed to practice engineering in the State of Delaware.
4. Individuals designated as certified construction reviewers shall attend and pass a Departmental sponsored or approved construction review training course. The course content will contain, at a minimum, information regarding the following items:
   A. Basic hydrology and hydraulics;
   B. Soils information including texture, limitations, erodibility, and classifications;
   C. Types of vegetation, growing times, and suitability;
   D. Erosion, sediment control, and stormwater management practices;
   E. Inspection and problem referral procedures;
   F. Aspects of State law, regulations, local ordinances, and approval procedures; and
   G. Sediment and stormwater management plan content.
5. The time frame for certification shall not exceed five years unless extended by the Department.
6. The responsibility of the certified construction reviewer will be to ensure the adequacy of construction pursuant to the approved sediment and stormwater management plan.
7. The certified construction reviewer shall be responsible for the following items:
   A. Provision of a construction review of active construction sites on at least a weekly basis;
   B. Within five calendar days, informing the person engaged in the land disturbing activity, and the contractor, by a written construction review report of any violations of the approved plan or inadequacies of the plan. The plan approval agency shall be informed, if the approved plan is inadequate, within five working days. In addition, the appropriate construction review agency shall receive copies of all construction review reports; and
   C. Referral of the project through the delegated inspection agency to the Department for appropriate enforcement action if the person engaged in the land disturbing activity fails to address the items contained in the written construction review report. Verbal notice shall be made to the Department within two working days and written notice shall be provided to the Department within five working days.
8. If the Secretary or his designee determines that a certified construction reviewer is not providing adequate site control or is not referring problem situations to the Department, the Secretary or his designee may suspend or revoke the certification of the construction reviewer.
9. In any situation where a certified construction reviewer's approval is being suspended or revoked, an opportunity for hearing before the Secretary or his designee shall be provided. During any suspension or revocation, the certified construction reviewer shall not be allowed to provide construction reviews pursuant to these regulations. The minimum time of suspension or revocation shall be 6 months.

Section 13 — Contractor Certification Program

1. The Department shall require certification of responsible personnel for any foreman or superintendent who is in charge of on-site clearing and land disturbing activities for sediment and stormwater control associated with a

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construction project. Responsible personnel are not required on any project involving silviculture or fewer than four residential homes. Responsible personnel shall obtain certification by completing a Department sponsored or approved training program. Enrollment of existing and future responsible personnel is the responsibility of employers. Response to a Department notice of training and certification in accordance with the provisions of item 3 of this section shall serve as an application for training. The Department shall notify employers of responsible personnel as to the date and location of training programs for attendance by responsible personnel and other interested persons.

2. After July 1, 1991, any applicant seeking sediment and stormwater plan approval shall certify to the appropriate plan approval agency that all responsible personnel involved in the construction project will have a certificate of attendance at a Departmental sponsored or approved training course for the control of sediment and stormwater before initiation of any land disturbing activity. The certificate of attendance shall be valid until the Department notifies the individual or announces in local newspapers that recertification is required due to a change in course content.

3. After July 1, 1991, employers of responsible personnel may receive interim certification for responsible personnel during the period before attendance at a Departmental sponsored or approved training course by submitting an enrollment form to the Department. Interim certification shall be valid until the scheduled date of attendance for training of responsible personnel. These enrollment forms are available from the Department and the Conservation Districts.

Section 14 — Construction Review and Enforcement Requirements

1. The land developer shall request, at least 24 hours ahead of time, that the appropriate inspection agency approve work completed at the stages of construction outlined in the sequence of construction contained on the approved plans. Any portion of the work which does not comply will be promptly corrected by the developer after written notice by the appropriate inspection agency. The notice shall set forth the nature of corrections required and the time frame within which corrections must be made.

2. The land developer shall notify the appropriate inspection agency before initiation of construction and upon project completion when a final inspection will be conducted to ensure compliance with the approved sediment and stormwater management plan.

3. The responsible inspection agency shall, for inspection purposes, do all of the following items:

   A. Ensure that the approved sediment and stormwater management plans are on the project site and are complied with;

   B. Ensure that every active site is inspected for compliance with the approved plan on a regular basis;

   C. Prepare and leave on site, or forward to the contractor, a written report after every inspection that describes:

      (1) The date and location of the site inspection;

      (2) Whether the approved plan has been properly implemented and maintained;

      (3) Approved plan or practice deficiencies; and

      (4) The action taken.

   D. Notification of on-site personnel or the owner/developer in writing when violations are observed, describing the

      (1) Nature of the violation;

      (2) Required corrective action; and

      (3) Time period for violation correction.

4. The Department may investigate complaints or refer any complaint received to the local inspection agency if the activity is located in a jurisdiction that has received delegation of sediment and stormwater management inspection. In conjunction with a referral, the Department may also initiate an on-site investigation after notification of the local inspection agency in order to properly evaluate the complaint. The Department shall take enforcement action when appropriate, and notify the local inspection agency in a timely manner of any enforcement actions taken.

5. The Department, at its discretion and upon notification to either the owner, developer, or contractor, may visit any site to determine the

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adequacy of sediment and stormwater management practices. In the event that the Department conducts site inspections, the appropriate inspection agency shall be notified prior to the initiation of any enforcement action. The appropriate inspection agency shall establish a time frame to obtain site compliance. This notification shall, in no way limit the right to the Department to take action subsequent to any provision of these regulations or Chapter. Formal procedures for interaction between the Department and the appropriate inspection agency on site inspection and referral will be developed on an individual basis.

6. The appropriate plan approval agency may require a revision to the approved plans as necessary due to differing site conditions. The appropriate plan approval agency shall establish guidelines to facilitate the processing of revised plans where field conditions necessitate plan modification. Where changes to the approved plan are necessary those changes shall be in accordance to the following:

   A. Major changes to approved sediment and stormwater management plans, such as the addition or deletion of a sediment basin, shall be submitted by the owner/developer to the appropriate plan approval agency for review and approval.

   B. Minor changes to sediment and stormwater management plans may be made in the field if approved by the construction reviewer and documented in the field review report. The appropriate inspection agency shall develop a list of allowable field modifications for use by the construction reviewer.

7. Stormwater management construction shall have inspections accomplished at the following stages:

   A. Infiltration practices shall be inspected at the commencement, during, and upon completion of construction;

   B. All ponds shall be inspected at the following stages:

      (1) Upon completion of excavation to sub-foundation and where required, installation of structural supports or reinforcement for structures, including, but not limited to

         (a) Core trenches for structural embankments,

         (b) Inlet-outlet structures and anti-seep structures, watertight connectors on pipes, and

         (c) Trenches for enclosed storm drainage facilities.

      (2) During placement of structural fill, concrete, and installation of piping and catch basins;

      (3) During backfill of foundations and trenches;

      (4) During embankment construction; and

      (5) Upon completion of final grading and establishment of permanent vegetation.

8. The agency responsible for construction review may, in addition to local enforcement options, refer a site violation to the Department for additional enforcement action.

9. Referral of a site violation to the Department may initiate a Departmental construction review of the site to verify site conditions. That construction review may result in the following actions:

   A. Notification through appropriate means to the person engaged in a land disturbing activity and the contractor to comply with the approved plan within a specified time frame; and

   B. Notification of plan inadequacy, with a time frame for the person engaged in a land disturbing activity to submit a revised sediment and stormwater plan to the appropriate plan approval agency and to receive its approval with respect thereto.

   The Department shall notify the local inspection agency in a timely manner of what enforcement action is taken on the site.

10. Failure of the person engaged in the land disturbing activity or the contractor to comply with Departmental requirements may result in the following actions in addition to other penalties as provided in Chapter 40.

    A. The Department shall have the power to issue a cease and desist order to any person violating any provision of Chapter 40

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and these regulations by ordering such person to cease and desist from any site work activity other than those actions necessary to achieve compliance with any administrative order.

B. The Department may request that the appropriate plan approval agency refrain from issuing any further building or grading permits to the person having outstanding violations until those violations have been remedied.

Section 15 — Maintenance Requirements

1. For erosion and sediment control, all practices shall be maintained in accordance with requirements specified in the Delaware Sediment and Erosion Control Handbook dated 1989 or as directed by the construction reviewer.

2. Prior to the issuance of any building or grading permit for which stormwater management is required, the responsible plan approval agency shall require the applicant or owner to execute an inspection and maintenance agreement binding on all subsequent owners of land served by the private stormwater management facility. Such agreement shall provide for access to the facility at reasonable times for regular inspection by an inspection agency and for an assessment of property owners to ensure that the stormwater management structure is maintained in proper design working condition.

3. The Department encourages, and will provide technical assistance to, any Conservation District or local jurisdiction who chooses to assume the maintenance responsibility for stormwater management structures on, at least, residential lands. Public maintenance provides a reasonable assurance that maintenance will be accomplished on a regular basis.

4. The owner or person responsible shall perform or cause to be performed preventive maintenance of all completed stormwater management practices to ensure proper functioning. The responsible inspection agency shall ensure preventive maintenance through inspection of all stormwater management practices. The inspections shall occur at least once each year.

5. Inspection reports shall be maintained by the responsible inspection agency on all detention and retention structures and those inspection reports shall include the following items:

   A. The date of inspection;

   B. The name of the inspector;

   C. The condition of

      (1) Vegetation,

      (2) Fences,

      (3) Spillways,

      (4) Embankments,

      (5) Reservoir area,

      (6) Outlet channels,

      (7) Underground drainage,

      (8) Sediment load, or

      (9) Other items which could effect the proper function of the structure.

   D. Description of needed maintenance.

6. Responsible inspection agencies shall provide procedures to ensure that deficiencies indicated by inspections are rectified. The procedures shall include the following:

   A. Notification to the person responsible for maintenance of deficiencies including a time frame for repairs;

   B. Subsequent inspection to ensure completion of repairs; and

   C. Effective enforcement procedures or procedures to refer projects to the Department if repairs are not undertaken or are not done properly.

Section 16 — Penalties

1. Any person who violates any rule, order, condition imposed in an approved plan or other provision of these regulations shall be fined not less than $200 or more than $2,000 for each offense. Each day that the violation continues shall constitute a separate offense. The Justice of the Peace Courts shall have jurisdiction of offenses brought under this subsection.

2. Any person who intentionally, knowingly, and after written notice to comply, violates or refuses to comply with any notice issued pursuant to these regulations shall be fined not less than $500 or more than $10,000 for each

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offense. Each day the violation continues shall constitute a separate offense. The Superior Court shall have jurisdiction of offenses brought under this subsection.

Section 17 — Hearings

The conduct of all hearings conducted pursuant to these regulations shall be in accordance with the relevant provisions of Delaware Code, Title 7, Chapter 60.

Section 18 — Severability

If any section, subsection, sentence, clause, phrase, or portion of these regulations are for any reason held invalid or unconstitutional by any court or competent jurisdiction, such provision and such holding shall not affect the validity of the remaining portions of these regulations.

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APPENDIX C

Additional Resources

American Society of Civil Engineers
345 East 47th Street
New York, NY 10017-2398

Delaware Department of Natural Resources and Environmental Control
Division of Soil and Water Conservation
89 Kings Highway
P.O. Box 1401
Dover, DE 19903

King County Resource Planning Section
3600 136th Place, SE, 4th Floor
Bellevue, WA 98006-1400

King County Surface Water Management Division
400 Yesler Way, 4th Floor
Seattle, WA 98104

Metropolitan Washington Council of Governments
Department of Environmental Programs
777 North Capitol Street, NE, Suite 300
Washington, DC 20002

Municipality of Metropolitan Seattle
Water Resources, 8th Floor Exchange Building
821 Second Avenue
Seattle, WA 98104

New Jersey Department of Environmental Protection
(formerly New Jersey Department of Environmental Protection and Energy)
Office of land and Water Planning, CN 423
Trenton, NJ 08625

North Carolina Department of Natural Resources and Community Development of Land Resources
Land Quality Section
P.O. Box 27687
Raleigh, NC 27611

Puget Sound Estuary Program
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Puget Sound Water Quality Authority
217 Pine Street, Suite 1100
Seattle, WA 98101

Rhode Island Resource Conservation and Development Area
5586 Post Road, Box 6
East Greenwich, RI 02818

Technical Services Section
Municipal Liquid and Industrial Waste Management Branch
Ministry of the Environment
777 Broughton Street, 2nd Floor
Victoria, BC V8V 1X5, Canada

Terrene Institute
1717 K Street, NW
Suite 801
Washington, DC 20006

University of Washington
Engineering Professional Programs, XD-15
Seattle, WA 98195

Urban Drainage and Flood Control District
2480 West 26th Avenue, Suite 156B
Denver, CO 80211-5500

U.S. Environmental Protection Agency
Assessment Branch
Environmental Research Laboratory
Athens, GA 30613

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U.S. Environmental Protection Agency
Assessment and Watershed Protection Division
Watershed Branch
(WH-553)
401 M Street, SW
Washington, DC 20460

U.S. Environmental Protection Agecny
Permits Division
NPDES Program Branch
401 M Street, SW
Washington, DC 20460

U.S. Geological Survey
Books and Open File Reports Section
Federal Center, Box 25425
Denver, CO 80225

Virginia Department of Conservation and Recreation
Division of Soil and Water Conservation
203 Governor Street, Suite 206
Richmond, VA 23219-2094

Washington Department of Ecology, PV-11
Urban Nonpoint Source Unit
Olympia, WA 98504

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APPENDIX D

Abbreviations

ACP	Agricultural Conservation Program
AETA	apparent effects threshold approach
APHA	American Public Health Association
API	American Petroleum Institute
ASCS	Agricultural Stabilization and Conservation Service
AVS	acid volatile sulfide
BMP	best management practice
BRRL	British Road Research Laboratory
CN	curve number
CP	coalescing plate
CRP	Conservation Reserve Program
CWA	Clean Water Act
EMC	event-mean concentration
EqPA	equilibrium partitioning approach
ESC	erosion and sediment control
GIS	geographic information system
HEC	Hydrologic Engineering Center
HSG	hydrologic soil groups
HSPF	Hydrologic Simulation Program—Fortran
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
ILLUDAS	Illinois Urban Drainage Area Simulation
I_{wb}	Index of Well-Being
LGCPA	Local Government Comprehensive Planning Act
MLRA	major land resource area
NASQAN	National Stream Quality Accounting Network
NEH	National Engineering Handbook
NOEL	no observed effects level
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NSTPA	national status and trends program approach
NURP	Nationwide Urban Runoff Program
OSDS	onsite wastewater disposal system
PEL	probable effects level
PNA	polynuclear aromatic hydrocarbons
QC	quality control
RC&D	Resource Conservation and Development Program

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RBP	rapid bioassessment protocol
SAB	Science Advisory Board
SBA	sediment background approach
SCS	Soil Conservation Service
SLCA	screening level concentration approach
SQAG	sediment quality assessment guideline
SQTA	sediment quality triad approach
SSBA	spiked sediment bioassay approach
STORM	Storage, Treatment, Overflow, and Runoff Model
SWMM	Stormwater Management Model
SWP	state water policy
TC	time of concentration
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TRA	tissue residue approach
TSS	total suspended solids
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
WATSTORE	National Water Data Storage and Retrieval System
WLF	water level fluctuation
WRP	Wetlands Reserve Program

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United States
Environmental Protection
Agency

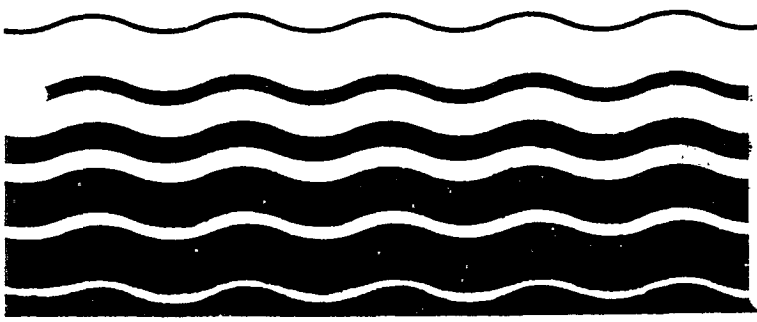
Enforcement And
Compliance Assurance
(2223A)

EPA 300-B-94-014
September 1994

EPA

NPDES Compliance Inspection Manual





ADMINISTRATIVE RECORD INDEX
DOCUMENTS - STORM WATER MANAGEMENT
VOL: —, FOLDER: 2 [illegible]

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NPDES Compliance Inspection Manuals.

Thanks to all of you who have "volunteered" to help with training development.

I have a small inventory of the attached manuals available now, let me know if you need more for your region. I will have more copies made if necessary.

I also have one copy of USEPA's training modules for NPDES inspectors. I am getting one copy made for each Region, which I will send to you ASAP. After your review, I will make additional copies if requested.

Margie Youngs

Inspections

(Focus on Compliance Sampling)

Outline

- Why inspect?
- What type of inspection should you do?
- What tasks should be done in the field?
- How do you set up an ISCO?
- How do you composite a sample?

Why inspect a site?

- To gather or verify information received in a ROWD
- To gain better understanding of treatment system & its operation
- To establish a relationship with the Discharger
- To meet workplan commitments
- To assess compliance w/ permit

What type of inspection should you do?

- Level A - Intense
  - Required for major permits 1X/ year
  - 2 day task if involves sampling
- Level B - Not as intense
  - Required for major & minor permits 1X/ year
  - 1 day task

* Consult your Administrative Procedures Manual for more info.

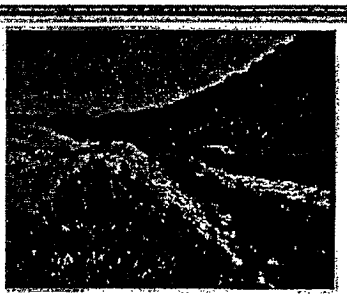
What tasks should you do?

- Prep. Work
  - Review file
  - Prepare supplies
- Fieldwork
  - Setup ISCO automatic sampler
  - Prepare samples & deliver to DHS lab
  - Documentation/ field notebook
- Follow-up office Work
  - Write up report
  - Review lab results

Example - POTW

- Camarillo Sanitation District WRP
- Design flow 6.75 MGD
- Treatment: comminution, 1ry sedimentation, activated sludge, 2ry clarification, chlorination & dechlorination (No flow equalization)
- Sludge is dried in beds & hauled away for land application or to landfill

Discharges to Conejo Creek

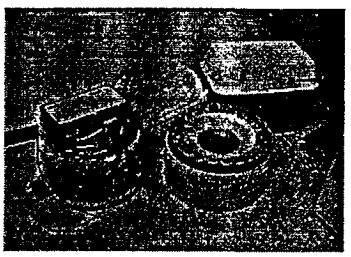


Fieldwork - Day 1

- Entrance Interview
- Setting up ISCO Sampler
- Tour the facility
- Question/ Answer Session



ISCO Wastewater Sampler



ISCO Self-prompting keypad



How do you set up an ISCO?

①Plug in ISCO and press "ON" key
②Press "PROGRAM/ STEP PROGRAM" key
③Enter value on numeric keypad (read it on LCD)
④Press "ENTER VALUE" key
⑤Press "PROGRAM/ STEP PROGRAM" key

How do you set up an ISCO?

⑥Repeat steps 3, 4 & 5 until all program quantities are set
⑦Press "START PROGRAM/ RESET DISTRIBUTION" key to start sampling program

Fieldwork - Day 2

- Disconnect ISCO
- Composite sample
- Deliver samples to DHS lab
- Clean equipment



How do you composite a sample?

- Gather the flow data from the POTW ;
- Identify the hour during the max. flow;
- Calculate volume fractions;
- Shake bottle & pour respective volume fractions from 24 bottles into 5 gal. Container;
- Mix contents of 5 gal. Container; and,
- Fill sample bottles.

Follow-up

- Review lab results;
- Write inspection report;
- Distribute copies to EO & IT Unit; and,
- File original in file.

Conclusion

- Why inspect?
- What type of inspection should you do?
- What tasks should be done in the field?
- How do you set up an ISCO?
- How do you composite a sample?



NPDES COMPLIANCE INSPECTION MANUAL

September 1994

U.S. Environmental Protection Agency
Office of Enforcement and Compliance Assurance
401 M Street, SW
Washington, DC 20460

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R0014471

TRANSMITTAL MEMORANDUM

The National Pollutant Discharge Elimination System (NPDES) Compliance Inspection Manual has been developed to support wastewater inspection personnel in conducting field inspections fundamental to the NPDES compliance program and to provide inspectors with standardized procedures for conducting complete, accurate inspections.

This manual is an update of the 1988 NPDES Compliance Inspection Manual. The modifications include recent changes to the regulations and citations. Authority for the NPDES Program is found in Section 402 of the Federal Water Pollution Control Act (FWPCA).

EPA's approach to performing compliance inspections is currently in transition. The expansion of this manual reflects EPA's desire to pursue a consolidated inspection approach where inspectors look beyond statute-specific guidance to carry out their mission. The Office of Compliance within the recently reorganized Office of Enforcement and Compliance Assurance is organized on a sector basis which enables the Agency to promote compliance with all environmental statutes that apply to each sector. New chapters of this manual covering pollution prevention and multi-media concerns support this transition to a whole sector approach to compliance improvement.

The information presented in the manual will guide a qualified inspector in conducting an adequate inspection. The manual presents standard procedures for inspection; it is assumed the inspector has a working knowledge of wastewater and related problems, regulations, and control technologies. The manual will serve the experienced inspector as a flexible and easy reference. New inspection personnel will find support in the orderly and detailed presentation of the material.

Regional and State personnel are encouraged to provide U.S. Environmental Protection Agency (EPA) Headquarters with changes or information that would improve the manual. Comments, information, and suggestions should be addressed to:

Chief, Energy and Transportation Branch (2223A)
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460

The information contained in this manual is comprehensive and designed to address a wide range of activities. Since each inspection may not involve all activities, the inspector should refer to those parts applicable to the particular inspection. Although the information is presented from the viewpoint of EPA, it is applicable to NPDES State inspectors and other regulatory authorities or their authorized representatives.

Manual Organization

The manual is organized into two parts. The first part, on basic inspection components, consists of seven chapters. The second part includes information on specific types of inspections.

Basic Inspection Components

- Chapter One, "Introduction," describes the NPDES program and provides general information relating to legal authority and inspector responsibilities.

- Chapter Two, "Inspection Procedures," discusses general procedures common to all NPDES inspections, including pre-inspection preparation, entry, opening conference, documentation, closing conference, and inspection report.

- Chapters Three through Seven provide the specific technical information necessary to conduct the full range of NPDES compliance inspection activities. Each chapter describes procedures for the major technical activities involved in compliance inspections:

  - Chapter Three, Documentation/Recordkeeping and Reporting
  - Chapter Four, Facility Site Review
  - Chapter Five, Sampling
  - Chapter Six, Flow Measurement
  - Chapter Seven, Laboratory Procedures and Quality Assurance.

Specific Information

- Chapter Eight, Toxicity
- Chapter Nine, Pretreatment
- Chapter Ten, Sewage Sludge
- Chapter Eleven, Storm Water
- Chapter Twelve, Combined Sewer Overflows
- Chapter Thirteen, Pollution Prevention
- Chapter Fourteen, Multi-Media Concerns

Within each chapter, tables illustrate the topics discussed in the text. These are located at the end of the chapter subsection in which they are referenced. Additional information and figures are also included in the appendices to the manual. As appropriate, references and checklists are provided at the end of the chapter. The checklists presented in this manual are intended as guidance. They can be used as presented or modified to address the needs of the inspection authority. (More detailed checklists for any individual inspection type may have also been developed by EPA or State agencies and are presented in the guidance materials specific to that type of inspection.)

It should be noted that the text often is written from the perspective of the Federal Clean Water Act requirements. State NPDES inspectors using this manual may find that State rules and procedures on such topics as notice to the permittees vary to some degree from the material found in this manual. The technical material will, we hope, prove to be useful to all NPDES inspectors.

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ACKNOWLEDGMENTS

This document represents an update of the May 1988 manual. We would like to thank the considerable efforts and cooperation of the persons who reviewed this document and provided comments.

This manual was prepared under the direction of Gary Polvi. Extensive reviews were conducted by EPA Headquarters, Regional Offices, and many State agencies during this update. These reviews provided valuable comments, most of which were incorporated into this manual.

This manual was revised by Science Applications International Corporation (SAIC) under EPA Contract No. 68-C8-0066.

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LIST OF ACRONYMS

Acronym	Full Phrase
APHA	American Public Health Association
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BAT/BCT	Best Available Technology/Best Control Technology
BMP	Best Management Practice
BMR	Baseline Monitoring Report
BOD	Biochemical Oxygen Demand
CAA	Clean Air Act
CBI	Compliance Biomonitoring Inspection
CEI	Compliance Evaluation Inspection
CEM	Continuous Emission Monitoring
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERI	Center for Environmental Research Information
CFR	*Code of Federal Regulations*
ChV	Chronic Value
COD	Chemical Oxygen Demand
COM	Continuous Opacity Monitoring
CPLR	Cumulative Pollutant Loading Rate
CSI	Compliance Sampling Inspection
CSO	Combined Sewer Overflow
CSS	Combined Sewer System
CWA	Clean Water Act
CWF	Combined Wastestream Formula
DI	Diagnostic Inspection
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DOI	Department of Interior
DOT	Department of Transportation
DSS	Domestic Sewage Study
DWO	Dry Weather Overflow
EC_{50}	Concentration that causes an effect in 50% of the test organisms
EMSL	Environmental Monitoring Systems Laboratory
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FINDS	Facility Index System
FR	*Federal Register*
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectroscopy
ICP	Inductively Coupled Plasma
IU	Industrial User
LC	Lethal Concentration
LC_{50}	Concentration at which 50% of the test organisms die in a specified time period

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LIST OF ACRONYMS (Continued)

Acronym	Full Phrase
LD_{50}	Dose at which 50% of the test organisms die in a specific time period
LDR	Land Disposal Restrictions
LOEC	Lowest-Observed-Effect-Concentration
LSI	Legal Support Inspection
LTCP	Long-Term Control Plan
LVE	Low Volume Exemption
MCL	Maximum Contaminant Level
MEP	Maximum Extent Practicable
MGD	Million Gallons per Day
MIT	Mechanical Integrity Testing
MPN	Most Probable Number
MSWLF	Municipal Solid Waste Landfill
MWPP	Municipal Water Pollution Prevention
NAAQS	National Ambient Air Quality Standards
NEIC	National Enforcement Investigation Center
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOC	Notice of Commencement
NOEC	No Observable Effect Concentration
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollutant Discharge Elimination System
NSPS	New Source Performance Standards
NURP	National Urban Runoff Program
O&M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
PAI	Performance Audit Inspection
PCB	Polychlorinated Biphenyl
PCI	Pretreatment Compliance Inspection
PCS	Permit Compliance System
PFRP	Processes to Further Reduce Pathogens
PIES	Pollution Information Exchange System
PIRT	Pretreatment Implementation Review Task Force
PL	Public Law
PMN	Premanufacture Notification
POTW	Publicly Owned Treatment Works
PPETS	Pretreatment Permits and Enforcement Tracking System
PPIC	Pollution Prevention Information Clearinghouse
PSD	Prevention Significant Deterioration
PSRP	Processes to Significantly Reduce Pathogens
QA	Quality Assurance
QC	Quality Control
QNCR	Quarterly Noncompliance Report
R&D	Research and Development
RBC	Rotating Biological Contactor
RCRA	Resource Conservation and Recovery Act
RI	Reconnaissance Inspection

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LIST OF ACRONYMS (Continued)

Acronym	Full Phrase
RNC	Reportable Noncompliance
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SNC	Significant Noncompliance
SNUR	Significant New Use Rule
SOUR	Specific Oxygen Uptake Rate
SPCC	Spill Prevention Control and Countermeasure Plan
SS	Suspended Solids
TCLP	Toxicity Characteristic Leaching Procedure
TDDP	Treatment, Destruction, and Disposal Facility
TIE	Toxicity Identification Evaluation
TKN	Total Kjeldahl Nitrogen
TME	Test Marketing Exemption
TRE	Toxicity Reduction Evaluation
TS	Total Solids
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
TSS	Total Suspended Solids
TVS	Total Volatile Solids
UIC	Underground Inspection Control
USC	United States Code
USDW	Underground Source of Drinking Water
USGS	United States Geological Survey
UST	Underground Storage Tank
VEO	Visible Emission Observation
VOC	Volatile Organic Compound
WEF	Water Environment Federation
WENDB	Water Enforcement Data Base
WET	Whole Effluent Toxicity
WPCF	Water Pollution Control Federation
WQA	Water Quality Act
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant
XSI	Toxics Sampling Inspection

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1. INTRODUCTION

A. Purpose and Objectives

Under 40 *Code of Regulations* (*CFR*) 123.26 (relating to State programs), three objectives should be met during a routine compliance inspection. According to this section, the inspection should be performed in a manner designed to:

- Determine compliance status with permit conditions and other program requirements
- Verify the accuracy of information submitted by permittees
- Verify the adequacy of sampling and monitoring conducted by the permittee.

Other purposes of compliance inspections include:

- Gathering evidence to support enforcement actions
- Obtaining information that supports the permitting process
- Assessing compliance with orders or consent decrees.

Inspection Types

This manual provides guidance applicable to each type of inspection a National Pollutant Discharge Elimination System (NPDES) inspector may be required to conduct at an NPDES permitted facility. The different types of inspections are described below.

Compliance Evaluation Inspection (CEI)

The CEI is a nonsampling inspection designed to verify permittee compliance with applicable permit self-monitoring requirements, effluent limits, and compliance schedules. This inspection involves records reviews, visual observations, and evaluations of the treatment facilities, laboratories, effluents, receiving waters, etc. The CEI examines both chemical and biological self-monitoring and forms the basis for all other inspection types except the Reconnaissance Inspection.

Compliance Sampling Inspection (CSI)

During the CSI, representative samples required by the permit are obtained. Chemical and bacteriological analyses are performed, and the results are used to verify the accuracy of the permittee's self-monitoring program and reports; determine compliance with discharge limitations; determine the quantity and quality of effluents; develop permits; and provide

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evidence for enforcement proceedings where appropriate. In addition, the CSI includes the same objectives and tasks as a CEI.

Performance Audit Inspection (PAI)

The PAI is used to evaluate the permittee's self-monitoring program. As with a CEI, the PAI is used to verify the permittee's reported data and compliance through a records check. However, the PAI provides a more resource-intensive review of the permittee's self-monitoring program and evaluates the permittee's procedures for sample collection, flow measurement, chain-of-custody, laboratory analyses, data compilation, reporting, and other areas related to the self-monitoring program. In a CEI, the inspector makes a cursory visual observation of the treatment facility, laboratory, effluents, and receiving waters. In a PAI, the inspector actually observes the permittee performing the self-monitoring process from sample collection and flow measurement through laboratory analyses, data workup, and reporting. The PAI does not include the collection of samples by the inspector. However, the inspector may require the permittee to analyze performance samples for laboratory evaluation purposes.

Compliance Biomonitoring Inspection (CBI)

This inspection includes the same objectives and tasks as a CSI. A CBI reviews a permittee's toxicity bioassay techniques and records maintenance to evaluate compliance with the biomonitoring terms of the NPDES permit and to determine whether the permittee's effluent is toxic. The CBI also includes the collection of effluent samples by the inspector to conduct acute and chronic toxicity testing to evaluate the biological effect of a permittee's effluent discharge(s) on test organisms.

Toxics Sampling Inspection (XSI)

The XSI has the same objectives as a conventional CSI. However, it places increased emphasis on toxic substances regulated by the NPDES permit. The XSI covers priority pollutants other than heavy metals, phenols, and cyanide, which are typically included in a CSI (if regulated by the NPDES permit). An XSI uses more resources than a CSI because highly sophisticated techniques are required to sample and analyze toxic pollutants. An XSI may also evaluate raw materials, process operations, and treatment facilities to identify toxic substances requiring controls.

Diagnostic Inspection (DI)

The DI primarily focuses on Publicly Owned Treatment Works (POTWs) that have not achieved permit compliance. POTWs who are having difficulty diagnosing their problems are targeted. The purposes of the DI are to identify the causes of noncompliance, suggest immediate remedies that will help the POTW achieve compliance, and support current or future enforcement action. Once the cause of noncompliance is defined, an administrative

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order is usually issued that requires the permittee to conduct a detailed analysis and develop a composite correction plan.

Reconnaissance Inspection (RI)

The RI is used to obtain a preliminary overview of a permittee's compliance program. The inspector performs a brief visual inspection of the permittee's treatment facility, effluents, and receiving waters. The RI uses the inspector's experience and judgment to summarize quickly any potential compliance problems. The objective of the RI is to expand inspection coverage without increasing inspection resources. The RI is the briefest and least resource intensive of all NPDES inspections.

Pretreatment Compliance Inspection (PCI)

The PCI evaluates the POTW's implementation of its approved pretreatment program. It includes a review of the POTW's records on monitoring, inspections, and enforcement activities for its industrial users (IUs). The PCI may be supplemented with IU inspections. An IU inspection is an inspection of any significant IU that discharges to the POTW. The inspection can include sampling or not, depending on the reason for the inspection. If feasible, inspectors should conduct the PCI concurrently with another NPDES inspection of the POTW. Additional guidance is available in the U.S. Environmental Protection Agency (EPA) *Guidance for Conducting a Pretreatment Compliance Inspection* (September, 1991).

It should be noted that a related type of review procedure, the pretreatment audit, is also performed by Approval Authorities. The pretreatment audit is not treated in depth in this manual because it is not regarded as a true NPDES compliance inspection. The pretreatment audit is defined and discussed in Section 1.2, page 1-1, of the U.S. EPA guidance manual *Pretreatment Compliance Inspection and Audit Manual for Approval Authorities* (July, 1986) and the *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992).

Legal Support Inspection (LSI)

The LSI is a resource intensive inspection conducted when an enforcement problem is identified as a result of a routine inspection or a complaint. For an LSI, the appropriate resources are assembled to deal effectively with a specific enforcement problem.

Summary

Table 1-1 matches minimum inspection activities with each of the inspection types. The given activities are only minimum requirements, and an inspector is not limited to the stated activities; additional activities may be conducted, depending upon the focus of the inspection.

The inspector should plan all activities and coordinate with compliance personnel before the inspection. The minimum requirements may serve as a basis for deciding what activities will be conducted onsite and for determining what additional information is to be gathered or

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verified during the inspection. Compliance personnel should choose the type of inspection to be conducted based on the compliance status of the facility, the information needed from the facility, and the type of facility involved.

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Table 1-1

Comparison of Inspection Activities With Inspection Types

Activity Description	Inspection Types							
	CEI	CSI	PAI	CBI	XSI	DI	RI	PCI
Pre-Inspection								
Review of Facility Background	I	I	I	I	I	I	I	I
Development of an Inspection Plan	O	I	O	I	I	O	O	O
Notification of the Facility	O	O	O	O	O	O	O	O
Entry Onsite								
Entry Procedures	I	I	I	I	I	I	I	I
Opening Conference	C	C	C	C	C	C	C	C
Recordkeeping and Reporting								
Permit Information Verification	I	I	I	C	I	I	O	O
Evaluation Procedures	I	I	I	C	I	I	C	C
Compliance Schedule Status Review	I	I	I	-	I	I	I	I
Pretreatment Record Review	C	O	O	-	O	C	-	I
Facility Site Review								
Physical Inspection	I	C	C	C	C	I	C	O
Operation Evaluation	C	C	C	C	C	I	C	O
Maintenance Evaluation	C	C	C	C	C	I	C	-
Sampling								
Evaluation of Permittee Program	I	I	I	O	I	I	C	C
Inspector's Compliance Sampling	-	I	-	I	I	O	-	O
Flow Measurement								
Evaluation of Permittee Flow Measurement	I	I	I	I	I	I	C	O
Verification of Flow Measurements	C	I	C	C	C	I	C	C
Biomonitoring								
Evaluation of Permittee Self-Monitoring Program	C	C	I	I	C	C	-	-
Compliance Biomonitoring	-	-	-	I	-	-	-	-
Laboratory Quality Assurance								
Sampling Techniques Evaluation	I	I	I	C	C	C	C	O
Analyses Techniques Evaluation	C	C	I	C	C	C	C	O
Laboratory Quality Assurance	C	C	I	C	C	C	C	O

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Table 1-1

Comparison of Inspection Activities With Inspection Types (Continued)

Activity Description	Inspection Types							
	CEI	CSI	PAI	CBI	XSI	DI	RI	PCI
Other Site Activities								
Inspection of Industrial Discharges to POTWs	-	-	-	-	-	-	-	O
Documentation of Hazardous Waste Storage and Disposal	-	O	O	O	O	O	O	O
Documentation of Air Pollution Releases	-	O	O	O	O	O	O	O
Sludge Management Releases		C	C	C	C	C	C	C
Documentation								
Field Notes and Statements	I	I	I	I	I	I	I	I
Photographs, Drawings, and Maps	O	C	O	O	O	I	C	O
Copies of Facility Records	O	O	O	O	O	I	O	I
Closing Procedures								
Closing Conference	I	I	I	I	I	I	I	I
Notice of Deficiency	O	O	O	O	O	O	O	O
Follow-Up								
Inspection Form	I	I	I	I	I	I	I	I
Narrative Comments/Checklists	I	I	I	I	I	I	I	I
Input on PCS	I	I	I	I	I	I	I	I

LEGEND
I - Activity is conducted in an in-depth manner.
C - Activity is conducted in a cursory manner.
O - Activity is optional, but may be recommended by Regional or State policy.

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1. INTRODUCTION

B. Legal Authority for NPDES Inspections

The Federal Water Pollution Control Act of 1972, as amended by the Clean Water Act (CWA or the Act) of 1977 and the Water Quality Act of 1987, gives the Environmental Protection Agency (EPA) the authority to regulate the discharge of pollutants to waters of the United States. The Act provides broadly defined authority to establish the NPDES Permit Program, define pollution control technologies, establish effluent limitations, obtain information through reporting and compliance inspections, and take enforcement actions (both civil and criminal) when violations of the Act occur. Table 1-2 provides a listing of applicable NPDES statutes and regulations.

Inspection Authority

Under Section 402 of the Act, point source dischargers of pollutants (e.g., municipal wastewater treatment plants, industries, animal feedlots, aquatic animal production facilities, and mining operations) are issued permits that set specific limits and operating conditions to be met by the permittee. Section 308 authorizes inspections and monitoring to determine whether NPDES permit conditions are being met. This section provides for two types of monitoring:

- Self-monitoring, where the facility must monitor itself
- Monitoring by the permit-issuing agency (EPA or State), a process that may include the agency's evaluating the self-monitoring and/or conducting its own monitoring.

According to the Act, EPA may conduct an inspection, including storm water, sludge, combined sewer overflows, and pretreatment, wherever there is an existing NPDES permit. Inspections may also be conducted where a discharge exists or is likely to exist and no permit has been issued.

State Program Authority

Much of the compliance with the NPDES program is monitored by the State. Sections 308 and 402 of the Act provide for the transfer of Federal program authority to States to conduct NPDES permit compliance monitoring. EPA Regional Administrators and some State water pollution control agencies have signed formal cooperative agreements that ensure timely, accurate monitoring of compliance with permit conditions. States may implement requirements and regulations that are more stringent than those under the CWA.

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Table 1-2

NPDES-Related Statutes and Regulations

Topic	Reference	
	CWA[1]	40 *CFR*[2]
Inspection Authority	§308	122.41(i), 123.26
Self-Monitoring and Recordkeeping Authority	§308	122.41(h), (j), and (l), 122.48
Confidential Information	§308(b)	2.201, 2.215, 2.302, 122.7
Emergency Authority	§504	123.27
Employee Protection	§507	———
Permits	§402	122, 123.25
EPA Permitting Procedures	§402	124
Technical Requirements	§§301,304,307	129, 133, 136
Best Management Practices (BMP)	§304(e)	125
Spill Prevention Control and	§311	112
Countermeasure (SPCC) Plan Waivers	§301	125, 230
Effluent Guidelines	§304	405-471
Pretreatment Standards	§§307, 402	122.21, 403, and 405-471
Sludge	§405	60, 61, 123, 258, 501, and 503

1 Clean Water Act
2 Code of Federal Regulations, Revised as of July 1, 1994

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1. INTRODUCTION

C. Responsibilities of the NPDES Inspector

The primary role of a NPDES inspector is to gather information that can be used to determine the reliability of the permittee's self-monitoring data and evaluate compliance with permit conditions, applicable regulations, and other requirements. The NPDES inspector also plays an important role in enforcement case development and support, and in permit development. To fulfill these roles, inspectors are required to know and abide by applicable regulations, permits, policies, and procedures; legal requirements concerning inspections; procedures for effective inspection and evidence collection; accepted safety practices; and quality assurance standards.

Legal Responsibilities

Inspectors must conduct all inspection activities within the legal framework established by the Act, including:

- Presenting proper credentials
- Properly handling confidential business information.

Inspectors also must be familiar with the conditions of the specific permit and with all applicable statutes and regulations.

Procedural Responsibilities

Inspectors must be familiar with general inspection procedures and evidence collection techniques to ensure adequate inspections and to avoid endangering potential legal proceedings on procedural grounds.

Inspection Procedures

Inspectors should observe standard procedures for conducting each inspection element. The elements of the inspection process listed in Table 1-3 are common to most NPDES compliance inspections. They are grouped by the major inspection activities:

- Pre-Inspection Preparation
- Entry
- Opening Conference
- Facility Inspection

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- Closing Conference
- Inspection Report.

While the emphasis given to each element may vary among facilities, the inspector's procedural responsibilities remain as listed.

Evidence Collection

Inspectors must be familiar with general evidence-gathering techniques. Because the Government's case in a civil, criminal, or administrative prosecution depends on the evidence they have gathered, inspectors must keep detailed records of each inspection. These data will be used for preparing the inspection report, determining the appropriate enforcement response, and giving testimony in an enforcement case.

In particular, inspectors must know how to:

- Substantiate facts with items of evidence, including samples, photographs, document copies, statements from witnesses, and personal observations
- Evaluate what evidence is necessary (routine inspections)
- Abide by chain-of-custody procedures
- Collect and preserve evidence in a manner that will be incontestable in legal proceedings
- Write clear, objective, and informative inspection reports
- Testify in court and administrative hearings.

Inspection procedures are discussed in detail in Chapter Two of this manual.

Safety Responsibilities

The inspection of wastewater and other environmental pollution control facilities always poses a certain degree of health and safety risk. To avoid unnecessary risks, the inspector should be familiar with all safety obligations and practices, including Regional or State policy and requirements. The safety equipment and procedures required for a facility will be based on either standard safety procedures or the response to the 308 (inspection notification) Letter. Inspectors should do the following:

- Use safety equipment in accordance with available guidance and labeling instructions.
- Maintain safety equipment in good condition and proper working order.

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- Dress appropriately for the particular activity and wear appropriate protective clothing. For example, gloves should be worn during sample collection to protect the inspector and to prevent the potential for sample contamination.

- Use any safety equipment customary in the establishment being inspected (e.g., hard hat or safety glasses).

- Never enter confined spaces unless properly trained, equipped, and permitted (if applicable).

For any safety-related questions not covered in this manual, consult the current approved safety manual for greater detail. Appendix A contains EPA's Order 1440.2, Health and Safety Requirements for Employees Engaged in Field Activities.

Professional Responsibilities

Inspectors are expected to perform their duties with the highest degree of professionalism. Procedures and requirements ensuring ethical actions have been established through many years of Government inspection experience. The procedures and standards of conduct listed below have evolved for the protection of the individual and EPA, as well as industry.

- All inspections are to be conducted within the framework of the United States Constitution and with due regard for individual rights regardless of race, sex, creed, or national origin.

- Inspectors are to conduct themselves at all times in accordance with the regulations prescribing employee responsibilities and conduct.

- The facts of an inspection are to be noted and reported completely, accurately, and objectively.

- In the course of an inspection, any act or failure to act motivated by reason of private gain is illegal. Actions that could be construed as such should be scrupulously avoided.

- A continuing effort should be made to improve professional knowledge and technical skill in the inspection field.

Professional Attitude

The inspector is a representative of EPA and is often the initial or only contact between EPA and the permittees. In dealing with facility representatives and employees, inspectors must be professional, tactful, courteous, and diplomatic. A firm but responsive attitude will encourage cooperation and initiate good working relations. Inspectors should not speak derogatorily of any product, manufacturer, or person.

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Attire

Inspectors should dress appropriately, including wearing protective clothing or equipment, for the activity in which they are engaged.

Gifts, Favors, Luncheons

Inspectors should not accept favors, benefits, or job offers under circumstances that might be construed as influencing the performance of governmental duties. If offered a bribe, the inspector should:

- Ask what the offer is for
- Explain, if the offer is repeated, that both parties to such transactions may be guilty of violating Federal statutes
- Not accept any money or goods
- Report the incident in detail to supervisor.

Employees are not authorized to accept business luncheons; they must pick up their own checks. (See page 20, *U.S. EPA Guidance on Ethics and Conflict of Interest*, February 1984, and 5 *CFR* 2635, Standards of Ethical Conduct for Employees of the Executive Branch, August 7, 1992.) If ethics issues arise, the inspector should contact the proper EPA or State official.

Requests for Information

EPA has an "open-door" policy on releasing information to the public. This policy is to make information concerning EPA and its work freely and equally available to all interested individuals, groups, and organizations. In fact, EPA employees have both a legal and traditional responsibility for making useful educational and safety information available to the public. This policy, however, does not extend to information about a suspected violation, evidence of possible misconduct, or confidential business information. The disclosure of information is discussed further in Chapter Two, Disclosure of Official Information.

Quality Assurance Responsibilities

The inspector must assume primary responsibility for ensuring the quality and accuracy of compliance inspection and analytical data. While other organizational elements play an important role in quality assurance, it is the inspector who must ensure that all data introduced into an inspection file are complete, accurate, and representative of existing conditions. To help the inspector meet this responsibility, Regional Offices have established quality assurance plans that identify individual responsibilities and document detailed procedures.

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The objective of a quality assurance plan is to establish standards that will guarantee that inspection and analytical data meet the requirements of all users. Many elements of quality assurance plans are incorporated directly into the basic inspection procedures and may not be specifically identified as quality assurance techniques.

The inspector must be aware that following established inspection procedures is critical to the inspection program. These procedures have been developed to reflect the following quality assurance elements:

- Valid data collection
- Approved standard methods
- Control of service, equipment, and supplies
- Standard data handling and reporting.

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Table 1-3

Inspector's Responsibilities

Pre-Inspection Preparation. Ensure effective use of inspection resources.

- Notify facility, if applicable.
- Establish purpose and scope of inspection.
- Review background information and EPA records, including permit and permittee compliance file.
- Contact appropriate staff personnel responsible for the permittee: compliance personnel, pretreatment coordinator, etc.
- Develop plan for inspection.
- Prepare documents and equipment, including appropriate safety equipment.
- Coordinate schedule with laboratory if samples are to be collected.
- Coordinate schedule with other appropriate regulatory authorities.
- Contact party responsible for sample transportation, for packing/shipping requirements.

Entry. Establish legal entry to facility.

- Present official credentials.
- Manage denial of entry if necessary.

Opening Conference. Orient facility officials to inspection plan.

- Discuss inspection objectives and scope.
- Establish working relationship with facility officials.

Facility Inspection. Determine compliance with permit conditions; collect evidence of violations.

- Conduct visual inspection of facility.
- Review facility records.
- Inspect monitoring location, equipment, and operations.
- Collect samples, if appropriate.
- Review laboratory records for QA/QC.
- Review laboratory procedures to verify use of approved methods.
- Document inspection activities.

Closing Conference. Conclude inspection.

- Collect missing or additional information.
- Clarify questions with facility officials.
- Prepare necessary receipts.
- Review inspection findings and inform officials of follow-up procedures.
- Issue deficiency notice, if appropriate.

Inspection Report. Organize inspection findings in a report so as to be useful in the development and support of evidence for potential enforcement action.

- Complete NPDES Compliance Inspection Report Form 3560.
- Prepare narrative report, checklists, and documentary information as appropriate.

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2. INSPECTION PROCEDURES

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2. INSPECTION PROCEDURES

A. Pre-Inspection Preparation

Pre-planning is necessary to ensure that the inspection is focused properly and is conducted smoothly and efficiently. It involves:

- Review of facility background information
- Development of an inspection plan
- Notification of the facility, if applicable
- State notification of Federal inspection
- Equipment preparation.

Review of Facility Background Information

Collection and analysis of available background information on the candidate facility are essential to the effective planning and overall success of a compliance inspection. Materials obtained from files of Federal, State, and local agencies, technical libraries, and other information sources will enable inspectors to familiarize themselves with facility operations; conduct a timely inspection; minimize inconvenience to the facility by not requesting data previously provided to the Federal, State, and/or local agencies; conduct a thorough and efficient inspection; clarify technical and legal issues before entry; and develop a sound and factual inspection report. The types of information that may be available for review are listed below. The inspector must determine the amount of background information necessary for the inspection and in collecting this information, should focus on the characteristics unique to the permittee: design, historical practices, legal requirements, etc.

General Facility Information

- Maps showing facility location, plumbing including wastewater discharge pipes, sampling points, overflow and bypass points, and geographic features
- Plant layout and process flow diagram
- Names, titles, and telephone numbers of responsible facility officials
- Any special entry requirements
- Any safety requirements
- Description of processing operations and wastewater discharges
- Production levels—past, present, and future

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- Hydrological data
- Geology/hydrogeology of the area
- Changes in facility conditions since previous inspection/permit application
- Available aerial photographs.

Requirements, Regulations, and Limitations

- Copies of Federal, State, and local existing permits, regulations, and requirements and restrictions placed on permittee discharges in the form of standards and compliance schedules
- Monitoring and reporting requirements and available monitoring stations
- Special exemptions and waivers, if any
- Receiving stream water quality standards
- Information concerning sludge, air, solid, and hazardous waste treatment and disposal.

Facility Compliance and Enforcement History

- Previous inspection reports
- Correspondence among facility, local, State, and Federal agencies
- Complaints and reports, follow-up studies, findings, and remedial action
- Documentation on past compliance violations, exceedences, status of requested regulatory corrective action, if any
- Enforcement actions such as compliance schedules and consent orders
- Status of current and pending litigation against facility
- Self-monitoring data and reports
- Previous Environmental Protection Agency (EPA), State, or consultant studies and reports
- Previous deficiency notices issued to facility
- Laboratory capabilities and analytical methods used by the facility
- Name(s) of contract laboratories, if applicable

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- Previous Discharge Monitoring Report (DMR)—Quality Assurance (QA) files and reports
- Permit Compliance System (PCS) information
- Reports from special studies (e.g., stream monitoring, internal audits) or compliance schedules.

Pollution Control and Treatment Systems

- Description and design data for pollution control system and process operation, if available
- Sources and characterization of discharge
- Type and amount of wastes discharged
- Spill prevention contingency plans, if available
- Available bypasses or diversions and spill containment facilities
- Pollution control units, treatment methods, and monitoring systems.

Pretreatment Information

- Information concerning compliance schedule to install technologies (industrial facilities) or develop a pretreatment program (Publicly Owned Treatment Works [POTWs])
- Pretreatment reports as required by the General Pretreatment Regulations, regional, State, or local requirements
- The POTW's enforcement response plan and sewer use ordinance, including local discharge limits
- Information concerning industrial discharges to POTWs, such as:

  - Industrial monitoring and reporting requirements
  - POTW monitoring and inspection program
  - Waste contribution to the POTW
  - Compliance status of industry with pretreatment requirements
  - POTW enforcement initiatives.

Chapter 9 of this manual discusses pretreatment program requirements in greater detail.

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Sources of Facility Background Information

Previous Inspections

Previous inspection reports can provide general facility information, as well as problems or concerns noted in previous inspections. Inspectors who have visited the facility for National Pollutant Discharge Elimination System (NPDES), pretreatment, or other regulatory programs may also provide information on the facility.

Laws and Regulations

The Clean Water Act (CWA) and related NPDES regulations establish procedures, controls, and other requirements applicable to a facility. In addition, State laws and regulations, and sometimes even local ordinances, are applicable to the same facility. Refer to Table 1-2 for a list of applicable NPDES-related statutes and regulations.

Permits and Permit Applications

Permits provide information on the limitations, requirements, and restrictions applicable to discharges; compliance schedules; and monitoring, analytical, and reporting requirements. Permit applications provide technical information on facility size, layout, and location of pollutant sources; treatment and control practices; contingency plans and emergency procedures; and pollutant characterization—types, amounts, applicability of effluent guidelines, and points/locations of discharge. Permit applications for air, solid, and hazardous waste treatment and disposal permits may provide additional information to the inspector that is not available elsewhere.

Regional and State Files and Personnel

Files or Regional and State personnel often can provide correspondence; facility self-monitoring data; inspection, Quarterly Noncompliance Report (QNCR), and DMR QA reports; and permits and permit applications applicable to individual facilities. They can provide compliance, enforcement, and litigation history; special exemptions and waivers applied for and granted or denied; citizen complaints and action taken; process operational problems/solutions; pollution problems/solutions; laboratory capabilities or inabilities; and other proposed or historical remedial actions. This information can provide design and operation data, recommendations for process controls, identification of pollutant sources, treatment/control systems improvement, and remedial measures.

Technical Reports, Documents, and References

These information sources provide generic information on waste loads and characterization, industrial process operations, and pertinent specific data on available treatment/control techniques, such as their advantages or disadvantages and limits of application and pollutant removal efficiencies. Such sources include Development Documents for Effluent Standards and Guidelines.

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Other Statutory Requirements

Facility files maintained by EPA and the State pursuant to other statutes (e.g., Toxic Substances Control Act [TSCA]; Resource Conservation and Recovery Act [RCRA]; Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]; Federal Insecticide, Fungicide and Rodenticide Act [FIFRA]; Clean Air Act [CAA]) may also contain information useful to the NPDES inspection.

Development of an Inspection Plan

Plans are helpful tools in organizing and conducting compliance inspections. A plan is, therefore, recommended to effectively conduct a compliance inspection. After reviewing the available background information, the inspector prepares a comprehensive plan to define inspection objectives, tasks and procedures, resources required to fulfill the objectives, inspection schedule, and when findings and conclusions on the work will be reported. At least the following items need to be considered:

- Objectives
  - What is the purpose of the inspection?
  - What is to be accomplished?
- Tasks
  - What tasks are to be conducted?
  - What information must be collected?
  - What records will be reviewed?
- Procedures
  - What procedures are to be used?
  - Will the inspection require special procedures?
- Resources
  - What personnel will be required?
  - What equipment will be required?
- Schedule
  - What will be the time requirements and order of inspection activities?
  - What will be the milestones?
- Coordination
  - What coordination with laboratories or other regulatory agencies will be required?

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An outline of tentative inspection objectives, meetings to be held, and records that will be reviewed can be prepared and presented to the facility officials during the opening conference.

Notification of the Facility

With regard to the EPA-administered NPDES program, the permittee is sometimes notified by a Section 308 Letter or "308 Letter" that the facility is scheduled for an inspection. (Appendix B is an example of a typical 308 Letter.) The signature authority for a 308 Letter may be delegated to a section chief. The 308 Letter advises the permittee that an inspection is imminent and usually requests information regarding on-site safety regulations to avoid problems concerning safety equipment at the time of inspection. The inspector may wish to facilitate the inspection process by suggesting that the permittee send general information to the inspector before the site visit. This information may include such items as names, addresses, and updated process information. The 308 Letter may specify the exact date of inspection, if coordination with the permittee is required. The 308 Letter also is used to inform the permittee of the right to assert a claim of confidentiality. Depending on the type of inspection, the permittee may be notified by telephone that an inspection is imminent. However, inspections are usually done without any pre-notification of the exact date.

Notification is not recommended when illegal discharges or emissions or improper records are suspected. The concern that physical conditions may be altered before the inspection or that records will be destroyed justifies an unannounced inspection. A written notification including information on the right to assert a claim of confidentiality can be presented at the time of the unannounced inspection.

State Notification of Federal Inspection

The inspector must be certain that the appropriate State regulatory agency is notified in a timely manner of inspections to be conducted in its jurisdiction. The State should be notified of all Federal inspections unless disclosing inspection information would jeopardize an unannounced inspection.

Preparation of Equipment and Supplies

If sampling is to be performed, part of the pre-inspection process involves obtaining and preparing sampling equipment. The type of equipment may vary according to the facility inspected and the type of inspection. Table 2-1 includes a list of field sampling equipment that may be needed. All equipment must be checked, calibrated, and tested before use. The inspector also must ensure that all materials necessary to complete an inspection are taken to the inspection site. The inspector is responsible for maintaining the equipment properly, in accordance with operating instructions.

Safety equipment and procedures required for a facility will be based on the response to the notification or 308 Letter and standard safety procedures. Safety requirements must be met,

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not only for safety reasons, but to ensure that the inspector is not denied entry to the facility or parts of it.

Photocopies of appropriate checklists to be used during the inspection should be obtained during the pre-inspection preparation.

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Table 2-1

List of Field Sampling Equipment

Field Equipment	
Documents and Recordkeeping Tools • File • Checklists • Log book • Shipping labels • Analysis request forms • Waterproof pen • Calculator	Protective Clothing • Hard hat • Hearing protection • Safety shoes • Gloves • Coveralls • Reflective safety vest • Safety glasses/goggles • Rainwear
Sampling Materials • Automatic samplers • Tubing • Sample containers, including extras • Batteries • Desiccant • Sample bottle labels/sample seals • Plastic security tape • Chain-of-custody forms • Dissolved oxygen meters • pH meter • TRC meter • pH buffer • Deionized water • Chart paper • Thermometer • Coolers/ice • Preservatives	Safety Equipment • First-aid kit • Meters (oxygen content, explosivity, and toxic gas • Safety harness and retrieval system • Ventilation equipment • Respirator • Filter cartridges • Self-contained breathing apparatus (if appropriate)
Sample Transportation Materials • Bubble pack material • Filament tape • Airbill/bill of lading	Tools • Multi-tooled jack knife (Swiss Army type) • Electrical and duct tape • Tape measure • Hand-held range finder and level • Camera/film • Flashlight • Screwdriver • Adjustable wrench and vise grips • Bucket (plastic or stainless steel, as appropriate) • Nylon cord
Flow Measurement Devices • Measurement devices (e.g., flumes, weirs, portable ultrasound or bubble systems) • Flow discharge tables • Level • Ruler • Stopwatch or watch with second hand	

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2. INSPECTION PROCEDURES

B. Entry

Entry Procedures

Authority

The basic authority for entry into a wastewater facility is §308(a)(4)(B) of the CWA which states:

> the Administrator or his authorized representative, upon presentation of his credentials shall have a right of entry to, upon, or through any premises in which an effluent source is located or in which any records are required to be maintained . . . and may at reasonable times have access to and copy any records, inspect any monitoring equipment or method . . . and sample any effluents which the owner or operator of such source is required to sample.

In addition, NPDES permits contain inspection authority provisions.

Arrival

Arrival at the facility and the facility inspection should occur during normal working hours. The facility owner or agent in charge should be located as soon as the inspector arrives on the premises. Prior to entering a facility, inspectors should observe it as thoroughly as possible from public grounds.

Credentials

When the proper facility officials have been located, the inspector must introduce himself or herself as an EPA/State inspector and present the proper EPA/State credentials. These credentials indicate that the holder is a lawful representative of the regulatory agency and is authorized to perform NPDES inspections. The credentials must be presented whether or not identification is requested.

After facility officials have reviewed the credentials, the officials may telephone the appropriate State or EPA Regional Office for verification of the inspector's identification. Credentials should never leave the sight of the inspector.

Consent

Consent to inspect the premises must be given by the owner or operator at the time of the inspection. As long as the inspector is allowed to enter, entry is considered voluntary and consensual, unless the inspector is expressly told to leave the premises. Expressed consent is not necessary; absence of an expressed denial constitutes consent.

Reluctance to Give Consent. The receptiveness of facility officials toward inspectors is likely to vary among facilities. Most inspections will proceed without difficulty. If consent to enter is flatly denied, the inspector should follow denial of entry procedures. In other cases, officials may be reluctant to give entry consent because of misunderstood responsibilities, inconvenience to a firm's schedule, or other reasons that may be overcome by diplomacy and discussion.

Whenever there is a difficulty in gaining consent to enter, inspectors should tactfully probe the reasons and work with officials to overcome the problems. Care should be taken, however, to avoid threats of any kind, inflammatory discussions, or deepening of misunderstandings. If the situation is beyond the authority or ability of the inspector to manage, the regulatory office should be contacted for guidance.

Claims of Confidentiality

The inspector should explain the permittee's right to claim material as confidential and that the inspector may examine areas related to effluent production or storage even if the permittee has asserted claims of confidentiality. Confidential information is discussed in greater detail later in this chapter.

Uncredentialed Persons Accompanying an Inspector. The consent of the owner or agent in charge must be obtained for persons accompanying an inspector to enter a site if they do not have specific authorization. If consent is not given, these persons may not enter the premises. If consent is given, they may not view confidential business information unless officially authorized for access.

Waivers, Releases, and Sign-In Logs

When the facility provides a blank sign-in sheet, log, or visitor register, it is acceptable for inspectors to sign it. However, EPA employees must not sign any type of "waiver" or "visitor release" that would relieve the facility of responsibility for injury or that would limit the rights of EPA to use data obtained from the facility. The inspector must not agree to any such unwarranted, restrictive conditions.

If such a waiver or release is presented, the inspectors should politely explain that they cannot sign and request a blank sign-in sheet. If the inspectors are refused entry because they do not sign the release, they should leave and immediately report all pertinent facts to the appropriate supervisory and/or legal staff. All events surrounding the refused entry should be

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fully documented. Problems should be discussed cordially and professionally. Facility officials must not be subjected to intimidation by the Federal/State inspectors.

Problems With Entry or Consent

Because inspections may be considered adversarial proceedings, the legal authority, techniques, and competency of inspectors may be challenged. Facility officials also may display antagonism toward EPA personnel. In all cases, inspectors must cordially explain the authorities and reasons for the protocols followed. If explanations are not satisfactory or disagreements cannot be resolved, the inspectors should leave and obtain further direction from the appropriate EPA supervisory or legal staff. Professionalism and politeness must prevail at all times. Appendix C contains EPA's Memorandum on Entry Procedures.

Denial of Entry

If an inspector is refused entry into a facility for the purpose of an inspection under the CWA, certain procedural steps must be followed. The procedures have been developed in accordance with the 1978 U.S. Supreme Court decision in Marshal v. Barlow's, Inc.

- Ensure that all credentials and notices are presented properly to the facility owner or agent in charge.
- If entry is not granted, ask why. Tactfully probe the reason for the denial to see if obstacles (such as misunderstandings) can be cleared. If resolution is beyond the authority of the inspector, he or she may suggest that the officials seek advice from their attorneys to clarify EPA's inspection authority under Section 308 of the CWA.
- If entry is still denied, the inspector should withdraw from the premises and contact his or her supervisor. The supervisor will confer with attorneys to discuss the desirability of obtaining an administrative warrant.
- All observations pertaining to the denial are to be carefully noted in the field notebook and inspection report. Include such information as the facility name and exact address, name and title of person(s) approached, authority of person(s) who refused entry, date and time of denial, detailed reasons for denial, facility appearance, and any reasonable suspicions that refusal was based on a desire to cover up regulatory violations. All such information will be important should a warrant be sought.

Important Considerations

- Under no circumstances should the inspector discuss potential penalties or do anything that may be construed as coercive or threatening.
- Inspectors should use discretion and avoid potentially threatening or inflammatory situations. If a threatening confrontation occurs, the inspector should document it and

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then report it immediately to the staff attorney. If feasible, statements from witnesses should be obtained and included in the documentation.

Withdrawal of Consent During Inspection

If the facility representative asks the inspector to leave the premises after the inspection has begun, the inspector should leave as quickly as possible following the procedures discussed previously for denial of entry. All activities and evidence obtained before the withdrawal of consent are valid. The inspector should ensure that all personal and government equipment is removed from the facility.

Denial of Access to Some Areas of the Facility

If, during the course of the inspection, access to some parts of the facility is denied, the inspector should make a notation of the circumstances surrounding the denial of access and of the portion of the inspection that could not be completed. He or she then should proceed with the rest of the inspection. After leaving the facility, the inspector should contact his or her supervisor and staff attorney at the Regional Office to determine whether a warrant should be obtained to complete the inspection.

Warrants

The inspector may be instructed by EPA attorneys, under certain circumstances, to conduct an inspection under search warrant. A warrant is a judicial authorization for appropriate persons to enter specifically described locations to inspect specific functions. A pre-inspection warrant possibly could be obtained where there is reason to believe that entry will be denied when the inspector arrives at the facility or when the inspector anticipates violations that could be hidden during the time required to obtain a search warrant.

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2. INSPECTION PROCEDURES

C. Opening Conference

Once credentials have been presented and legal entry has been established, the inspector can proceed to outline inspection plans with facility officials. At the opening conference, the inspector provides names of the inspectors, the purpose of the inspection, authorities under which the inspection is being conducted, and procedures to be followed. EPA encourages cooperation between the inspectors and the facility officials in order to facilitate assignments and ensure the success of the inspection.

Considerations

Inspection Objectives

An outline of inspection objectives will inform facility officials of the purpose and scope of the inspection and may help avoid misunderstandings.

Order of Inspection

A discussion of the order in which the inspection will be conducted will help eliminate wasted time by allowing officials time to make records available and start up intermittent operations.

Meeting Schedules

A schedule of meetings with key personnel will allow facility officials adequate time to spend with the inspector.

List of Records

A list of facility records that will need to be reviewed as part of the inspection should be provided to facility officials. This will allow the officials adequate time to gather the records and make them available for the inspector.

Accompaniment

It is important that a facility official accompany the inspector during the inspection not only to answer questions and describe the plant and its principal operating characteristics, but also for safety and liability considerations. Discussion of such needs with facility officials will provide them the opportunity to allocate personnel for this purpose. It is also advisable that the

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inspector talk to the personnel actually responsible for performing sample collection and analysis to gather specific information on these procedures.

Permit Verification

The inspector should verify pertinent information included in the permit, such as facility name and address, receiving waters, and discharge points.

Safety Requirements

The inspector should reaffirm which Occupational Safety and Health Administration (OSHA) and facility safety regulations will be involved in the inspection and should determine whether preparations were adequate.

Closing Conference

A post-inspection meeting should be scheduled with appropriate officials to provide a final opportunity to gather information, answer questions, present findings and deficiencies, and complete administrative duties.

New Requirements

The inspector should discuss and answer questions pertaining to any new rules and regulations that might affect the facility. If the inspector is aware of proposed rules that might affect the facility, he or she may wish to encourage facility officials to obtain a copy.

Split Samples

Facility officials should be informed during the opening conference of their right to receive a split or duplicate of any physical sample collected for laboratory analysis if sufficient sample volume is collected. Officials should indicate at this point their desire to receive split and duplicate samples so that arrangements can be made to secure the samples during inspection.

Photographs

Photographs can be used to prepare a more thorough and accurate inspection report, as evidence in enforcement proceedings, and to explain better conditions found at the plant. The facility officials, however, may object to the use of cameras on their property. If a mutually acceptable solution cannot be reached and photographs are considered essential to the inspection, EPA supervisory and legal staff should be contacted for advice.

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Facility personnel also may request that any photographs taken during the visit be considered confidential. EPA is obliged to comply with this request pending further legal determination. Facility officials may refuse permission to take photographs unless they can see the finished print. Self-developing film, although of lower quality, is useful in certain situations. Duplicate photographs (one for the inspector and the other for the facility) should also satisfy this need.

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2. INSPECTION PROCEDURES

D. Documentation

Providing strong documentary support of discrepancies discovered in an inspection is an inspector's basic responsibility. Documentation serves to "freeze" the actual conditions existing at the time of inspection so that evidence can be examined objectively by compliance personnel.

Documentation is a general term referring to all printed information and mechanical media produced, copied, or taken by an inspector to provide evidence of suspected violations. Some types are the field notebook, statements, photographs, videotapes, drawings, maps, printed matter, mechanical recordings, and copies of records.

Inspector's Field Notebook

The core of all documentation relating to an inspection is the field notebook, which provides accurate and inclusive documentation of all inspection activities. A bound notebook should be used, and entries should be made in permanent ink. The notebook will form the basis for written reports and should contain only facts and pertinent observations.

The date and time of arrivals and departures should be noted each day. Language should be objective, factual, and free of personal feelings or terminology that might prove inappropriate. Any errors in the notebook should be crossed out and initialed. The field notebook should never leave the inspector's possession during the inspection, and a facility should generally not be allowed to copy the field notebook. Notebooks become an important part of the evidence package and can be entered in court. The field notebook is a part of EPA's files and is not to be considered the inspector's personal record. Notebooks are held indefinitely pending disposition instructions.

Inspection Notes

Since an inspector may be called to testify in an enforcement proceeding, it is imperative that each inspector keep detailed records of inspections, investigations, samples collected, and related inspection functions. Types of information that should be entered into the field notebook include the following:

Observations. All conditions, practices, and other observations that will be useful in preparing the inspection report or that will validate evidence should be recorded.

Documents and Photographs. All documents taken or prepared by the inspector such as the completed checklists for the inspection report should be noted and related to specific inspection activities. (Photographs taken at a sampling site should be listed and described.)

Unusual Conditions and Problems. Unusual conditions and problems should be noted and described in detail.

General Information. Names and titles of facility personnel and the activities they perform should be listed along with statements they have made and other general information. Weather conditions should be recorded. Information about a facility's recordkeeping procedures may also be useful in later inspections.

Samples

For the analysis of a sample to be admissible as evidence, a logical and documented connection must be shown between samples taken and analytical results reported. This connection is shown by using a chain-of-custody system that identifies and accompanies a sample between the time it is collected and the time it is analyzed. Sampling techniques and procedures are discussed in detail in Chapter Five, "Sampling."

Statements

Inspectors can attempt to obtain a formal statement from a person who has personal, firsthand knowledge of facts pertinent to a potential violation. This statement of facts is signed and dated by the person who can testify to the facts in court, and it may be admissible as evidence.

The principal objective of obtaining a statement is to record in writing, clearly and concisely, relevant factual information so that it can be used to document an alleged violation.

Procedures and Considerations

- Determine the need for a statement. Will it provide useful information? Is the person making the statement qualified to do so by personal knowledge?
- Ascertain all the facts. Make sure all information is factual and firsthand. Record those that are relevant and that the person can verify in court. Avoid taking statements that cannot be personally verified.
- In preparing a statement, use simple narrative style; avoid stilted language.
  - Narrate the facts in the words of the person making the statement.
  - Use the first-person singular ("I am manager of . . .").

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  - Present the facts in chronological order (unless the situation calls for another arrangement).

- Positively identify the person making the statement (name, address, position).
- Show why the person is qualified to make the statement.
- Present the pertinent facts.
- Have the person read the statement and make any necessary corrections before signing. If necessary, read the statement to the person in the presence of a witness.
  - All mistakes that are corrected must be initialed by the person making the statement.
- Ask the person making the statement to write a brief concluding paragraph indicating that he or she read and understood the statement. This safeguard will counter a later claim that the person did not know what he or she was signing.
- Have the person making the statement sign it.
- If he or she refuses to sign the statement, elicit an acknowledgment that it is true and correct. Ask for a statement in his or her own hand ("I have read this statement and it is true, but I am not signing it because . . ."). Failing that, declare at the bottom of the statement that the facts were recorded as revealed and that the person read the statement and avowed it to be true. Attempt to have any witness to the statement sign the statement including the witness' name and address.
- Provide a copy of the statement to the signer if requested.

Photographs

The documentary value of photographs ranks high as admissible evidence. Clear photographs of relevant subjects provide an objective record of conditions at the time of inspection. If possible, keep "sensitive" operations out of the photographed background. Photographs showing confidential operations or information must be handled as confidential information.

When a situation dictates the use of photographs, the inspector should obtain the permittee's approval before taking them. The inspector should be tactful in handling any concerns or objections a permittee may have about the use of a camera. In some cases, the inspector may explain to the permittee's representative that wastestreams, receiving waters, and wastewater treatment facilities are public information, not trade secrets. In the event the permittee's representative still refuses to allow photographs and the inspector believes the photographs will have a substantial impact on future enforcement proceedings, Regional enforcement attorneys should be consulted for further instructions.

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At all times, the inspector is to avoid confrontations that might jeopardize the completion of the inspection. (Photographs always may be taken from areas of public access [e.g., across a stream, from a parking lot].)

Equipment

A single-lens reflex camera should be used whenever one is available. This type of camera will take high-quality photographs, enable the inspector to use a variety of film speeds, and allow the use of appropriate lenses. Fully automatic 35-mm and pocket cameras can also be used for routine inspections to record the conditions of the facility during the inspection.

All photographs should be made with color print film because additional equipment, such as a projector and screen, is not needed to review them. Also, the negatives from color print film are easily duplicated and the prints can be enlarged and distributed as needed.

Scale, Location, and Direction

It is sometimes useful to photograph a subject from a point that will indicate the location and direction of the subject. The inclusion in the photograph of an object of known size (e.g., a person or an auto) will help indicate the approximate size of the subject.

Safety

In areas where there is a danger of explosion, flash photographs should not be taken. If there is a danger of electrical shock, photographs should be taken from a distance known to be safe.

Documentation

Photographs taken during an inspection are used to supplement the testimony of the inspector as a witness during a court proceeding. The photographs are not intended to refute testimony but rather to aid the witness in recalling actual conditions on-site.

A photographic log should be maintained in the inspector's field notebook for all photographs taken during an inspection; the entries should be made at the time the photograph is taken. These entries are to be numerically identified so that, after the film is developed, the prints can be serially numbered to correspond with the logbook descriptions and, if necessary, pertinent information can be easily transferred to the back of the photograph. The log entries should include:

- Name and signature of the photographer and witness
- Time of day, weather conditions
- Date
- Location
- Brief description of each subject being photographed.

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Date-back cameras that place the date and time on the photograph are useful. Some Regions use special stick-on labels to document photographs. These are useful only if they are prepared objectively and are completely filled in.

Videotapes

Videotapes can provide an objective means of documenting subjects of interest in an inspection. As with any photographed site or equipment, permission from the permittee to produce a videotape should be obtained, and the same precautions as those for photographs (previous section) should be taken for sensitive material. Additionally, sound videos can be produced, whereby a narrative to the tape can quickly record much of the information needed to complete an inspection report. As with written notes, the narrative description should be neutral and should not include personal comments or opinions. Written notes should be prepared during the site visit as a backup to the videotape in case mechanical problems occur with the recording. If necessary, color photographs can be made later by stopping the televised video at frames of interest and photographing the picture.

Drawings and Maps

Schematic drawings, maps, charts, and other graphic records can be useful in supporting violation documentation. They can provide graphic clarification of site location relative to the overall facility, relative height and size of objects, and other information which, in combination with samples, photographs, and other documentation, can produce an accurate, complete evidence package.

Drawings and maps should be simple and free of extraneous details. Basic measurements and compass points should be included to provide a scale for interpretation. Drawings and maps should be identified by source and inspector's initials and should be dated.

Printed Matter

Brochures, literature, labels, and other printed matter may provide important information regarding a facility's conditions and operations.

These materials may be collected as documentation if, in the inspector's judgment, they are relevant. All printed matter should be identified with date, inspector's initials, and origin.

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Mechanical Recordings

Electronic records can be entered as evidence if properly dated and signed. Charts, graphs, and other hard copy documents produced from computer output should be treated as documentation and handled accordingly.

Copies of Records

Records may be stored in a variety of information retrieval systems, including written or printed materials, computer or electronic systems, or visual systems such as microfilm and microfiche.

Obtaining Copies of Necessary Records

When copies of records are necessary for an inspection report, storage and retrieval methods must be considered.

- Written or printed records generally can be photocopied on-site. Portable photocopy machines may be available to inspectors through the Regional Office. When necessary, inspectors are authorized to pay a facility a "reasonable" price for the use of facility copying equipment. If the facility does not have a photocopier and a portable photocopier is not available, a photocopy machine is usually accessible at a nearby site (e.g., post office, convenience store). However, inspectors must obtain permission from the permittee prior to taking records offsite for copying.
  - At a minimum, all copies made for or by the inspector should be initialed and dated for identification purposes. (See identification details below.)
  - When photocopying is impossible or impractical, closeup photographs or videotape may be taken to provide suitable copies.
- Computer or electronic records may require the generation of hard copies for inspection purposes. Arrangements should be made during the opening conference, if possible, for these copies.
  - Photographs of computer screens possibly may provide adequate copies of records if other means are not exist.
- Visual systems (microfilm, microfiche) may have photocopying capacity built into the viewing machine, which can be used to generate copies. Photographs of the viewing screen may provide adequate copies if hard copies cannot be generated.

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Identification Procedures

Immediate and adequate identification of records reviewed is essential to ensure the identification of records throughout the EPA custody process and their admissibility in court. When inspectors are called to testify, they must be able to identify positively each particular document and state its source and the reason for its collection.

Initial, date, number, and enter the facility's name on each record, and log these items into the field notebook.

Initialing/Dating. Each inspector should develop a unique system for initialing (or coding) and dating records and copies of records so that he or she can easily verify their validity. This can be done by initialing each document in a similar position, or by another method, at the time of collection. All record identification notations should be made on the back of the document. The inspector must be able to identify positively that he or she so marked the document.

Numbering. Each document or set of documents substantiating a suspected violation(s) should be assigned an identifying number unique to that document. The number should be recorded on each document and in the field notebook.

Logging. Documents obtained during the inspection should be entered in the field notebook by a logging or coding system. The system should include the identifying number, date, and other relevant information:

- The reason for copying the material (i.e., the nature of the suspected violation or discrepancy)
- The source of the record (i.e., type of file, individual who supplied record)
- The manner of collection (i.e., photocopy, other arrangements).

General Considerations

- Originals must be returned to the proper person or to their correct location
- Related records should be grouped together
- Confidential business records should be handled according to the special confidential provisions discussed below.

Routine Records

The inspector may find it convenient to make copies of some records, such as laboratory analysis sheets and data summaries, to refresh his or her memory when preparing the inspection report. It is not always necessary to follow the formal identification and logging

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requirements when such records are obtained for general information purposes or to aid in the preparation of routine inspection reports.

Confidential Information

Disclosure of Official Information

Inspectors may give general information about EPA programs and activities and describe what they are doing, but they should be cautious about divulging specific information regarding an inspection. It is permissible to discuss with the permittee's representative deficiencies encountered during an evaluation of self-monitoring procedures and the action required to correct these deficiencies. However, it is generally not advisable to discuss information collected during the course of an inspection that may indicate the occurrence of a criminal or civil violation. Therefore, when an inspector has reason to believe that an enforcement action may be required, no information should be disclosed before consulting with the attorney in the Regional Office. Caution should be exercised in disclosing findings, and the inspector should not speculate on the type of action EPA may choose to take.

Trade Secrets and Confidential Business Information

Trade secrets and confidential business information are protected from public disclosure by Section 308(b)(2) of the CWA. The type of information that may be considered confidential business information is defined in Title 40, *Code of Federal Regulations*, Part 2 (40 *CFR* Part 2).

Section 308(a)(4) of the CWA states that an inspector may sample an effluent, request information, have access to the location of the effluent, and inspect any monitoring equipment. The information that is collected is available to the public. If a permittee does not want inspection information to be available to the public, he or she must request that the EPA Administrator consider the information confidential. Confidential information includes trade secrets, such as chemical identity, processes, or formulae. The permittee must show that the information, if made available, would divulge trade secrets. The information then may be classified confidential, but still may be disclosed to authorized representatives of EPA concerned with enforcing the Act.

Therefore, a business is entitled to a claim of confidentiality for all information that an inspector requests or has access to; however, a business may not refuse to release information requested by the inspector under the authority of Section 308 of the Act on the grounds that the information is considered confidential or a trade secret. The claim of confidentiality relates only to the public availability of such data and cannot be used to deny access to a facility to EPA inspectors performing duties under Section 308 of the Act. A claim of confidentiality may be made at the time of the inspection or at any time subsequent to the inspection. Claims must be made in writing and signed by a responsible company official. Information claimed as confidential can be later reviewed to determine whether the claim is valid.

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Handling Confidential Business Information

Routine security measures will help ensure that reasonable precautions are taken to prevent unauthorized persons from viewing confidential information. When practical circumstances prohibit the inspector from following the procedures exactly, he or she should take steps to protect the information. All confidential information received must be marked as such and placed in a locked filing cabinet or a safe immediately after the inspection is completed. A chain-of-custody record must be maintained for all confidential information. Since confidential information requires special handling procedures, it may be useful to keep it in a separate notebook. By doing this, only the confidential material, and not the entire notebook of inspection findings, would have to be kept in a locked filing cabinet.

While Traveling. The inspector may be on the road for several days while conducting inspections. The inspector is responsible for ensuring that the information collected is handled securely.

- Documents and field notes are considered secure if they are in the physical possession of the inspector and are not visible to others while in use.

- Inspection documents contain sensitive information and should be kept in a locked briefcase. If it is impractical to carry the briefcase, the briefcase may be stored in a locked area, such as the trunk of a motor vehicle.

- Physical samples should be placed in locked containers and stored in a locked portion of a motor vehicle. The chain-of-custody procedures provide further protection for ensuring the integrity of the sample.

In the Office. Only personnel authorized by the Regional Administrator, Division Director, or Branch Chief will be allowed access to the file. An access log should be maintained for all transactions. Copies should not be made of information marked "trade secret" and/or "confidential" unless written authorization has been obtained from the Regional Administrator, Division Director, or Branch Chief. Requests for access to confidential information by any member of the public, or by an employee of a Federal, State, or local agency, must be handled according to the procedures contained in the Freedom of Information Act regulations (40 *CFR* Part 2). All such requests should be referred to the responsible Regional organizational unit.

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2. INSPECTION PROCEDURES

E. Closing Conference

To achieve the most effective results from compliance inspections, the inspector must communicate results promptly to the facility management and/or operating personnel. However, the inspector's discussion should be limited to specific findings of the visit and the inspector should make it clear that all the findings may not be presented during the conference. If appropriate, findings should be compared with the permittee's NPDES permit requirements, consent decrees, administrative orders, and other enforcement actions.

Precautions and Guidelines

Although a discussion of the inspection results is important, certain precautions are essential:

- The inspector should generally not discuss compliance status or any legal effects or enforcement consequences with the permittee's representative or with facility operating personnel.
- The inspector should refrain from recommending a particular consultant or consulting firm, even if asked to do so. Inspectors should tell the permittee's representative to contact a professional society or approved listing for advice concerning this matter.

These guidelines are subject to rules promulgated by the Regional Administrator or State Director regarding permittee contacts in the Region/State.

Deficiency Notice

The inspector may issue a Deficiency Notice that specifies existing or potential problems in a permittee's self-monitoring program. Issuing a Deficiency Notice on-site or after the site visit provides a swift and simple method for improving the quality of data from NPDES self-monitoring activities. An example Deficiency Notice and EPA's memorandum on Deficiency Notice Guidance are provided in Appendix D. Notices allow the inspector formally to assign responsibility to the permittee and to track each step of the compliance/enforcement process. The Deficiency Notice also helps the permittee to comply with the self-monitoring requirements of the permit.

This tool should be used in conjunction with any type of NPDES compliance inspection during which the inspector identifies problems with the permittee's self-monitoring activities. It is to be used by the inspector only to alert permittees to deficiencies in their self-monitoring activities. The enforcement office of the regulatory authority, not the inspector, handles effluent violations. (Under the proposed amendments to the CWA, inspectors may be able to issue field citations.)

Inspectors can issue the Deficiency Notice to a permittee immediately following a compliance inspection, or after the site visit is completed, if they discover any permit deficiencies in the following seven categories that the Notice addresses:

- Monitoring location
- Flow measurement
- Sample collection/holding time
- Sample preservation
- Test procedures, Section 304(h), 40 *CFR* Part 136
- Recordkeeping
- Other self-monitoring deficiencies.

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2. INSPECTION PROCEDURES

F. Inspection Report

The adequacy of compliance follow-up to correct problems or deficiencies noted during inspection greatly depends on the report prepared by the inspector. The sections of this chapter detail procedures for collecting and substantiating the information used to prepare this report. Once collected, however, the material must be organized and arranged so that compliance personnel can make maximum use of it. The information presented in this section provides general guidelines for organizing evidence and preparing an inspection report.

Objective of the NPDES Inspection Report

The objective of an NPDES inspection report is to organize and coordinate all inspection information and evidence into a comprehensive, usable document. To meet this objective, information in an inspection report must be presented in a clear, well-organized manner. The information should be objective and factual; the report must not speculate on the ultimate result of the inspection findings. Of particular importance are the following:

- Only accurate information may be included in the report. It should be factual and based on sound inspection practices. Observations should be the verifiable result of firsthand knowledge. Compliance personnel must be able to depend on the accuracy of all information.

- Information in an inspection report should be relevant to the subject of the report. Irrelevant facts and data will clutter a report and may reduce its clarity and usefulness. Personal comments and opinions should be avoided.

- Suspected violation(s) should be substantiated by as much factual, relevant information as is feasible to gather. All information pertinent to the subject should be organized into a complete package. Documentary support (e.g., photographs, statements, sample documentation) accompanying the report should be referenced clearly so that anyone reading the report will get a complete, clear overview of the situation. The more comprehensive the evidence is, the better and easier the prosecution's task will be.

Elements of a Report

Although specific information requirements for an inspection report will vary, most reports will contain the same basic elements:

- NPDES Compliance Inspection Report Form
- Supplementary narrative information
- Copies of completed checklists
- Documentary support.

NPDES Compliance Inspection Report Form

The inspector is responsible for reporting all compliance inspection activities by completing the current Compliance Inspection Report Form 3560-3 as soon as possible after the inspection. A copy of the form is included as Appendix E. The Federal or State compliance office should forward the inspection report form to the regulatory authority no later than 30 days after completion of the inspection. Copies should be sent to the permittee in a timely manner (generally within 30 days of inspection date) except when formal enforcement procedures are under way. In this instance, the case attorney will direct any disclosure of data.

Supplementary Narrative Information

Supplementary narrative information could be a memorandum in the case of routine inspections or a narrative report when major violations are detected. When a narrative report is necessary to describe fully a compliance inspection, the contents of the report should focus on supporting or explaining the information provided in the Compliance Inspection Report Form.

The narrative report should be a concise, factual summary of observations and activities, organized logically and legibly, and supported by specific references to accompanying documentary support.

A work plan will simplify preparation and will help ensure that information is organized in a usable form. Basic steps in writing the narrative report include the following:

Reviewing the Information. The first step in preparing the narrative is to collect all information gathered during the inspection. The inspector's field notebook should be reviewed in detail. All evidence should be reviewed for relevance and completeness. A telephone call or, in unusual circumstances, a follow-up visit may be needed to obtain additional or supplementary information.

Organizing the Material. The information may be organized according to need, but it should be presented logically and comprehensively. The narrative should be organized so that it is understood easily.

Referencing Accompanying Material. All documentary support accompanying a narrative report should be referenced clearly so that the reader will be able to locate the items easily. The "Documentation" section in this chapter provides details on document identification. The inspector should check all documentary support for clarity before writing the report.

Writing the Narrative Report. Once the material collected by the inspector has been reviewed, organized, and referenced, the narrative can be written. The purpose of the narrative is to

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record factually the procedures used in, and findings resulting from, the evidence-gathering process. The inspector should refer to routine procedures and practices used during the inspection, but should detail facts relating to potential violations and discrepancies. The field notebook is a guide for preparing the narrative report.

If the inspector has followed the steps presented in this manual, the report will develop logically from the organizational framework of the inspection. In preparing the narrative, the inspector should make simplicity paramount.

- Write simply; avoid stilted language.
- Use the active, not passive, voice: (e.g., "He said that . . ." rather than "It was said that . . .").
- Keep paragraphs brief and to the point.
- Avoid repetition.
- Proofread the narrative carefully.

Copies of Completed Checklists

Comprehensive checklists are included in the technical chapters of this manual. When appropriate, these checklists may be used by the inspector to collect information during the inspection or they may be modified by the Region or State to address additional specific concerns. Copies of all completed checklists should be included in the inspection report.

Documentary Support

All documentation produced or collected by the inspector to provide evidence of suspected violations should be included in the inspection report. The "Documentation" section in this chapter provides details on obtaining and organizing this material.

The Permit Compliance System (PCS)

The inspection office should ensure that all data listed in Section A of the NPDES Compliance Inspection Report Form 3560-3 are entered into the PCS, which is used for national tracking of NPDES permit information. An inspection is not credited to the inspection program office until it has been coded into the PCS. Therefore, timely completion of reports and data entry into PCS is essential to follow up effectively a compliance inspection. Every effort should be made to ensure that data are entered no later than 30 days after the inspection is completed.

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3. DOCUMENTATION/ RECORDKEEPING AND REPORTING

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3. DOCUMENTATION/ RECORDKEEPING AND REPORTING

A. Inspection Authority and Objectives

Authority and Objectives	
Statutory Recordkeeping Authority:	Clean Water Act (CWA) §308 and §402
Regulatory Requirements:	40 *Code of Federal Regulations (CFR)* Parts 122, 401, 403, 405-471, and 503, as applicable
Inspection Authority:	CWA §308

The National Pollutant Discharge Elimination System (NPDES) permit system requires permittees to maintain records and report periodically on the amount and nature of discharged effluent waste components. The permit stipulates recordkeeping and reporting conditions. Evaluations are conducted at selected permittee facilities to determine compliance with permit requirements. The procedures listed below should be used for these routine inspections. If suspected violations are disclosed during the routine evaluation, a more intensive investigation should be conducted.

A review of facility records should determine that recordkeeping requirements are being met. The following questions should be answered in particular:

- Is all required information available?
- Is the information current?
- Is the information being maintained for the required time period?
- Do the records reviewed indicate areas needing further investigations?
- Are the records organized?

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3. DOCUMENTATION/ RECORDKEEPING AND REPORTING

B. Evaluation Procedures

Verification, Recordkeeping, and Reporting Evaluation Procedures

During the facility site inspection, the inspector should verify the following requirements of the permit:

- That the number and location of discharges are as described in the permit
- That all discharges are in accordance with the general provisions of the permit, such as no noxious odors, no discharge, no visible entrained solids in discharge, no deposits at or downstream of the outfall, no color change in the receiving stream, and no fish or vegetation kills near the outfalls.

The inspector should review the permit to determine recordkeeping and reporting requirements. Throughout the inspection, the facility's operations should be compared with the permit to verify that required permit activities are correct, current, and complete. Some of the information needed to verify the permit can be obtained during the opening conference and compared with the facility permit. This information includes:

- Correct name and address of facility
- Correct name and location of receiving waters
- Number and location of discharge points
- Principal products and production rates (where appropriate).

The inspector should check for records that will verify that notification has been made to Environmental Protection Agency (EPA) or to the State when (1) discharges differ from those stated in the permit, (2) a permit violation has occurred, and (3) bypassing has occurred. The inspector should also check to ensure that the appropriate records are maintained for a minimum of 3 years. These records may include the following:

- Sampling and Analysis Data
  - Dates, times, and locations of sampling
  - Sample types collected
  - Analytical methods and techniques
  - Results of analyses
  - Dates and times of analyses
  - Name(s) of analytical and sampling personnel.

- Monitoring Records
  - Discharge Monitoring Reports (DMRs), including information on flow, pH, Dissolved Oxygen (DO), etc., as required by permit
  - Original charts from continuous monitoring instrumentation.
- Laboratory Records
  - Calibration and maintenance of equipment
  - Calculations (i.e., on bench sheets or books)
  - Quality Assurance/Quality Control (QA/QC) analysis data.
- Facility Operating Records
  - Daily operating log
  - Summary of all laboratory tests run and other required measurements, including reference test method used (general reference to Standard Methods or 40 *CFR* Part 136 methods is not adequate)
  - Chemicals used (pounds of chlorine per day, etc.)
  - Weather conditions (temperature, precipitation, etc.)
  - Equipment maintenance completed and scheduled
  - Spare parts inventory
  - Flowmeter and pH meter calibration records.
- Treatment Plant Records (required as part of the Federal Construction Grants program)
  - Plant Operations and Maintenance (O&M) Manual
  - Percent removal records
  - "As built" engineering drawings
  - Copy of construction specifications
  - Equipment supplier manual
  - Data cards on all equipment.
- Management Records
  - Average monthly operating records
  - Annual reports
  - Emergency conditions (power failures, bypass, and chlorine failure reports, etc.).

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- Pretreatment Records
  - Publicly Owned Treatment Works (POTW) and industrial monitoring and reporting requirements
  - Industrial user discharge data
  - Compliance status records
  - POTW enforcement initiatives.
- Spill Prevention Control and Countermeasure (SPCC) Plan

  When required, a properly completed SPCC Plan should be available. The inspector also may gather information on the SPCC and forward this information to the appropriate program office for follow-up action.
- Best Management Practices (where required)

  Two types of Best Management Practice (BMP) plans are included in NPDES permits:
  - BMP plans to minimize or prevent release of significant amounts of any toxic or hazardous pollutants to public waters. The plans may discuss general operations and maintenance of the plant, good housekeeping procedures on the facility grounds, and other plans and procedures specific to best management of the facility.
  - Site-specific BMP plans to address particular toxic or hazardous chemicals or other conditions particular to the facility. Site-specific BMP may include procedures, monitoring requirements, construction of barriers such as dikes and berms, or other appropriate measures for solving specific problems.

In addition, inspectors should ensure that sludge records to verify compliance with 40 *CFR* Part 503 are maintained for a minimum of 5 years. Certain records that need to be reviewed (such as sludge records and laboratory records) may be kept offsite.

The inspector should document all inspection activities (see Chapter Two, Section D). Inadequacies, discrepancies, or other problems disclosed during this review may warrant more intensive investigation.

Compliance Schedule Status Review

If the permit contains a compliance schedule or if the facility is under an enforcement action with a compliance schedule, a status review should be conducted to determine:

- Whether the permittee is conforming to the compliance schedule and, if not, whether final requirements will be achieved on time

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- The accuracy of reports relating to compliance schedules
- The length of delay associated with a particular construction violation
- Whether any schedule violations are beyond the control of the discharger
- Whether requests for permit modifications are valid.

If the permit contains a compliance schedule for actions such as beginning new construction, contract and equipment orders, authorization and financing arrangements, and/or attainment of operational status, the schedule should be addressed in detail only if the need becomes apparent during records review and preparation of the inspection plan. The specific compliance schedule actions are described below.

Construction Progress

The inspector must know whether contracts for labor and material have been fulfilled and whether the permittee or the permittee's engineering consultant is monitoring progress. These aspects are extremely important, particularly in plants where numerous contracts are likely for labor and equipment.

If the permittee or the engineering consultant reports that construction or acquisition of equipment is behind schedule, the inspector should:

- Ask to see the permittee's or the resident engineer's progress report and determine whether the report indicates that the final compliance schedule required by the permit can be met.
- If the report indicates that the final date will not be met, advise the permittee that the compliance schedule of the NPDES permit requires the permittee to notify the permit-issuing authority promptly of any possible delay in achieving compliance and of measures taken to minimize the delay.
- Inquire whether the facility superintendent or chief operator and operating personnel are receiving adequate training concerning the operational aspects of the new treatment unit while construction is under way. They must be prepared to perform the essential operating functions when the facility is placed in service.

Construction Contracts and Equipment Orders

The inspector should review the appropriate documents to determine whether the permittee has obtained the necessary approval to begin construction. The inspector should note the start and completion dates (or scheduled delivery dates in service or equipment contracts).

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Authorization and Financing

If construction is incomplete, the inspector should determine whether the permittee has the authority and financial capability (mortgage commitments, corporate resolution, etc.) to complete the required structures.

Attainment of Operational Status

If construction has been completed but the facility is not yet operational, the inspector should determine whether appropriate procedures are being used to ensure attainment of working status at the earliest possible time. The inspector should verify the following:

- Adequate self-monitoring procedures have been initiated. It is especially important that the result of operational and effluent quality monitoring be reviewed to determine whether progress is being made toward optimum efficiency in each treatment unit and in the entire plant.
- Adequate recordkeeping procedures have been established or initiated.
- Adequate work schedules and assignments have been established. (For municipal facilities, the O&M Manual should provide essential guidance.)

POTW Pretreatment Requirements Review

The inspector must collect specific information to evaluate compliance with pretreatment requirements. The procedures developed to collect this information are summarized below and discussed in greater detail in Chapter Nine, "Pretreatment."

As part of the inspection, the inspector must collect information about the POTW's compliance with its approved pretreatment program and applicable regulations as well as the compliance status of its industrial users with categorical pretreatment standards or locally developed discharge limitations. The inspector should review POTW records to determine the following:

- Number of contributing industries, including the number of significant industrial users.
- Whether all industries are properly identified and classified.
- Whether industries have submitted required reports and notifications to the POTW. These include baseline monitoring reports, 90-day compliance reports, periodic compliance reports, notifications of changed discharge, potential problem discharges, violation and resampling, and hazardous waste discharge.
- Number of contributing industries in compliance with applicable standards.
- Whether permits containing all required elements have been issued to significant industrial users in a timely manner.

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- Whether inspections and sampling (including evaluation of the need for slug control plans) of significant industrial users are conducted at the required frequency.
- Whether the POTW has notified all affected users of classification and applicable standards and requirements, including Resource Conservation and Recovery Act (RCRA) obligations.
- Whether appropriate enforcement actions have been taken against all noncompliant industries and whether the names of all users in significant noncompliance are published at least annually.
- Whether contributing industries with compliance schedules are meeting applicable schedule deadlines and compliance schedule reporting requirements.

Indepth Investigations

An indepth inspection of a permittee's records and reports will be conducted when necessary to substantiate a suspected violation, to verify self-monitoring data that may be used as corroborative evidence in an enforcement action, or to confirm apparent sampling, analysis, or reporting discrepancies discovered during the limited inspection. Discrepancies warrant an indepth review if, for example:

- The discharge does not meet required standards and no definite operational problems have been established
- Self-reported data are suspected of being grossly inaccurate and the problem appears to be with recordkeeping procedures and/or the filing of reports
- The cursory review indicates omissions or laxity in the preparation of records
- There is evidence of falsification of records.

If more guidance or assistance is needed in performing an indepth investigation, the inspector should confer with his or her supervisor.

Indepth Investigation Procedures

The following procedures should guide the inspector in conducting an indepth investigation:

- Determine Investigation Objective. What is the specific purpose of the investigation?
- Determine Information Needed. What specific data will substantiate a violation or respond to the investigation objective?
- Determine Data Source. What records will contain these required data?
- Review Inspection Authority. Authority to inspect under Section 308 is limited to those

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records required by the permit. Specific authority may be necessary to inspect other documents.

- Inspect Direct and Indirect Data Sources. Examine records likely to provide the required data directly. In the absence of direct data, indirect sources of information can be used to develop a network of information relevant to the data being sought.

- Take Statements From Qualified Facility Personnel. See Chapter Two, Section D, for procedures.

- Prepare Documentation. Copy and identify all records relevant to the information being sought; see Chapter Two, Section D, for specific procedures.

- Follow Confidentiality Procedures. Any record inspected may be claimed by the facility as confidential. Such records must be treated in accordance with EPA procedures; see Chapter Two, Section D, the discussion on Confidential Business Information.

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3. DOCUMENTATION/ RECORDKEEPING AND REPORTING

C. Verification, Recordkeeping, and Reporting Evaluation Checklist

VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST

A. PERMIT VERIFICATION

Mailing Address:

Brief Facility Description:

Yes	No	N/A	1.	Inspection observations verify information contained in permit.
Yes	No	N/A	2.	Current copy of permit is onsite.
Yes	No	N/A	3.	Name and mailing address of permittee are correct.
Yes	No	N/A	4.	Facility is as described in permit.
Yes	No	N/A	5.	Notification was given to EPA/State of new, different, or increased discharges.
Yes	No	N/A	6.	Accurate records of influent volume maintained, when appropriate.
Yes	No	N/A	7.	Number and location of discharge points are as described in permit.
Yes	No	N/A	8.	Name and location of receiving waters are correct.
Yes	No	N/A	9.	All discharges are permitted.
Yes	No	N/A	10.	Federal Construction Grant funds were used to build plant.

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VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST

B. RECORDKEEPING AND REPORTING EVALUATION

Yes	No	N/A	1. Records and reports are maintained as required by permit.
Yes	No	N/A	2. All required information is available, complete, and current.
Yes	No	N/A	3. Information is maintained for 3 years.
Yes	No	N/A	4. If the facility monitors more frequently than required by permit (using approved methods), these are results reported.
Yes	No	N/A	5. Analytical results are consistent with data reported on DMRs.
			6. Sampling and analyses data are adequate and include:
Yes	No	N/A	a. Dates, times, and location of sampling
Yes	No	N/A	b. Name of individual performing sampling
Yes	No	N/A	c. Analytical methods and techniques
Yes	No	N/A	d. Results of analyses and calibration
Yes	No	N/A	e. Dates of analyses
Yes	No	N/A	f. Name of person performing analyses
Yes	No	N/A	g. Instantaneous flow at grab sample stations.
			7. Monitoring records are adequate and include:
Yes	No	N/A	a. Flow, pH, DO, etc., as required by permit
Yes	No	N/A	b. Monitoring charts kept for 3 years
Yes	No	N/A	c. Flowmeter calibration records kept.
Yes	No	N/A	8. Laboratory equipment calibration and maintenance records are adequate.
Yes	No	N/A	9. Plant records* are adequate and include:
Yes	No	N/A	a. O&M Manual
Yes	No	N/A	b. "As-built" engineering drawings
Yes	No	N/A	c. Schedules and dates of equipment maintenance repairs
Yes	No	N/A	d. Equipment supplies manual
Yes	No	N/A	e. Equipment data cards.
Yes	No	N/A	* Required only for facilities built with Federal construction grant funds.
			10. Pretreatment records are adequate and contain inventory of industrial waste contributors, including:
Yes	No	N/A	a. Monitoring data
Yes	No	N/A	b. Inspection reports
Yes	No	N/A	c. Compliance status records
Yes	No	N/A	d. Enforcement actions.

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VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST

C. COMPLIANCE SCHEDULE STATUS REVIEW

Yes	No	N/A	1. Permittee is meeting compliance schedule.
Yes	No	N/A	2. Permittee has obtained necessary approvals to begin construction.
Yes	No	N/A	3. Financing arrangements are complete.
Yes	No	N/A	4. Contracts for engineering services have been executed.
Yes	No	N/A	5. Design plans and specifications are completed.
Yes	No	N/A	6. Construction has begun.
Yes	No	N/A	7. Construction is on schedule.
Yes	No	N/A	8. Equipment acquisition is on schedule.
Yes	No	N/A	9. Construction has been completed.
Yes	No	N/A	10. Startup has begun.
Yes	No	N/A	11. Permittee has requested an extension of time.
Yes	No	N/A	12. Permittee has met compliance schedule.

D. POTW PRETREATMENT REQUIREMENTS REVIEW

Yes	No	N/A	THE FACILITY IS SUBJECT TO PRETREATMENT REQUIREMENTS
			1. Status of POTW pretreatment program
Yes	No	N/A	a. The POTW pretreatment program has been approved by EPA. (If not, is approval in progress?)
Yes	No	N/A	b. The POTW is in compliance with the pretreatment program compliance schedule. (If not, note why, what is due, and intent of the POTW to remedy.)
			2. Status of Compliance with Categorical Pretreatment Standards.
Yes	No	N/A	a. How many industrial users of the POTW are subject to Federal or State pretreatment standards?
Yes	No	N/A	b. Are these industries aware of their responsibility to comply with applicable standards?
Yes	No	N/A	c. Have baseline monitoring reports (403.12) been submitted for these industries?
			i. Have categorical industries in noncompliance (on BMR reports) submitted compliance schedules?
			ii. How many categorical industries on compliance schedules are meeting the schedule deadlines?
Yes	No	N/A	d. If the compliance deadline has passed, have all industries submitted 90-day compliance reports?
Yes	No	N/A	e. Are all categorical industries submitting the required semiannual report?
Yes	No	N/A	f. Are all new industrial discharges in compliance with new source pretreatment standards?
Yes	No	N/A	g. Has the POTW submitted an annual pretreatment report?
Yes	No	N/A	h. Has the POTW taken enforcement action against noncomplying industrial users?

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VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST
(Continued)

Yes	No	N/A		
			i.	Is the POTW conducting inspections of industrial contributors?
Yes	No	N/A	3.	Are the industrial users subject to Prohibited Limits (403.5) and Local Limits more stringent than EPA in compliance? (If not, explain why, including need for revision of limits.)

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4. FACILITY SITE REVIEW

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3. DOCUMENTATION/ RECORDKEEPING AND REPORTING

C. Verification, Recordkeeping, and Reporting Evaluation Checklist

VERIFICATION, RECORDKEEPING, AND REPORTING EVALUATION CHECKLIST

A. PERMIT VERIFICATION

Mailing Address:

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Brief Facility Description:

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Yes	No	N/A	1.	Inspection observations verify information contained in permit.
Yes	No	N/A	2.	Current copy of permit is onsite.
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Yes	No	N/A	4.	Facility is as described in permit.
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Yes	No	N/A	6.	Accurate records of influent volume maintained, when appropriate.
Yes	No	N/A	7.	Number and location of discharge points are as described in permit.
Yes	No	N/A	8.	Name and location of receiving waters are correct.
Yes	No	N/A	9.	All discharges are permitted.
Yes	No	N/A	10.	Federal Construction Grant funds were used to build plant.

*** NOTES ***

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4. FACILITY SITE REVIEW

B. Physical Inspection of the Facility

During the "walk-through" of the facility, the inspector should consider the operational factors listed below. The physical inspection should be carefully documented. Areas that should be covered are the following:

- Influent characteristics, including:
  - Appearance (color, odor, etc.)
  - Combined sewer loads
  - Infiltration/inflow
  - Industrial contributions
  - Diurnal/seasonal loading variations
- Process control
- Unit operations including supply of treatment chemicals
- Equipment condition
- Maintenance and operation staff
- Safety controls and equipment
- Effluent characteristics, including:
  - Appearance of outfall
  - Receiving stream appearance including any staining or deposits
  - Evidence of toxicity of the discharge
- Other conditions particular to the plant.

Environmental Protection Agency's (EPA's) *Field Manual for Performance Evaluation and Trouble Shooting at Municipal Wastewater Facilities* (USEPA 1978), published by the Municipal Operations Branch of EPA, is a good reference for operational characteristics of plants.

The physical inspection may lead the inspector to determine:

- Whether a major facility design problem may require an engineering solution
- Whether problems can be solved through proper operation and maintenance of the treatment facilities
- Whether periodic equipment malfunctions need to be addressed by complete overhaul or replacement of equipment.

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If a facility design problem exists, one of the recommendations will be to develop engineering solutions. In this case, the inspector must evaluate the operation and maintenance procedures from the viewpoint of what can be done to simplify the solution. When the inspection findings indicate that specific practices of the facility contribute to or cause problems, the inspector should detail the problems. When possible, the inspector should use the information to evaluate the operation and maintenance procedures.

When conducting the walk-through, the inspector should be aware of and look for physical conditions that indicate past, existing, or potential problems. The presence of these conditions will give the inspector an idea of the types of problems present, the parts of the treatment process causing the problems, and the potential solution to existing problems. Conditions to look for in the plant generally and in specific processes are listed in the following sections.

General Conditions in Overall Plant

General Indicators

- Excessive scum buildup; grease, foam, or floating sludge in clarifiers.
- Hydraulic overload caused by storms or discharges of cooling water.
- Noxious odors in wet wells and grit chambers and around aerobic and anaerobic biological units, scum removal devices, and sludge handling facilities.
- Evidence of severe corrosion at the treatment plant and in the collection system.
- Discoloration of the ground or a strong chemical smell may indicate past spills at the plant; further investigation of spills may be warranted.
- Vital treatment units out of service for repairs. Determine when the units went out of service, the type of failure, and when they will be put back in service.
- Excessive noise from process or treatment.
- Any unusual equipment intended to correct operation problems (e.g., special pumps, floating aerators in diffused air systems, chemical feeders, temporary construction or structures, or any improvised system).
- Ruptures in chemical feed lines.

Flow Indicators

- Surcharging of influent lines, overflow weirs, and other structures.
- Flowthrough bypass channels.
- Overflows at alternative discharge points, channels, or other areas.

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- Excessive septage dumping by septic tank pumpers.
- Flow from unknown source or origin
- Open-ended pipes that appear to originate in a process or storage area and periodically contain flows to the ground or to surface water. Although these pipes have been disconnected from a closed system or otherwise removed from service, they can still be connected to a discharge source.

Unusual Wastes Indicators

- Collected screenings, slurries, sludges, waste piles, or by-products of treatment. Their disposal, including runoff of any water, must be such that none enters navigable waters or their tributaries.
- Improper or lack of recycling of filtrates and supernatants from sludge beds.
- Improper storage of chemicals and hazardous substances with particular attention to the proper diking of chemicals and hazardous substances and segregation of incompatible chemicals. Generally, spill containment should be such that the dike could contain the contents of the largest tank.
- Spills or mishandling of chemicals.

Preliminary Treatment

Screening

- Excessive screen clogging
- Oil and grease buildup
- Disposal of screenings.

Shredding/Grinding

- Excessive buildup of debris against screen
- Grit chamber clogged or subject to odors.

Grit Removal

- Excessive organic content of grit
- Wear of grit removal/handling equipment
- Excessive odors in grit removal area.

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Flow Equalization

- Excessive odors
- Inoperable aerators, if aerated
- Ability to bypass directly to surface water.

Primary Clarifier

General Indicators

- Excessive gas bubbles or grease on surface
- Black and odorous wastewater
- Poor suspended solids removal in primary clarifier
- Excessive buildup of solids in center well of circular clarifier
- Unlevel discharge weirs
- Fouling of overflow weirs
- Evidence of short circuiting
- Ineffective scum rake
- Scum overflow or lack of adequate scum disposal, full scum pit
- Excessive floating sludge
- Excessive sludge on bottom, inadequate sludge removal
- Noisy sludge scraper drive
- Broken sludge scraper.

Secondary Biological Treatment Units

Trickling Filter

- Trickling filter ponding (indicating clogged media)
- Leak at center column of trickling filter's distribution arms
- Uneven distribution of flow on trickling filter surface
- Uneven or discolored growth
- Excessive sloughing of growth
- Odor
- Clogging of trickling filter's distribution arm orifices
- Restricted rotation of distribution arms
- Filter flies, worms, or snails
- Ice buildup on trickling filter media or distribution arms.

Rotating Biological Contactors

- Development of white biomass on rotating biological contactor (RBC) media
- Excessive sloughing of growth
- Excessive breakage of rotating disks or shafts in RBC units
- Excessive breakage of paddles on brush aerators
- Shaft, bearing, drive gear, or motor failure on disk or brush aerators.

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Activated Sludge Tanks

- Dead spots in aeration tanks; dark foam or bad odor in aeration tanks
- Failure of surface aerators
- Inoperative air compressors
- Air rising unevenly
- Excessive air leaks in compressed air piping
- Dark mixed liquor in aeration tank
- Dark foam or bad odor on aeration tanks
- Stable dark tan foam on aeration tanks that sprays cannot break up
- Thick billows of white, sudsy foam on aeration tank
- Low Dissolved Oxygen (DO, < 1.0 mg/l) in aeration tank.

Stabilization Ponds/Lagoons

- Erosion of stabilization pond bank or dike
- Excessive foliage or animal burrows in pond bank or dike
- Excessive weeds in stabilization ponds
- Foaming and spray in aerated lagoon
- Dead fish or aquatic organisms
- Buildup of solids around influent pipe
- Excessive scum on surface.

Secondary Clarifier

General Indicators

- Excessive gas bubbles on surface
- Fouling of overflow weirs
- Unlevel overflow weirs
- Evidence of short circuiting
- Excessive buildup of solids in center well of circular clarifier
- Deflocculation in clarifier
- Pin floc in overflow
- Ineffective scum rake
- Floating sludge on surface
- Billowing sludge
- Excessively high sludge blanket
- Clogged sludge withdrawal ports on secondary clarifier.

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Advanced Physical Treatment Units

Filtration

- Filter surface clogging
- Short filter run
- Gravel displacement of filter media
- Formation of mud balls in filter media
- Air binding of filter media
- Loss of filter media during backwashing
- Recycled filter backwash water in excess of 5 percent.

Microscreening

- Erratic rotation of microscreen drums.

Activated Carbon Adsorption

- Excessive biological growth resulting in strong odor
- pH above 9.0 S.U.
- Plugged carbon pores
- Presence of carbon fines (dust) in effluent.

Nitrification

- Hydraulic overload.

Denitrification

- Temperature below 15°C
- pH below 6.0 S.U. or above 8.0 S.U.
- Excessive methanol.

Ammonia Stripping

- Excessive hydraulic loading rate
- Tower packing coated with calcium carbonate
- pH below 10.8 S.U.
- Inadequate tower packing depth
- Air temperature below 65°F.

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Chlorination and Dechlorination Units

Chlorination

- Sludge buildup in contact chamber
- Gas bubbles
- Inadequate retention time
- Floating scum and/or solids
- Evidence of short circuiting
- Inadequate ventilation of chlorine feeding room and storage area
- High temperatures in chlorination rooms
- Improper operation of automatic feed or feedback control
- Excessive foaming downstream
- Evidence of toxicity downstream (dead fish, other dead organisms)
- Improper chlorine feed, storage, and reserve supply.

Dechlorination

- Improper storage of sulfur dioxide cylinders
- Inadequate ventilation of sulfur dioxide feeding room
- Automatic sulfur dioxide feed or feedback control not operating properly
- Depressed DO after dechlorination
- Proper storage and mixture of sodium metabisulfite containers
- Reduced efficiency of activated carbon dechlorination units because of organic and inorganic compound interference.

Sludge Handling

General Indicators

- Inadequate sludge removal from clarifiers or thickeners
- Poor dewatering characteristics of thermal treated sludge
- Thickened sludge too thin
- Fouling of overflow weirs on gravity thickeners
- Air flotation skimmer blade binding on beaching plate
- Substantial down time of sludge treatment units
- Sludge disposal inadequate to keep treatment system in balance
- Sludge decant or return flows high in solids.

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Sludge Anaerobic Digestion

- Inoperative mechanical or gas mixers
- Inoperative sludge heater
- Floating cover of anaerobic digester tilting
- Inadequate gas production
- Gas burner not burning or inoperative
- Supernatant exuding a sour odor from either primary or secondary anaerobic digester
- Excessive suspended solids in supernatant
- Supernatant recycle overloading the Wastewater Treatment Plant (WWTP)
- pH problems from industrial wastewaters with high sugar content.

Sludge Aerobic Digestion

- Excessive foaming in tank
- Objectionable odor in aerobically digested sludge
- Insufficient dissolved oxygen in digester
- Digester overloaded
- Clogging of diffusers in digester
- Mechanical aerator failure in digester
- Inadequate supernatant removal from sludge lagoons.

Sludge Drying/Filtering

Drying beds

- Poor sludge distribution on drying beds
- Vegetation in drying beds (unless reed design)
- Dry sludge remaining in drying beds
- Inadequate drying time on drying beds
- Some unused drying beds
- Dry sludge stacked around drying beds where runoff may enter navigable waters
- Filtrate from sludge drying beds returned to front of plant.

Centrifuge

- Excessive solids in fluid phase of sample after centrifugation
- Inadequate dryness of centrifugal sludge cake.

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Filter Press

- High level of solids in filtrate from filter presses or vacuum filters
- Thin filter cake caused by poor dewatering
- Vacuum filter cloth binding
- Low vacuum on filter
- Improperly cleaned vacuum filter media
- Sludge buildup on belts and/or rollers of filter press
- Excessive moisture in belt filter press sludge cake
- Difficult cake discharge from filter presses
- Filter cake sticks to solids-conveying equipment of filter press
- Frequent media binding of filter press
- Sludge blowing out of filter press
- Insufficient run time of sludge dewatering equipment.

Lagoon

- Objectionable odor from sludge lagoon
- Broken dikes between sludge drying lagoons
- Unlined sludge lagoons
- Sludge lagoons full, overflowing sludge back to plant or to natural drainage.

Composting

- Piles that give off foul odor
- Inoperable blower
- Temperature does not reach 122-140°F (50-60°C).

Sludge Disposal

- Sludge constituents not analyzed before disposal
- Sludge not transported in appropriate and approved vehicle
- Surface runoff of sludge at land application site
- Liquid sludge (i.e., less than 10 percent solids) applied to landfill site
- Inadequate coverage of sludge in subsurface plow injection system
- Malodors generated at land application site
- Slow drying of soil-sludge mixture in subsurface injection system
- Sludge ponding at land application sites
- Flies breeding and/or odors at landfill site

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- Inadequate burial of sludge at landfill site
- Excessive erosion at sludge sites
- Waste sludges disposed of onsite in nonpermitted sites or in landfills, surface impoundments, or land application units not according to Federal, State, or local regulations
- Inadequate runoff control at landfill or land application sites.

Polishing Ponds or Tanks

- Objectionable odor, excessive foam, floating solids, or oil sheens in polishing ponds or tanks
- Solids or scum accumulations in tank or at side of pond
- Evidence of bypassed polishing ponds or tanks because of low capacity.

Plant Effluent

- Excessive suspended solids, turbidity, foam, grease, scum, color, and other macroscopic particulate matter present
- Potential toxicity (dead fish, dead plants at discharge)
- Stained sediments in receiving waters.

Flow Measurement

- Improper placement of flow measurement device
- Flow totalizer not calibrated
- Buildup of solids in flume or weir
- Broken or cracked flume or weir
- Improperly functioning magnetic flowmeter
- Clogged or broken stilling wells
- Weir plate edge corroded or damaged, not sharp edged (< 1/8"), or not level

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- System not capable of measuring maximum flow
- Sizing of system adequate to handle flow range
- Flow measurement error greater than ± 10%
- Flow measurement that includes all wastewater discharged and does not include wastestreams that are recirculated back to the treatment plant.

Chemical Treatment Units

- Evident heavy corrosion
- No portion-measuring device at feed unit
- pH measuring not evident at pH adjustment tank
- Chemicals left in open atmosphere
- Chemicals outdated
- Chemical containers stored improperly or hazardously
- Inappropriately stored, moved, or handled chemical tanks cars (trucks or train)
- Spilled dry chemicals on floor between storage area and feed units
- Improperly disposed of empty chemical containers
- Large containers handled improperly, container transfer equipment not maintained
- No appropriate sized berms or dikes at liquid chemical feed units
- Inadequate supply of chemicals
- Chemical dust covering feed unit area or storage and transfer areas
- Use of an inappropriate coagulant
- Improperly stored or handled glass carboys (acid storage).

General Housekeeping

- Facility control panel in disrepair or not in use
- Wastewater pipelines not clearly distinguished from product pipelines
- Spills or leaks in dry areas not remediated in a timely manner.

Production Changes

Industries frequently make production changes because of advances in technology and availability of new products. Therefore, during the tour of an industrial facility, the inspector also should inquire about the following:

- Whether a permittee has made any changes to:
  - Production processes
  - Raw materials
  - Amount of finished product

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  - Water use
  - Water reuse or recycling
  - Waste treatment processes
  - Other such changes

- Whether the permittee has modified any production process that would change the pollutant types or loadings

- Whether the regulatory agency (EPA, State, or local municipality as appropriate) was notified of such changes

- What changes will need to be reflected in any National Pollutant Discharge Elimination System (NPDES) or local permit modifications.

The inspector should verify any changes and include the results of the findings and other pertinent information in the Compliance Inspection Report. Changes in the loading to Publicly Owned Treatment Works (POTWs) by the addition of a significant industrial discharger or large population growth also should be ascertained and reported.

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4. FACILITY SITE REVIEW

C. Operation and Maintenance Evaluation

Operation Evaluation

Operating factors affecting plant performance range from qualitative factors such as the skills and aptitudes of operators (e.g., process knowledge and general aptitude), to physical deficiencies in laboratory equipment or a lack of flexibility in process equipment. The evaluation of operation functions must focus on wastewater treatment, sludge treatment/ disposal, and laboratory analysis. The evaluation should be based on the following topics:

- Policies and procedures
- Organization
- Staffing
- Planning
- Management controls.

Table 4-1 presents the basic review questions that an inspector should ask in evaluating operation functions. Although each of the preceding evaluation topics must be covered in the review of operation functions, the four areas discussed in the following paragraphs should particularly concern the inspector:

Policies and Procedures

Written operating procedures and standard reference texts enable the operator to achieve efficient plant operation. The operations manual prepared for the facility is the most important reference that an inspector should review when evaluating plant policies and procedures. Other reference materials relating to operations that should be available to the operator include manufacturers' literature, publications by professional organizations (e.g., the Water Environment Federation), and EPA publications.

Staffing

Even the best engineered facility cannot perform to its potential without a sufficient number of capable and qualified staff. The inspector must consider the abilities and limitations of the operating staff. Staff interviews may include the individual in charge of overall operation, the chief operator, specific unit process operators, and laboratory staff.

Health and Safety

At all times, safe operating procedures should be followed. Employees must be trained in emergency shut-down, fire control, and spill response procedures, as well as in the use of safety equipment, safe sampling techniques, and safe handling of chemicals and wastes. Employees also should not enter confined spaces unless properly trained and equipped. Managers must be aware of the Occupational Safety and Health Administration (OSHA) Right-to-Know laws regarding potentially dangerous chemicals in the workplace. This law specifically requires a written hazard communication program, labeling of chemicals, and the availability of material safety data sheets to employees upon request.

Management Controls

Monitoring practices are a good indicator of both the emphasis placed on operations and the operator's understanding of process controls. Factors affecting a facility's monitoring capabilities are:

- The sampling program
- Performance testing
- Analytical capabilities
- Recordkeeping practices.

An effective process control program is essential to a treatment facility's optimal performance. However, process control cannot be easily quantified by the inspector. In most cases, the inspector must rely on discussions with the plant superintendent and/or operators to supplement available records and the technical evaluation. The key considerations for effective process controls are:

- Process control data
- Process knowledge of the operators
- The basis for the control practices
- Implementation of the control practices
- Past performance
- Operator emphasis on controls
- Recordkeeping.

Maintenance Evaluation

Facility maintenance directly affects the ability of the facility to run efficiently and to comply with its NPDES permit. The two types of facility maintenance are preventive maintenance and corrective maintenance:

- Preventive maintenance
  - Reduces facility operating costs by eliminating breakdowns and the need for corrective maintenance

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- Improves the facility's reliability by minimizing the time equipment is out of service
- Increases the useful life of equipment, thus avoiding costly premature replacement
- Avoids possible compliance violations.

- Corrective maintenance
  - Returns malfunctioning equipment to operation
  - Avoids or minimizes possible compliance violations.

Evaluation of the maintenance function must focus on the ability to maintain process equipment, supply of treatment chemicals, vehicles, and building and grounds. Although each of the five evaluation topics (policies and procedures, organization, staffing, planning, and management controls) must be covered for each facility inspected, the principal areas of concern in the operations evaluation are the same in the maintenance function:

- Staffing and training
- Planning and scheduling
- Management control—records systems and inventory control.

Only well-trained, competent plant staff can be expected to perform adequate physical inspections, repairs, and preventive maintenance. Wastewater facility maintenance is complex and requires a variety of skills. Because many of these skills are not readily available, an ongoing training program is essential.

Maintenance planning and scheduling are essential to effective corrective and preventive maintenance. The maintenance supervisor must prepare work schedules listing job priorities, work assignments, available personnel, and timing.

A detailed records system is the basis of any maintenance program. Records are used to establish maintenance histories on equipment, diagnose problems, and anticipate—and thereby avoid—equipment failure, making records an effective tool for preventive maintenance.

A central inventory of spare parts, equipment, and supplies must be maintained and controlled. The basis for the inventory should be the equipment manufacturer's recommendations, supplemented by specific, historical experience with maintenance problems and requirements. Inventoried supplies must be kept at levels sufficient to avoid process interruptions.

A maintenance cost control system should be an integral part of every wastewater facility. Budgets must be developed from past cost records and usually are categorized according to preventive maintenance, corrective maintenance, and projected and actual major repair requirements. Annual costs must be compared to the budget periodically to control maintenance expenditures. Evaluating costs this way serves to control expenditures and provides a baseline for future budgets.

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The basic concerns that need to be addressed and evaluated during the inspector's maintenance program review are presented in Table 4-1. These questions may help identify the causes of a facility's operation and maintenance problems.

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Table 4-1

Operation and Maintenance Function Evaluation Questions

Policies and Procedures

- Is there a formal or informal set of policies for facility operations?
- Do policies address:
  - Remaining in compliance?
  - Maintaining process controls?
  - Quality control?
  - Preventive maintenance?
- Is there a set of standard procedures to implement these policies?
- Are the procedures written or informal?
- Do the procedures consider the following areas?
  - Safety
  - Emergency
  - Laboratory
  - Process control
  - Operating procedures
  - Monitoring
  - Labor relations
  - Energy conservation
  - Treatment chemical supply
  - Collection system
  - Pumping stations
  - Treatment process
  - Sludge disposal
  - Equipment record system
  - Maintenance planning and scheduling
  - Work orders
  - Inventory management
- Are the procedures followed?

Organization

- Is there an Organizational Plan (or Chart) for operations?
- Does the Plan include:
  - Delegation of responsibility and authority
  - Job descriptions
  - Interaction with other functions (such as maintenance)?
- Is the Plan formal or informal?
- Is the Plan available to and understood by the staff?
- Is the Plan followed?
- Is the Plan consistent with policies and procedures?
- Is the Plan flexible? Can it handle emergency situations?

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Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Does the Plan clearly define lines of authority and responsibility in the following subfunctional areas?

  - Laboratory
  - Process control
  - Instrumentation
  - Sludge disposal
  - Collection system
  - Pumping stations
  - Monitoring practices
  - Mechanical
  - Electrical
  - Buildings and grounds
  - Automotive
  - Supplies and spare parts?

Staffing

- Is there an adequate number of staff to achieve policies and procedures?
- Are staff members adequately qualified for their duties and responsibilities by demonstrating the following:

  - Certification
  - Qualifications
  - Ability
  - Job performance
  - Understanding of treatment processes

- Is staff effectively used?
- Has the potential for borrowing personnel been considered?
- Are training procedures followed for:

  - Orientation of new staff?
  - Training new operators?
  - Training new supervisors?
  - Continuing training of existing staff?
  - Cross training?

- Which of the following training procedures are used?

  - Formal classroom
  - Home study
  - On-the-job training
  - Participation in professional organization

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Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Does the training program provide specific instruction for the following operations and maintenance activities?

  - Safety
  - Laboratory procedures
  - Treatment processes
  - Instrumentation
  - Equipment troubleshooting
  - Handling personnel problems
  - Monitoring practices
  - Emergency procedures
  - Mechanical
  - Electrical
  - Automotive
  - Building maintenance
  - Inventory control

- Does management encourage staff motivation?
- Does management support its first-line supervisors?
- Is staff motivation maintained through any of the following tools?

  - Encouragement for training
  - Job recognition
  - Promotional opportunities
  - Salary incentives
  - Job security
  - Working environment

Operations

- How are operating schedules established?
- Do schedules attempt to attain optimum staff utilization?
- Are line supervisors included in manpower scheduling?
- Are staff involved in and/or informed of manpower planning?
- Is there sufficient long-term planning for staff replacement and system changes?
- Are there procedures in manpower staffing for emergency situations?
- How are process control changes initiated?
- How do process control changes interact with management controls?
- How effectively are laboratory results used in process control?
- Are there emergency plans for treatment control?
- Is there an effective energy management plan? Is the plan used?
- To what extent are operations personnel involved in the budget process?

R0014574

Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Do budgets adequately identify and justify the cost components of operations?
- Are future budgets based on current and anticipated operating conditions?
- Do operating and capital budget limits constrain operations?
- Can budget line items be adjusted to reflect actual operating conditions?

Maintenance

- Are maintenance activities planned? Is the planning formal or informal?
- Does the facility have sufficient management controls to affect realistic planning and scheduling? If the controls exist, are they used?
- Are operating variables exploited to simplify maintenance efforts?
- To what extent are the supply and spare part inventories planned in conjunction with maintenance activities?
- Have minimum and maximum levels been established for all inventory items?
- Does the facility have a maintenance emergency plan?
- Is the maintenance emergency plan current? Is the staff knowledgeable about emergency procedures?
- Does a plan exist for returning to the preventive maintenance mode following an emergency?
- Are preventive maintenance tasks scheduled in accordance with manufacturers' recommendations?
- Is adequate time allowed for corrective maintenance?
- Are basic maintenance practices (preventive and corrective) and frequencies reviewed for cost-effectiveness?
- Do the management controls provide sufficient information for accurate budget preparation?
- Does the maintenance department receive feedback on cost performance to facilitate future budget preparation?
- To what extent are maintenance personnel involved in the budget process?

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Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- Do budgets adequately identify and justify the cost components of maintenance?
- Are future budgets based on current and anticipated operating and maintenance conditions?
- Do maintenance and capital budget limits constrain preventive maintenance (equipment replacement and improvements)?
- Does the maintenance department receive adequate feedback on cost performance?
- Can budget line items be adjusted to reflect actual maintenance conditions?

Management Controls

- Are current versions of the following documents maintained?
  - Operating reports
  - Work schedules
  - Activity reports
  - Performance reports (labor, supplies, energy)
  - Expenditure reports (labor, supplies, energy)
  - Cost analysis reports
  - Emergency and complaint calls
  - Process control data, including effluent quality
- Do the reports contain sufficient information to support their intended purpose?
- Are the reports usable and accepted by the staff?
- Are the reports being completed as required?
- Are the reports consistent among themselves?
- Are the reports used directly in process control?
- Are the reports reviewed and discussed with operating staff?
- What type of summary reports are required?
- To whom are reports distributed and when?

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Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

Management Controls (Maintenance)

- Does a maintenance record system exist? Does it include the following?
  - As-built drawings
  - Shop drawings
  - Construction specifications
  - Capital and equipment inventory
  - Maintenance history (preventive and corrective)
  - Maintenance costs
- Is the base record system kept current as part of daily maintenance practices?
- Is there a work order system for scheduling maintenance? Is it explicit or implicit?
- Which of the following do work orders contain?
  - Date
  - Location
  - Work requirements
  - Assigned personnel
  - Work order number
  - Nature of problem
  - Time requirements
  - Space for reporting work performed, required supplies, time required, and cost summary
  - Responsible staff member and supervisory signature requirements

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Table 4-1

Operations and Maintenance Function Evaluation Questions (Continued)

- When emergency work must be performed without a work order, is one completed afterward?
- Are work orders usable and acceptable by staff as essential to the maintenance program? Are they actually completed?
- Is work order information transferred to a maintenance record system?
- Does a catalog or index system exist for controlling items in inventory?
- Are withdrawal tickets used for obtaining supplies from inventory?
- Do the tickets contain cost information and interact well with inventory controls and the work order system?
- Is the cost and activity information from work orders aggregated to provide management reports? Is this information also used for budget preparation?
- Is the maintenance performance discussed regularly with staff?
- How is the cost of contract maintenance or the use of specialized assistance recorded?
- Are safeguards and penalties adequate to prevent maintenance cards from being returned without the work being done?
- Is the preventive maintenance record checked after an emergency equipment failure?

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*** NOTES ***

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4. FACILITY SITE REVIEW

D. References and Facility Site Review Checklist

References

U.S. Environmental Protection Agency. 1973. *Maintenance Management Systems for Municipal Wastewater Facilities.* EPA 430/9-74-004.

U.S. Environmental Protection Agency. 1978. *Field Manual for Performance Evaluation and Troubleshooting at Municipal Wastewater Treatment Facilities.* MO No. 16, EPA 430/9-78-001.

U.S. Environmental Protection Agency. 1979. *Inspector's Guide for Evaluation of Municipal Wastewater Treatment Plants.* EPA 430/9-79-010.

U.S. Environmental Protection Agency. 1982. *Comprehensive Diagnostic Evaluation and Selected Management Issues.* EPA 430/9-82-003.

Water Pollution Control Federation (WPCF). 1990. *Operation of Wastewater Treatment Plants.* MOP No. 11, WPCF, 1990.

Water Environment Federation (WEF). 1992. *Wastewater Treatment Plant Design.* MOP No. 8, WEF, 1992.

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FACILITY SITE REVIEW CHECKLIST

A. OPERATION AND MAINTENANCE EVALUATION

Yes	No	N/A	1. Treatment units are properly operated and maintained.
Yes	No	N/A	2. Standby power or other equivalent provision is provided.
Yes	No	N/A	3. Adequate alarm system for power or equipment failures is available.
Yes	No	N/A	4. Sludge disposal procedures are appropriate:
Yes	No	N/A	a. Disposal of sludge according to regulations
			b. State approval for sludge disposal received.
Yes	No	N/A	5. All treatment units, other than backup units, are in service.
Yes	No	N/A	6. Procedures for facility operation and maintenance are followed.
Yes	No	N/A	7. Sufficient sludge is disposed of to maintain treatment process equilibrium.
Yes	No	N/A	8. Organizational Plan (chart) for operation and maintenance is provided.
Yes	No	N/A	9. Operating schedules are established.
Yes	No	N/A	10. Emergency plan for treatment control established.
Yes	No	N/A	11. Maintenance record system exists and includes:
Yes	No	N/A	a. As-built drawings
Yes	No	N/A	b. Shop drawings
Yes	No	N/A	c. Construction specifications
Yes	No	N/A	d. Maintenance history
Yes	No	N/A	e. Maintenance costs
Yes	No	N/A	f. Repair history
Yes	No	N/A	g. Records of equipment repair and timely return to service.
Yes	No	N/A	12. Adequate number of qualified operators on-hand.
Yes	No	N/A	13. Established procedures are available for training new operators.
Yes	No	N/A	14. Adequate spare parts and supplies inventory are maintained.
Yes	No	N/A	15. Instruction files are kept for operation and maintenance of each item of major equipment.
Yes	No	N/A	16. Operation and maintenance manual is available.
Yes	No	N/A	17. Regulatory agency is notified of any bypassing. (Dates _____)
Yes	No	N/A	18. a. Hydraulic overflows and/or organic overloads are experienced.
Yes	No	N/A	b. Untreated bypass discharge occurs during power failure.
Yes	No	N/A	c. Untreated overflows occurred since last inspection. Reason: _____
Yes	No	N/A	d. Flows were observed in overflow or bypass channels.
Yes	No	N/A	e. Checking for overflows is performed routinely.
Yes	No	N/A	f. Overflows are reported to EPA or to the appropriate State agency as specified in the permit.

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FACILITY SITE REVIEW CHECKLIST
(Continued)

B. SAFETY EVALUATION

Yes	No	N/A	1. Undiked oil/chemical storage tanks are used at facility.
Yes	No	N/A	2. Up-to-date equipment repair records ARE maintained.
Yes	No	N/A	3. Dated tags show out-of-service equipment.
Yes	No	N/A	4. Routine and preventive maintenance is scheduled/performed on time.
Yes	No	N/A	5. Personal protective clothing is provided (safety helmets, ear protectors, goggles; gloves, rubber boots with steel toes, eyewashes in labs).
Yes	No	N/A	6. Safety devices are readily available: a. Fire extinguishers b. Oxygen deficiency/explosive gas indicator c. Self-contained breathing apparatus near entrance to chlorine room d. Safety harness e. First aid kits f. Ladders to enter manholes or wetwells (fiberglass or wooden for electrical work) g. Traffic control cones h. Safety buoy at activated sludge plants i. Life preservers for lagoons j. Fiberglass or wooden ladder for electrical work k. Portable crane/hoist.
Yes	No	N/A	7. Plant has general safety structures such as rails around or covers over tanks, pits, or wells.
Yes	No	N/A	8. Emergency phone numbers are listed, including EPA and State.
Yes	No	N/A	9. Plant is generally clean, free from open trash areas.
Yes	No	N/A	10. Portable hoists, for equipment removal, are available.
Yes	No	N/A	11. All plant personnel are immunized for typhoid and tetanus.
Yes	No	N/A	12. No cross connections exist between a potable water supply and nonpotable source.
Yes	No	N/A	13. Gas/explosion controls such as pressure-vacuum relief values, no smoking signs, explosimeters, and drip traps are present near anaerobic digesters, enclosed screening or degritting chambers, and sludge-piping or gas-piping structures.
Yes	No	N/A	14. All electrical circuitry is enclosed and identified.
Yes	No	N/A	15. Personnel are trained in electrical work to be performed as well as safety procedures.

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FACILITY SITE REVIEW CHECKLIST
(Continued)

B. SAFETY EVALUATION (Continued)

Yes No N/A Yes No N/A Yes No N/A Yes No N/A Yes No N/A Yes No N/A Yes No N/A Yes No N/A	16. Chlorine safety precautions are followed: a. NIOSH-approved 30-minute air pack b. All standing chlorine cylinders chained in place c. All personnel trained in the use of chlorine d. Chlorine repair kit available e. Chlorine leak detector tied into plant alarm system f. Chlorine cylinders stored in adequately ventilated areas? g. Ventilation fan with an outside switch h. Posted safety precautions.
Yes No N/A	17. Facility has complied with the six employer responsibilities for the Worker Right-to-Know Law (P.A. 83-240)
Yes No N/A	18. Emergency Action Plan on file with local fire department and appropriate emergency agency.
Yes No N/A	19. Laboratory safety devices (eyewash and shower, fume hood, proper labeling and storage, pipette suction bulbs) available.
Yes No N/A	20. Warning signs (no smoking, high voltage, non potable water, chlorine hazard, watch-your-step, and exit) posted.

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5. SAMPLING

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F Example Chain-of-Custody Form

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*** NOTES ***

5. SAMPLING

A. Evaluation of Permittee Sampling Program and Compliance Sampling

Wastewater sampling/analysis is an integral part of the National Pollutant Discharge Elimination System (NPDES) Compliance Monitoring Program. NPDES permits contain specific and legally enforceable effluent limitations and monitoring requirements.

Objectives and Requirements

When evaluating the permittee sampling program, the inspector should:

- Verify that the permittee's sampling program complies with the permit
- Verify that the permittee's sampling program complies with 40 *Code of Federal Regulations (CFR)* Parts 136.1 to 136.5 and Appendices A, B, and C (Guidelines for Establishing Test Procedures for the Analysis of Pollutants)
- Document violations to support enforcement action.

In addition, specific objectives of the sampling conducted by inspectors include the following:

- Verify compliance with daily maximum effluent limitations
- Verify accuracy of reports and program self-monitoring
- Support enforcement action
- Support permit development reissuance and/or revision
- Determine the quantity and quality of effluent.

Sampling, analysis, preservation technique, sample holding time, and sample container requirements are provided under 40 *CFR* Part 136 as authorized by Section 304(h) of the Clean Water Act (CWA). More information on required analytical procedures can be found under "Laboratory Analyses Techniques Evaluation" in Chapter Seven. A checklist for use in evaluating the permittee's sampling program is located at the end of this chapter.

For all NPDES permittees, an evaluation of the permittee sampling program should include a review of sampling procedures used by the facility and of quality control measures used to ensure the integrity of sample data.

Evaluation of sampling procedures should include an assessment of the following six areas:

- Sample collection techniques
- Sample identification

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- Sample preservation and holding time
- Transfer of custody and shipment of samples
- Quality control
- Data handling and reporting.

Significant Industrial User Monitoring Program

It is the responsibility of the permitted Publicly Owned Treatment Works (POTW) with a pretreatment program to oversee sampling procedures of industrial users and to conduct compliance monitoring of its own. Therefore, during a Pretreatment Compliance Inspection (PCI) or audit, the inspector may also need to evaluate POTW sampling procedures for significant industrial users who discharge to the POTW in addition to evaluating the sampling procedures of any permitted POTW. According to the General Pretreatment Regulations, 40 *CFR* 403.12(o), industrial users and POTWs subject to 40 *CFR* 403.12 reporting requirements must maintain the following monitoring records:

- Date, exact place, method and time of sampling, and name of sampler
- Date of analysis
- Name of analyst
- Analytical techniques/methods used
- Analytical results.

During a PCI or an audit, the inspector evaluates the POTW industrial user monitoring program with respect to the criteria specified in the POTW pretreatment program. Elements of the sampling scheme will include the six areas addressed above and any other areas specifically addressed in the particular pretreatment program. Chapter Nine, "Pretreatment," discusses the focus of this evaluation in greater detail.

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5. SAMPLING

B. Sampling Procedures and Techniques

Whether an inspector is evaluating a permittee's sampling program or conducting compliance sampling on the permittee's effluent, that inspector must be familiar with the procedures and techniques necessary for accurate sampling of wastewaters. The following discussion details the procedures for sample collection, preservation, transfer, quality control, and data handling.

Sample Collection Techniques

Sample collection is an important part of the compliance monitoring program. Without proper sample collection procedures, the results of such monitoring programs are neither useful nor valid, even with the most precise and accurate analytical measurements.

Selection of Representative Sampling Sites

Samples should be collected at the location specified in the permit. In some instances, the sampling location specified in the permit or the location chosen by the permittee may not be adequate for the collection of a representative sample. In that case, the inspector should determine the most representative sampling point available and collect a sample at both locations. The reason for the conflict must be documented for later resolution by the permitting authority.

Influent Samples. These samples should be taken at points of high turbulence flow to ensure good mixing. In some instances, the most desirable location may not be accessible. Sampling points always should be above plant return lines, and sampling equipment should be placed so that it does not interfere with flow measuring devices. The preferred sampling points for raw wastewater are:

- Waste flowing from last process in a manufacturing operation
- Pump wet well (if turbulent)
- Upstream collection lines, tank, or distribution box following pumping from the wet well or sump
- Flume throat

- Aerated grit chamber
- Upstream siphon following the comminutor (in absence of grit chamber).

If it is not possible to sample at a preferred point, an alternative location should be chosen and the basis for choosing that location must be documented.

Effluent Samples. These samples should be collected at the site specified in the permit or, if no site is specified in the permit, at the most representative site downstream from all entering wastestreams before they enter the receiving waters. For most municipal plants, samples should be collected after chlorination. Occasionally, municipal plant permits may specify sampling prior to chlorination. For these plants, all parameters can be monitored at the upstream location except fecal coliforms, pH, and total residual chlorine. Wastewater for use in bioassays should be collected at the location specified in the facility's NPDES permit.

Samples can be collected either manually (grab or composite) or with automatic samplers (continuous or composite). The following general guidelines apply when taking samples:

- Take samples at a site specified in the NPDES permit and/or at a site selected to yield a representative sample.
- Use a sampling method (grab, composite, continuous) as required in the permit. Some parameters that are not to be collected by automatic samplers, but must be hand collected are dissolved oxygen, total residual chlorine, oil and grease, coliforms, purgeable organics, sulfides, cyanide, and total phenols.
- Avoid collecting large nonhomogeneous particles and objects.
- Collect the sample facing upstream to avoid contamination.
- Do not rinse sample container with sample when collecting oil and grease and microbiological samples, but fill it directly to within 2.5 to 5 cm from the top.
- Fill the container completely if the sample is to be analyzed for purgeable organics, oxygen, ammonia, hydrogen sulfide, free chlorine, pH, hardness, sulfite, ammonium, ferrous iron, acidity, or alkalinity.
- Collect sufficient volume to allow for quality assurance testing. (Table 5-1 provides a guide to numerous sample volumes, but additional volumes may be necessary for quality assurance testing.)

Sample Types

Two types of sample techniques are used: grab and composite. For many monitoring procedures, the sample type is not specified in 40 *CFR* Part 136. For these procedures, the NPDES permit writer determines the appropriate sample type and specifies them in the NPDES permit.

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Grab Samples. Grab samples are individual samples collected over a period of time not exceeding 15 minutes and are representative of conditions at the time the sample is collected. The sample volume depends on the type and number of analyses to be performed. The collection of a grab sample is appropriate when a sample is needed to:

- Sample an effluent discharge that is not on a continuous basis
- Provide information about instantaneous concentrations of pollutants at a specific time
- Allow collection of a variable sample volume
- Corroborate composite samples
- Monitor parameters not amenable to compositing (e.g., pH, temperature, dissolved oxygen, chlorine, purgeable organics, oil and grease, coliform bacteria, and others specified by the NPDES permit, which may include phenols, sulfites, and hexavalent chromium). Volatile organics, sulfides, phenols, and phosphorus samples can be composited but require special handling procedures.

Composite Samples. These samples are collected over time, either by continuous sampling or by mixing discrete samples, and represent the average characteristics of the wastestream during the compositing period. Composite samples are used when stipulated in a permit and when:

- Average pollutant concentration during the compositing period is determined
- Mass per unit time loadings is calculated
- Wastewater characteristics are highly variable.

Various methods for compositing samples are available and are based on either time or flow proportioning. Table 5-2 lists the advantages and disadvantages of various methods. The permit may specify which type of composite sample to use. Composite samples can be collected either manually or with automatic samplers. Inspectors should consider variability in wastestream flow rate and parameter concentrations carefully when choosing compositing methods, sampling equipment (tubing and containers), and quality assurance procedures. The compositing methods are as follows:

- Time Composite Sample—This method requires discrete sample aliquots collected in one container at constant time intervals. This method is appropriate when the flow of the sampled stream is constant (flow rate does not vary more than ±10 percent of the average flow rate) or when flow monitoring equipment is not available.
- Flow-Proportional Composite Sample—There are two methods used for this type of sample. One method collects a constant sample volume at varying time intervals proportional to stream flow (e.g., 200 milliliters sample collected for every 5,000 gallons of flow). In the other method, the sample is collected by increasing the volume of each aliquot as the flow increases, while maintaining a constant time interval between the aliquots.

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- Sequential Composite Sample—This method requires discrete samples collected in individual containers at constant time intervals or discharge increments—for example, samples collected every 15 minutes, composited into separate containers each hour. The discrete samples can then be manually flow-proportioned to form the composite sample. Alternatively, a constant sample volume is taken at constant discharge increments, as measured with a totalizer.

- Continuous Composite Sample—This example must be collected continuously from the wastestream. The sample may be constant volume, or the volume may vary in proportion to the flow rate of the wastestream.

Sample Volume

The volume of samples collected depends on the type and number of analyses needed, as reflected in the parameters to be measured. The volume of the sample obtained should be sufficient for all the required analyses plus an additional amount to provide for any split samples or repeat analyses. Table 5-1 provides a guide to sample volumes required for determining the constituents in wastewater. The laboratory receiving the sample should be consulted for any specific volume required. Specific recommended minimum sample volumes for different pollutant parameters can be found in EPA's *Methods for Chemical Analysis of Water and Wastes* (USEPA 1979b) and *Handbook for Sampling and Sample Preservation of Water and Wastewater* (USEPA 1982), and the current Environmental Protection Agency (EPA)-approved edition of *Standard Methods for the Examination of Water and Wastewater* [American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF)].

Sample Containers

Required sample containers, sample preservation, and sample holding time are described in 40 *CFR* Part 136. Table 5-3 includes this material. It is essential that the sample containers be made of chemically resistant material unaffected by the concentrations of the pollutants measured. In addition, sample containers must have a closure that will protect the sample from contamination. Wastewater samples for chemical analysis generally are collected in plastic (polyethylene) containers. Exceptions to this general rule are oil and grease samples, pesticides, phenols, Polychlorinated Biphenyls (PCBs), and other organic pollutant samples. These are collected in properly cleaned glass jars or bottles and sealed. Bacteriological samples always are collected in properly sterilized plastic or glass containers. Samples that contain constituents that will oxidize when exposed to sunlight (such as iron cyanide complexes) should be collected in dark containers.

Sample containers should be clean and uncontaminated. Some analytical procedures specify container cleaning procedures to be followed. Precleaned and sterilized disposable containers can be used (e.g., polyethylene cubitainers). If these are not used or if the analytical method does not specify procedures, the following procedures for cleaning sample containers can generally be used:

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- Wash with hot water and detergent.
- Rinse with acid (e.g., nitric for metals).
- Rinse with tap water, then rinse three or more times with organic-free water.
- Rinse glass containers with an interference-free, redistilled solvent (such as acetone or methylene chloride for extractable organics).
- Dry in contaminant-free area.

EPA Sample Identification Methods

Each sample must be accurately and completely identified. Any label or tag used to identify the sample must be moisture-resistant and able to withstand field conditions. A waterproof pen should be used to complete the labels or tags. A numbered label or tag associated with a field sample data sheet containing detailed information on the sample is preferable to using only a label or tag for information. The information provided for each sample should include the following:

- Facility name/location
- Sample site location
- Sample number
- Name of sample collector
- Date and time of collection
- Indication of grab or composite sample with appropriate time and volume information
- Identification of parameter to be analyzed
- Preservative used.

Sample Preservation and Holding Time

In most cases, wastewater samples contain one or more unstable pollutants that require immediate preservation and/or analysis. Appropriate chemical preservation should be provided before samples are transferred to the laboratory. Procedures used to preserve samples include cooling, pH adjustment, and chemical treatment. For some parameters such as cyanide and phenols, preservatives must be added to sample bottles prior to or immediately following sample collection. For many samples, if preservatives are not appropriately used, bacteria can quickly degrade certain constituents (such as phenols and phosphorus). Other constituents may volatilize (such as volatile organics and sulfides) or may

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react to form different chemical species (hexavalent chromium, for example). Proper preservation and holding times are essential to ensure sample integrity. (See Table 5-3 and refer to 40 *CFR* Part 136.)

Prompt analysis is the most positive assurance against error from sample deterioration, but prompt analysis is not feasible for composite samples in which portions may be stored for as long as 24 hours. Where possible, sample preservation must be provided during compositing, usually by refrigeration to 4°C (or icing). If an automatic sampler is used with ice, the ice must be replaced as necessary to maintain low temperatures. This is a particular limitation of automatic samplers used during the summer when ice must be frequently replaced.

Maximum sample holding times are also indicated in 40 *CFR* Part 136. Times listed are the maximum holding times between sample collection and analysis that are allowed for the sample to be considered valid. Typically, the holding time limitations begin upon combination of the last aliquot in a sample.

Transfer of Custody and Shipment of Samples

To ensure the validity of the permit compliance sampling data in court, written records must accurately trace the custody of each sample through all phases of the monitoring program. The primary objective of this chain-of-custody is to create an accurate written record (see Appendix F, an example chain-of-custody form) that can be used to trace the possession and handling of the sample from the moment of its collection through its analysis and introduction as evidence.

- Sample seals should be used to protect the sample's integrity from the time it is collected to the time it is opened in the laboratory. The seal should indicate the collector's name, the date and time of sample collection, and sample identification number.

- Samples should be packed properly to prevent breakage. The shipping container should be sealed or locked so that any evidence of tampering can be readily detected. Use of tamperproof evidence tape is recommended.

- Samples should be placed on ice or synthetic ice substitute that will maintain sample temperature at 4°C throughout shipment.

- Every sample must be accompanied by a sample tag and a chain-of-custody record that has been completed, signed, and dated. The chain-of-custody record should include the names of sample collectors, sample identification numbers, date and time of sample collection, location of sample collection, and names and signatures of all persons handling the sample in the field and in the laboratory.

- The responsibility for proper packaging, labeling, and transferring of possession of the sample lies with the person taking it.

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- All sample shipments must be accompanied by the chain-of-custody record and other pertinent forms. A copy of these forms should be retained by the originator. Also, all receipts associated with the shipment should be retained.

- When transferring possession of samples, the transferee must sign and record the date and time on the chain-of-custody record (use the currently approved record). In general, custody transfers are made for each sample, although samples may be transferred as a group, if desired. Each person who takes custody must fill in the appropriate section of the chain-of-custody record.

Quality Control

Control checks should be conducted during the actual sample collection to determine the performance of sample collection techniques. In general, the most common monitoring errors usually are caused by improper sampling, improper preservation, inadequate mixing during compositing and splitting, and excessive sample holding time. In addition, the following samples should be collected and analyzed to check sample collection techniques:

- Duplicate samples are separate samples taken from the same source at the same time. These samples provide a check on sampling equipment and precision techniques.

- Split samples are samples that have been divided into two containers for analysis by separate laboratories. These samples provide an excellent means of identifying discrepancies in the permittee's analytical techniques and procedures.

The laboratories performing the sample analyses should also use the following quality control measures:

- Spiked samples are samples to which a known quantity of substance has been added. They provide a way to verify the accuracy of the analytical procedures.

- Sample preservative blanks are samples of distilled water to which a known quantity of preservative is added. They are analyzed to determine the effectiveness of the preservative, providing a check on the contamination of chemical preservatives.

Table 5-4 indicates quality control procedures for field analyses and equipment. Quality control is discussed in greater detail in Chapter Seven of this manual and EPA's *NPDES Compliance Inspector Training Laboratory Analyses Manual*, April 1990.

Data Handling and Reporting

Verified analytical results are normally entered into a laboratory data management system of some type. The system should contain the sampling data, including time and exact location, analysis dates and times, names of analysts, analytical methods/techniques used, and analytical results. Data are then reported to the project officer (inspector) for inclusion into the

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compliance report. The quality assurance manual by EPA (*Handbook for Analytical Quality Control in Water and Wastewater Laboratories*, USEPA 1979) and the article by J.J. Delfino ("Quality Assurance In Water and Wastewater Analysis Laboratories," Delfino 1977) provide useful information to the inspector on a number of data management techniques.

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Table 5-1

Volume of Sample Required for Determination of the Various Constituents of Industrial Wastewater (Associated Water and Air Resource Engineers, Inc. 1973 *Handbook for Monitoring Industrial Wastewater.* USEPA Technology Transfer.)

Tests	Volume of Sample,(1) ml
PHYSICAL	
Color and Odor(2)	100 to 500
Corrosivity(2)	Flowing sample
Electrical conductivity(2)	100
pH, electrometric(2)	100
Radioactivity	100 to 1,000
Specific gravity(2)	100
Temperature(2)	Flowing sample
Toxicity(2)	1,000 to 20,000
Turbidity(2)	100 to 1,000
CHEMICAL	
Dissolved Gases:	
Ammonia,(3) NH(3)	500
Carbon dioxide,(3) free $C0_2$	200
Chlorine,(3) free Cl_2	200
Hydrogen,(3) H_2	1,000
Hydrogen sulfide,(3) H_2S	500
Oxygen,(3) O_2	500 to 1,000
Sulfur dioxide,(3) free SO_2	100
Miscellaneous:	
Acidity and alkalinity	100
Bacteria, iron	500
Bacteria, sulfate-reducing	100
Biochemical oxygen demand (BOD)	100 to 500
Carbon dioxide, total $C0_2$ (including $C0_3^{--}$, $HC0_3^-$, and free)	200
Chemical oxygen demand (dichromate)	50 to 100
Chlorine requirement	2,000 to 4,000
Chlorine, total residual Cl_2 (including OCl^-, HOCl, NH_2Cl, $NHCl_2$, and free)	200
Chloroform-extractable matter	1,000
Detergents	100 to 200
Hardness	50 to 100
Hydrazine	50 to 100
Microorganisms	100 to 200
Volatile and filming amines	500 to 1,000
Oily matter	3,000 to 5,000
Organic nitrogen	500 to 1,000
Phenolic compounds	800 to 4,000
pH, colorimetric	10 to 20
Polyphosphates	100 to 200
Silica	50 to 1,000
Solids, dissolved	100 to 20,000
Solids, suspended	50 to 1,000
Tannin and lignin	100 to 200

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Table 5-1

Volume of Sample Required for Determination of the Various Constituents of Industrial Wastewater (Continued)

Tests	Volume of Sample, (1) ml
Cations:	
Aluminum, Al^{+++}	100 to 1,000
Ammonium,(3) $NH4^{+}$	500
Antimony, Sb^{+++} to Sb^{+++++}	100 to 1,000
Arsenic, As^{+++} to As^{+++++}	100 to 1,000
Barium, Ba^{++}	100 to 1,000
Cadmium, Cd^{++}	100 to 1,000
Calcium, Ca^{++}	100 to 1,000
Chromium, Cr^{+++} to Cr^{++++++}	100 to 1,000
Copper, Cu^{++}	100 to 1,000
Iron,(3) Fe^{++} and Fe^{+++}	200 to 4,000
Lead, Pb^{++}	100 to 1,000
Magnesium, Mg^{++}	100 to 4,000
Manganese, Mn^{++} to Mn^{+++++}	100 to 1,000
Mercury, Hg^{+} and Hg^{++}	100 to 1,000
Potassium, K^{+}	100 to 1,000
Nickel, Ni^{++}	100 to 1,000
Silver, Ag^{+}	100 to 1,000
Sodium, Na^{+}	100 to 1,000
Strontium, Sr^{++}	100 to 1,000
Tin, Sn^{++} and Sn^{++++}	100 to 1,000
Zinc, Zn^{++}	100 to 1,000
Anions:	
Bicarbonate, HCO_3^{-}	100 to 200
Bromide, Br^{-}	100
Carbonate, CO_3^{--}	100 to 200
Chloride, Cl^{-}	25 to 100
Cyanide, Cn^{-}	25 to 100
Fluoride, Fl^{-}	200
Hydroxide, OH^{-}	50 to 100
Iodide, I^{-}	100
Nitrate, NO_3^{-}	10 to 100
Nitrite, NO_2^{-}	50 to 100
Phosphate, ortho, PO_4^{---}, HPO_4^{--}, $H_2PO_4^{-}$	50 to 100
Sulfate, SO_4^{--}, HSO_4^{-}	100 to 1,000
Sulfide, S^{--}, HS^{-}	100 to 500
Sulfite, SO_3^{--}, HSO_3^{-}	50 to 100

(1) Volumes specified in this table should be considered as guides for the approximate quantity of sample necessary for a particular analysis. The exact quantity used should be consistent with the volume prescribed in the standard method of analysis, whenever a volume is specified.
(2) Aliquot may be used for other determinations.
(3) Samples for unstable constituents must be obtained in separate containers, preserved as prescribed; containers must be completely filled and sealed against air exposure.

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Table 5-2

Compositing Methods

Method	Advantages	Disadvantages	Comments
Time Composite			
• Constant sample volume, constant time interval between samples	Minimal instrumentation and manual effort; requires no flow measurement	May lack representativeness, especially for highly variable flows	Widely used in both automatic samplers and manual handling
Flow-Proportional Composite			
• Constant sample volume, time interval between samples proportional to stream flow	Minimal manual effort	Requires accurate flow measurement reading equipment; manual compositing from flowchart	Widely used in automatic as well as manual sampling
• Constant time interval between samples, sample volume proportional to total stream flow at time of sampling	Minimal instrumentation	Manual compositing from flowchart in absence of prior information on the ratio of minimum to maximum flow; chance of collecting too small or too large individual discrete samples for a given composite volume	Used in automatic samplers and widely used as manual method
• Constant time interval between samples, sample volume proportional to total stream flow since last sample	Minimal instrumentation	Manual compositing from flow chart in absence of prior information on the ratio of minimum to maximum flow; chance of collecting either too small or too large individual discrete samples for a given composite volume	Not widely used in automatic samplers but may be done manually
Sequential Composite			
• Series of short period composites, constant time intervals between samples	Useful if fluctuations occur and time history is desired	Requires manual compositing of aliquots based on flow	Commonly used; however, manual compositing is labor intensive
• Series of short period composites, aliquots taken at constant discharge increments	Useful if fluctuations occur and the time history is desired	Requires flow totalizer; requires manual compositing of aliquots based on flow	Manual compositing is labor intensive
Continuous Composite			
• Constant sample volume	Minimal manual effort, requires no flow measurement highly variable flows	Requires large sample capacity; may lack representativeness for highly representative flows	Practical but not widely used
• Sample volume proportional to stream flow flows;	Minimal manual effort, most representative especially for highly variable sample volume, variable pumping capacity and power	Requires accurate flow measurement equipment, large sample volume, variable pumping capacity, and power	Not widely used

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
BACTERIAL TESTS			
Coliform, fecal and total	P,G	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	6 hours
Fecal streptococci	P,G	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	6 hours
INORGANIC TESTS			
Acidity	P,G	Cool, 4°C	14 days
Alkalinity	P,G	Cool, 4°C	14 days
Ammonia	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P,G	Cool, 4°C	48 hours
Biochemical oxygen demand, carbonaceous	P,G	Cool, 4°C	48 hours
Bromide	P,G	None required	28 days
Chemical oxygen demand	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Chloride	P,G	None required	28 days
Chlorine, total residual	P,G	None required	Analyze immediately
Color	P,G	Cool, 4°C	48 hours

Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II) (Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
Cyanide, total and amenable to chlorination	P,G	Cool, 4°C NaOH to pH>12 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P,G	HNO_3 to pH<2, H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P,G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
METALS[7]			
Chromium VI	P,G	Cool, 4°C	24 hours
Mercury	P,G	HNO_3 to pH<2	28 days
Metals except above	P,G	HNO_3 to pH<2	6 months
Nitrate	P,G	Cool, 4°C	48 hours
Nitrate-nitrite	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Nitrite	P,G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C HCl, H_2SO_4 to pH<2	28 days
Organic carbon	P,G	Cool, 4°C HCl, H_2SO_4 to pH<2	28 days

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times
(Excerpt from 40 *CFR* Part 136, Table II)
(Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
Orthophosphate phosphorus	P,G	Filter immediately Cool, 4°C	48 hours
Dissolved oxygen Probe Winkler	 G bottle & top G bottle & top	 None required Fix onsite and store in the dark	 Analyze immediately 8 hours
Phenols	G	Cool, 4°C H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total dissolved	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Residue, total	P,G	Cool, 4°C	7 days
Residue, filterable	P,G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P,G	Cool, 4°C	7 days
Residue, settleable	P,G	Cool, 4°C	48 hours
Residue, volatile	P,G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P,G	Cool, 4°C	28 days
Sulfate	P,G	Cool, 4°C	28 days
Sulfide	P,G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH >9	7 days
Sulfite	P,G	None required	Analyze immediately
Surfactants	P,G	Cool, 4°C	48 hours

Table 5-3

Required Containers, Preservation Techniques, and Holding Times
(Excerpt from 40 *CFR* Part 136, Table II)
(Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
Temperature	P,G	None required	Analyze immediately
Turbidity	P,G	Cool, 4°C	48 hours
ORGANIC TESTS[8]			
Purgeable halocarbons	G, teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable aromatic hydrocarbons	G, teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$[5] HC1 to pH2[9]	14 days
Acrolein and acrylonitrile	G, teflon-lined septum	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Adjust pH to 4-5[10]	14 days
Phenols[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction 40 days after extraction
Benzidenes[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
Nitrosamines[11,14]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Store in the dark	7 days until extraction; 40 days after extraction
Polychlorinated biphenyls (PCBs)[11]	G, teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction

Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136, Table II) (Continued)

Parameter	Container[1]	Preservative[2,3]	Maximum Holding Time[4]
Nitroaromatics and isophorone[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Store in the dark	7 days until extraction; 40 days after extraction
Polynuclear aromatic hydrocarbons[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5] Store in the dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Chlorinated hydrocarbons[11]	G, teflon-lined cap	Cool, 4°C	7 days until extraction; 40 days after extraction
2,3,7,8-tetrachlorodibenzo-p-dioxin[1]	G, teflon-lined cap	Cool, 4°C 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PESTICIDES TEST			
Organochlorine pesticides[11]	G, teflon-lined cap	Cool, 4°C pH 5-9[15]	7 days until extraction; 40 days after extraction
RADIOLOGICAL TEST			
Alpha, beta, and radium	P,G	HNO_3 to pH<2	6 months

1	Polyethylene (P) or glass (G).
2	Sample preservation should be performed immediately upon sample collection. For composite chemical samples, each aliquot should be preserved at the time of collection. When use of an automatic sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting are completed.

Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136 Table II (Continued)

3	When any sample is to be shipped by common carrier or sent through the Unites States mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 *CFR* Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of this Table, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: hydrochloric acid (HC1) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and sodium hydroxide (NaOH) in water solutions at concentrations of 0.08% by weight or less (pH about 12.3 or less).
4	Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability.
5	Should only be used in the presence of residual chlorine.
6	Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments to determine whether sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered, then NaOH is added to pH 12.
7	Samples should be filtered immediately onsite before adding preservative for dissolved metals.
8	Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific organic compounds.
9	Samples receiving no pH adjustment must be analyzed within 7 days of sampling.

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Table 5-3

Required Containers, Preservation Techniques, and Holding Times (Excerpt from 40 *CFR* Part 136 Table II (Continued)

10	The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
11	When the extractable analytes of concern fall within a single chemical category, the specified preservation and maximum holding times should be observed for optimum safeguarding of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to between 6 and 9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12 and 13 (re: the analysis of benzidine).
12	If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.
13	Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
14	For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to between 7 and 10 with NaOH within 24 hours of sampling.
15	The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% Na_2SO_3.

Table 5-4

Quality Control Procedures for Field Analysis and Equipment

Parameter	General	Daily	Quarterly
Dissolved Oxygen			
• Membrane Electrode	Enter the make, model, and serial and/or ID number for each meter in a logbook.	Calibrate meter using manufacturer's instructions or Winkler-Azide method.	Check instrument calibration and linearity using a series of at least three dissolved oxygen standards.
	Report data to nearest 0.1 mg/l.	Check membrane for air bubbles and holes. Change membrane and KCl if necessary.	Take all meters to the laboratory for maintenance, calibration, and quality control checks.
		Check leads, switch contacts, etc., for corrosion and shorts if meter pointer remains off-scale.	
• Winkler-Azide method	Record data to nearest 0.1 mg/l.	Duplicate analysis should be run as a precision check. Duplicate values should agree within ±0.2 mg/l.	
pH			
• Electrode Method	Enter the make, model, and serial and/or ID number for each meter in a logbook.	Calibrate the system against standard buffer solutions of known pH value (e.g., 4, 7, and 9 at the start of a sampling run).	
		Periodically check the buffers during the sample run and record the data in the logbook.	
		Be on the alert for erratic meter response arising from weak batteries, cracked electrodes, fouling, etc.	
		Check response and linearity following highly acidic or alkaline samples. Allow additional time for equilibration.	
		Check against the closest reference solution each time a violation is found.	
		Rinse electrodes thoroughly between samples and after calibration.	

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Table 5-4

Quality Control Procedures for Field Analysis and Equipment (Continued)

Parameter	General	Daily	Quarterly
Conductivity			
	Enter the make, model, and serial and/or ID number for each meter in a logbook.	Standardize with KCl standards having similar specific conductance values to those anticipated in the samples. Calculate the cell constant using two different standards.	Take all meters to lab for maintenance, calibration, and quality control checks.
			Check temperature compensation.
			Check date of last platinizing, if necessary.
		Rinse cell after each sample to prevent carryover.	Analyze NITS or EPA reference standard, and record actual vs. observed readings in the logbook.
Residual Chlorine			
Amperometric Titration	Enter the make, model, and ID and/or serial number of each titration apparatus in a logbook. Report results to nearest 0.01 mg/l.	Refer to instrument manufacturer's instructions for proper operation and calibration procedures.	Biweekly, return instrument to lab for maintenance and addition of fresh, standardize reagents.
Temperature			
Manual	Enter the make, model, and serial and/or ID number and temperature range.	Check for air spaces of bubbles in the column, cracks, etc. Compare with a known source if available.	Biweekly, check at two temperatures against a NITS or equivalent thermometer. Enter data in logbook.

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Table 5-4

Quality Control Procedures for Field Analysis and Equipment (Continued)

Parameter	General	Daily	Quarterly
Temperature (Continued)			
	All standardization should be against a traceable NITS or NITS calibrated thermometer. Reading should agree within ±1°C. If enforcement action is anticipated, calibrate the thermometer before and after analysis. All data should be read to the nearest 1°C. Report data between 10° and 99°C to two significant figures.		Temperature readings should agree within ±1°C or the thermometer should be replaced or recalibrated. Initially and biannually, determine accuracy throughout the expected working range of 0°C to 50°C. A minimum of three temperatures within the range should be used to verify accuracy. Preferable ranges are 5-10°C, 15-25°C, and 35-45°C.
• Thermistors, Thermographs, etc.	Enter the make, model, and serial and/or ID number of the instrument in a logbook. All standardization shall be against a NITS or NITS calibrated thermometer. Reading should agree within ±1°C. If enforcement action is anticipated, refer to the procedure listed above.	Check thermistor and sensing device for response and operation according to the manufacturer's instruction. Record actual vs. standard temperature in logbook.	Initially and biannually, determine accuracy throughout the expected working range of 0°C to 50°C. A minimum of three temperatures within the range should be used to verify accuracy. Preferable ranges are 5-10°C, 15-25°C, and 35-45°C.
Flow Measurement			
	Enter the make, model, and serial and/or ID number of each flow measurement instrument in a logbook.	Install the device in accordance with the manufacturer's instructions and with the procedures given in owner's manual.	Annually affix record of calibration (NITS, manufacturer) to the instrument log.
Automatic Samplers			
	Enter the make, model, and serial and/or ID number of each sampler in a logbook.		Check intake velocity vs. head (minimum of three samples), and clock time setting vs. actual time interval.

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*** NOTES ***

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5. SAMPLING

C. References and Permittee Sampling Inspection Checklist

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PERMITTEE SAMPLING INSPECTION CHECKLIST

A. PERMITTEE SAMPLING EVALUATION

Yes	No	N/A	1. Samples taken at sites specified in permit.
Yes	No	N/A	2. Locations adequate for representative samples.
Yes	No	N/A	3. Flow proportioned samples obtained when required by permit.
Yes	No	N/A	4. Sampling and analysis completed on parameters specified by permit.
Yes	No	N/A	5. Sampling and analysis done in frequency specified by permit .
Yes	No	N/A	6. Permittee uses method of sample collection required by permit. Required method:_____ If not, method being used is: ( ) Grab ( ) Manual composite ( ) Automatic Composite
			7. Sample collection procedures adequate:
Yes	No	N/A	a. Samples refrigerated during compositing.
Yes	No	N/A	b. Proper preservation techniques used.
Yes	No	N/A	c. Containers and sample holding times before analyses. conform to 40 *CFR* Part 136.3.
Yes	No	N/A	d. Samples analyzed in timeframe needed (same day).
Yes	No	N/A	8. Monitoring and analyses performed more often than required by permit; if so, results reported in permittee's self-monitoring report.
Yes	No	N/A	9. Samples contain chlorine.
Yes	No	N/A	10. Contract laboratory used for sample analysis.
Yes	No	N/A	11. POTW collects samples from industrial users in pretreatment program.

B. SAMPLING INSPECTION PROCEDURES AND OBSERVATIONS

Yes	No	N/A	1. Grab samples obtained.
Yes	No	N/A	2. Composite sample obtained. Compositing Frequency: ___ Preservation: _____
Yes	No	N/A	3. Sample refrigerated during compositing.
Yes	No	N/A	4. Flow proportioned sample obtained.
Yes	No	N/A	5. Sample obtained from facility sampling device.
Yes	No	N/A	6. Sample representative of volume and nature of discharge.
Yes	No	N/A	7. Sample split with permittee.
Yes	No	N/A	8. Chain-of-custody procedures employed.
Yes	No	N/A	9. Samples collected in accordance with permit.
Yes	No	N/A	10. Excessive foam, grease, floating solids observed at the outfall.

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*** NOTES ***

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6. FLOW MEASUREMENT

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*** NOTES ***

6. FLOW MEASUREMENT

A. Evaluation of Permittee's Flow Measurement

Objectives and Requirements

To comply with the permit requirements established under the National Pollutant Discharge Elimination System (NPDES), the permittee must accurately determine the quantity of wastewater being discharged. Therefore, discharge flow measurement is an integral part of the NPDES program and the accuracy of the measurement must be evaluated by the inspector.

In addition to providing usable information for enforcement purposes, flow measurement serves to:

- Provide data for pollutant mass loading calculations
- Provide operating and performance data on the wastewater treatment plant
- Compute treatment costs, based on wastewater volume
- Obtain data for long-term planning of plant capacity, versus capacity used.

A Flow Measurement Inspection Checklist for the inspector's use appears at the end of this chapter.

Evaluation of Facility-Installed Flow Devices and Data

Two types of wastewater flow can be encountered: closed channel flow and open channel flow. Closed channel flow occurs under pressure in a liquid-full conduit (usually a pipe). Flow in closed channels is usually measured by a metering device inserted into the conduit. Examples of closed channel flow measuring devices are the Venturi meter, the pitot tube, the paddle wheel, and the electromagnetic flowmeter. In practice, closed channel flow is normally encountered between treatment units in a wastewater treatment plant, where liquids and/or sludges are pumped under pressure.

Open channel flow occurs in conduits that are not liquid-full. Partially full pipes, not under pressure, are classified as open channels. Open channel flow is the most prevalent type of flow at NPDES-regulated discharge points.

Open channel flow is measured using primary and secondary devices. Primary devices are standard hydraulic structures, such as flumes and weirs, that are inserted in the open channel. Accurate flow measurements can be obtained merely by measuring the depth of liquid (head) at the specific point in the primary device. In a weir application, for example, the flow rate is a function of the head of liquid above the weir crest.

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Secondary devices are used in conjunction with primary devices to automate the flow measuring process. Typically, secondary devices measure the liquid depth in the primary device and convert the depth measurement to a corresponding flow, using established mathematical relationships. Examples of secondary devices are floats, ultrasonic transducers, and bubblers. The output of the secondary device is generally transmitted to a recorder and/or totalizer to provide instantaneous and historical flow data to the operator. Outputs may also be transmitted to sampling systems to facilitate flow proportioning. Further information on flow measurement devices is included in Appendix G.

The permittee must obtain accurate wastewater flow data to calculate mass loading (quantity) from measured concentrations of pollutants discharged as required by many NPDES permits. The permittee must produce data that meet requirements in terms of precision and accuracy. Precision refers to data reproducibility or the ability to obtain consistent data from repeated measurements of the same quantity. Accuracy refers to the agreement between the amount of a component measured by the test and the amount actually present.

The accuracy of flow measurement (including both primary and secondary devices) varies widely with the device, its location, environmental conditions, and other factors such as maintenance and calibration. Faulty fabrication, construction, and installation of primary devices are common sources of errors. Improper calibration, misreading, and variation in the speed of totalizer drive motors are major errors related to secondary devices. When evaluating facility installed devices, the inspector should do the following:

- Verify that the primary and secondary devices have been installed according to manufacturer's instructions and other applicable plans and specifications.
- Inspect the primary device for evidence of corrosion, scale formation, or solids accumulation that may bias the flow measurement.
- Verify that weirs are level, plumb, and perpendicular to the flow direction.
- Verify that flumes are level, the throat walls are plumb, and the throat width is the standard size intended.
- Inspect historical records (strip charts, logs, etc.) for evidence of continuous flow measurements. Compare periods of missing data with maintenance logs for explanations of measuring system problems.
- Observe the flow patterns near the primary device for excessive turbulence or velocity. The flow lines should be straight.
- Ensure that the flow measurement system or technique being used measures the entire wastewater discharge as required by the NPDES permit. A careful inspection should be conducted to determine whether there are any wastewater diversions, return lines, or bypasses around the system. Make sure the system meets the permit requirement, such as instantaneous or continuous, daily, or other time interval. Anomalies should be noted in the inspection report.

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- Verify that the site chosen for flow measurement is appropriate and is in accordance with permit requirements.
- Verify that the site chosen for flow measurement is suitable for type of discharge, flow range, suspended solids concentration, and other relevant factors.
- Verify that closed channel flow measuring devices are placed where the pipe is always full.
- Verify that tables, curves, and formulas are appropriate and are used correctly to calculate flow rates.
- Review and evaluate calibration and maintenance programs for the discharger's flow measurement system. The permit normally requires that calibration be checked regularly by the permittee. The calibration of flow measurement systems must be checked often enough to ensure their accuracy. Flow measurement systems should be calibrated by an independent source at least once a year. Lack of such a program is considered unacceptable for NPDES compliance purposes.
- Verify that primary and secondary devices are adequate for normal flow as well as maximum expected flow. Note whether the flow measurement system can measure the expected range of flow.
- Collect accurate flow data during inspection to validate self monitoring data collected by the permittee.

Evaluation of Permittee Data Handling and Reporting

The permittee or facility must keep flow measurement records for a minimum period of three years as the permit requires. Many flow measuring devices produce a continuous flowchart for plant records. Flow records should contain date, flow, time of reading, and operator's name, if applicable. Maintenance, inspection dates, and calibration data should also be recorded.

The inspector should review the permittee's records and note the presence or absence of data such as:

- Frequency of routine operational inspections
- Frequency of maintenance inspections
- Frequency of flowmeter calibration (should be as specified in permit, generally at least once per year)
- Irregularity or uniformity of flow.

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Evaluation of Permittee Quality Control

The following quality control issues should be evaluated carefully during a compliance inspection:

- Proper operation and maintenance of equipment
- Accurate records
- Sufficient inventory of spare parts
- Valid flow measurement techniques
- Precise flow data
- Adequate frequency of calibration checks.

Precision can be evaluated at float driven devices when flows are stable. The float is pushed gently downward, held for 30 seconds, then allowed to return normally. The recorded flow rate should be the same before and after the float was moved. Accuracy can be evaluated by measuring the instantaneous flow rate at the primary device used at the facility and comparing the value against the value on the meter, graph, integrator, or company record. The difference between two stable totalizer readings (flow is steady for 10 minutes or more) should not exceed ±10 percent of the instantaneous flow measured at the primary device.

Accuracy can also be evaluated by installing a second flow measurement system, sometimes referred to as a reference system. Agreement in measured flow rates between the two systems should be within ±10 percent of the reference rate if all conditions are as recommended for the systems.

6. FLOW MEASUREMENT

B. Flow Measurement Compliance

Objectives

The current compliance strategy depends heavily on the permittee's submittal of self-monitoring data. The flow discharge measured during the NPDES compliance inspection should verify the flow measurement data collected by the permittee, support any enforcement action that may be necessary, and provide a basis for reissuing or revising the NPDES permit.

Flow Measurement System Evaluation

The responsibility of the inspector includes collecting accurate flow data during the inspection and validating data collected during the permittee's self-monitoring.

The NPDES inspector must check both the permittee's flow data and the flow measurement system to verify the permittee's compliance with NPDES permit requirements. When evaluating a flow measurement system, the inspector should consider and record findings on the following:

- Whether the system measures the entire discharge flow.
- The system's accuracy and good working order. This will include a thorough physical inspection of the system and comparison of system readings to actual flow or those obtained with calibrated portable instruments.
- The need for new system equipment.
- The existence or absence of a routine calibration and maintenance program for flow measurement equipment.

If the permittee's flow measurement system is accurate within ±10 percent, the inspector is encouraged to use the installed system. If the flow sensor or recorder is found to be inaccurate, the inspector should determine whether the equipment can be corrected in time for use during the inspection. If the equipment cannot be repaired in a timely manner, the portable flow sensor and recorder used to assess the accuracy of the permittee's system should be used for the duration of the inspection. If nonstandard primary flow devices are being used, the permittee should supply data on the accuracy and precision of the method being employed.

For flow measurement in pipelines, the inspector may use a portable flowmeter. The inspector should select a flowmeter with an operating range wide enough to cover the

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anticipated flow to be measured. The selected flowmeter should be tested and calibrated before use. The inspector should select the site for flow measurement according to permit requirements and install the selected flowmeter according to the manufacturer's specifications. The inspector should use the proper tables, charts, and formulas as specified by the manufacturer to calculate flow rates.

Four basic steps are involved in evaluating the permittee's flow measurement system:

- Physical inspection of the primary device
- Physical inspection of the secondary device and ancillary equipment
- Flow measurement using the primary/secondary device combination of the permittee
- Certification of the system using a calibrated, portable instrument.

In the following sections, procedures are presented for inspecting the more common types of primary and secondary devices, for measuring flow using common permanent and portable systems, and for evaluating flow data. It must be emphasized that the number of primary/secondary device permutations is limitless; therefore, it is not feasible to provide procedures for all systems. When systems other than those discussed here are encountered, the inspector is strongly encouraged to consult the manufacturers for advice before preparing a written inspection procedure.

Primary Device Inspection Procedures

The two most common open channel primary devices are sharp-crested weirs and Parshall flumes. Common sources of error when using them include the following:

- Faulty fabrication—weirs may be too narrow or not "sharp" enough. Flume surfaces may be rough, critical dimensions may exceed tolerances, or throat walls may not be vertical.
- Improper installation—weirs and flumes may be installed too near pipe elbows, valves, or other sources of turbulence. The devices may be out of level or plumb.
- Sizing errors—the primary device's recommended applications may not include the actual flow range.
- Poor maintenance—primary devices corrode and deteriorate. Debris and solids may accumulate in them.

Specific inspection procedures for the sharp crested weir, the Parshall flume, and the Palmer-Bowlus flume devices follow.

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Sharp-Crested Weir Inspection Procedures

- Inspect the upstream approach to the weir.
  - Verify that the weir is perpendicular to the flow direction.
  - Verify that the approach is a straight section of conduit with a length at least 20 times the maximum expected head of liquid above the weir crest.
  - Observe the flow pattern in the approach channel. The flow should occur in smooth stream lines without velocity gradients and turbulence.
  - Check the approach, particularly in the vicinity of the weir, for accumulated solids, debris, or oil and grease. The approach must have no accumulated matter.
- Inspect the sharp-crested weir
  - Verify that the crest of the weir is level across the entire conduit traverse.
  - Measure the width of the weir crest. The edge of the weir crest should be no more than 1/8-inch thick.
  - Make certain the weir crest corresponds to zero gauge elevation (zero output on the secondary device).
  - Measure the angle formed by the top of the crest and the upstream face of the weir. This angle must be 90 degrees.
  - Measure the chamfer on the downstream side of the crest. The chamfer should be approximately 45 degrees.
  - Visually survey the weir-bulkhead connection for evidence of leaks or cracks which permit bypass.
  - Measure the height of the weir crests above the channel floor. The height should be at least twice the maximum expected head (2H) of liquid above the crest.
  - Measure the width of the end contraction. The width should be at least twice the maximum expected head (2H) of the liquid above the crest.
  - Inspect the weir for evidence of corrosion, scale formation, or clinging matter. The weir must be clean and smooth.
  - Observe flow patterns on the downstream side of the weir. Check for the existence of an air gap (ventilation) immediately adjacent to the downstream face of the weir. Ventilation is necessary to prevent a vacuum that can induce errors

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in head measurements. Also ensure that the crest is higher than the maximum downstream level of water in the conduit.

- Verify that the nappe is not submerged and that it springs free of the weir plate.

- If the weir contains a V-notch, measure the apex angle. The apex should range from 22.5 degrees to 90 degrees. Verify that the head is between 0.2 and 2.0 feet. The weir should not be operated with a head of less than 0.2 feet since the nappe may not spring clear of the crest.

King's *Handbook of Hydraulics*, 1963, frequently referenced throughout this chapter, provides a detailed discussion on weirs.

Parshall Flume Inspection Procedures

- Inspect the flume approach.
  - The flow pattern should be smooth with straight stream lines, be free of turbulence, and have a uniform velocity across the channel.
  - The upstream channel should be free of accumulated matter.
- Inspect the flume.
  - The flume should be located in a straight section of the conduit.
  - Flow at the entrance should be free of "white" water.
  - The flume should be level in the transverse and translational directions.
  - Measure the dimensions of the flume. Dimensions are strictly prescribed as a function of throat width (see Figure G-5 in Appendix G for critical dimensions).
  - Measure the head of liquid in the flume and compare with the acceptable ranges in Table G-4.
- Inspect the flume discharge
  - Verify that the head of water in the discharge is not restricting flow through the flume. The existence of a "standard wave" is good evidence of free flow and verifies that there is no submergence present.
  - Verify whether submergence occurs at near maximum flow (e.g., look for water marks on the wall).

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Palmer-Bowlus Flume Inspection Procedures

- Inspect the flume approach as outlined above (these flumes are seldom used for effluent flow measurement).
- Inspect the flume
  - The flume should be located in a straight section of the conduit.
  - Flow at the entrance should be free of "white" water.
  - Observe the flow in the flume. The profile should approximate that depicted in Figure G-8.
  - The flume should be level in the transverse direction and should not exceed the translational slope in Table G-6.
  - Measure the head of water in the flume. Head should be within the ranges specified in Table G-6.
- Inspect the flume discharge
  - Verify that free flow exists. Look for the characteristic "standing wave" in the divergent section of the flume.

Venturi Meter Inspection Procedures

- Verify that the Venturi meter is installed according to manufacturer's instructions.
- Verify that the Venturi meter is installed downstream from a straight and uniform section of pipe, at least 5 to 20 diameters, depending on the ratio of pipe to throat diameter and whether straightening vanes are installed upstream. (Installation of straightening vanes upstream will reduce the upstream piping requirements.)
- Verify that the pressure measuring taps are not plugged.
- Calibrate the Venturi meter in place by either the volumetric method or the comparative dye dilution method to check the manufacturer's calibration curve or to develop a new calibration curve.

Secondary Device Inspection Procedures

The following are common sources of error in the use of secondary devices:

- Improper location—gauge is located in the wrong position relative to the primary device.

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- Inadequate maintenance—gauge is not serviced regularly.
- Incorrect zero setting—zero setting of gauge is not the zero point of the primary device.
- Operator error—human error exists in the reading.

Specific inspection procedures follow.

Flow Measurement in Weir Applications

- Determine that the head measurement device is positioned 3 to 4 head lengths upstream of a weir.
- Verify that the zero or other point of the gauge is equal to that of the primary device.

The inspector should use an independent method of measuring head, such as with a yardstick or carpenter's rule (be sure to measure at least 4 H_{max} upstream and convert to nearest hundredth of a foot). To determine flow rate, use the appropriate head discharge relationship formula (see Table G-1).

Flow Measurement in Parshall Flume Applications

Flow Measurement—Free-Flow Conditions.

- Determine upstream head (H_a) using staff gauge.
  - Verify that staff gauge is set to zero head. A yardstick or carpenter's rule can be used.
  - Verify that staff gauge is at proper location (two-thirds the length of the converging section back from the beginning of the throat).
  - Read to nearest division the gauge division at which liquid surface intersects gauge.
  - Read H_a in feet from staff gauge.
- To determine flow rate, use Figure G-6 in the unit desired, use tables published in flow measurement standard references, or calculate using the coefficients in Table G-5.

Flow Measurement—Submerged-Flow Condition. Generally, it is difficult to make field measurements with submerged-flow conditions. In cases when measurements can be obtained (using a staff or float gauge), the procedures listed below should be followed:

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- Determine upstream head using staff or float gauge.
  - Read to nearest division and, at the same time as for H_b, the gauge division at which liquid surface intersects gauge.
  - Calculate H_a from gauge reading.
- Determine downstream head (H_b) using staff or float gauge.
  - H_b refers to a measurement at the crest.
  - Read to nearest division, and at the same time as for H_a, the gauge division at which liquid surface intersects gauge.
  - Calculate H_b from staff reading.
- Determine flow rate.
  - Calculate percent submergence:

$$\left[\frac{H_b}{H_a}\right] \times 100.$$

  - Consult Table G-6.
  - When a correction factor is obtained, use H_a and find free-flow from Figure G-6.
  - Multiply this free-flow value by the correction factor to obtain the submerged flow.

The inspector may use an independent method of measuring head, such as a yardstick or carpenter's rule at the proper head measurement point. Because of the sloping water surface in the converging section of a flume, it is essential that the proper head measurement point be used.

Flow Measurement in Palmer-Bowlus Flume Applications

- Obtain head measurements as in the Parshall Flume application, using the secondary device. The head is the height of water above the step. The total depth upstream of the step is not the head.
- Refer to manufacturer-supplied discharge tables to convert head measurements to flow data. Palmer-Bowlus flumes, unlike Parshall flumes, are not constructed to standard dimensional standards. The inspector must not use discharge tables supplied by other manufacturers.

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Verification

Most flow measurement errors result from inadequate calibration of the flow, totalizer, and recorder. If the inspector has determined that the primary device has been installed properly, verification of the permittee's system is relatively simple. The flow determined from the inspector's independent measurement is compared to the flow of the permittee's totalizer or recorder. The inspector's flow measurements should be within 10 percent of the permittee's measurements to certify accurate flow measurement. Optimally, flow comparisons should be made at various flow rates to check system accuracy.

When the permit requires that the daily average flow be measured by a totalizing meter, the inspector should verify that the totalizer is accurate, i.e., properly calibrated. This can be done during a period of steady flow by reading the totalizer and at the same time starting a stopwatch. The stopwatch should be started just as a new digit starts to appear on the totalizer. After 10 to 30 minutes, the totalizer should be read again; just as a new digit begins to appear, the stop watch is read. By subtraction of the two totalizer readings, the total flow over the measured time period can be obtained. The flow rate in gallons per minute can be calculated by using the time from the stop watch. This flow rate should be compared to the flow determined by actual measurement of the head made at the primary device at the time interval. The calibration of the totalizer should be considered satisfactory if the two flows are within 10 percent of each other, when the actual measured flow is used as the known value, or divisor, in the percent calculation.

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6. FLOW MEASUREMENT

C. References and Flow Measurement Inspection Checklist

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FLOW MEASUREMENT INSPECTION CHECKLIST

A. GENERAL

Yes	No	N/A	1. a.	Primary flow measuring device properly installed and maintained.
Yes	No	N/A	b.	Flow measured at each outfall? _____ Number of outfalls? _____
Yes	No	N/A	c.	Is there a straight length of pipe or channel before and after the flowmeter of at least 5 to 20 diameters?
Yes	No	N/A	d.	If a magnetic flowmeter is used, are there sources of electric noise in the near vicinity?
Yes	No	N/A	e.	Is the magnetic flowmeter properly grounded?
Yes	No	N/A	f.	Is the full pipe requirement met?
Yes	No	N/A	2. a.	Flow records properly kept.
Yes	No	N/A	b.	All charts maintained in a file.
Yes	No	N/A	c.	All calibration data entered into a log book.
Yes	No	N/A	3.	Actual discharged flow measured.
Yes	No	N/A	4.	Effluent flow measured after all return lines.
Yes	No	N/A	5.	Secondary instruments (totalizers, recorders, etc.) properly operated and maintained.
Yes	No	N/A	6.	Spare parts stocked.
Yes	No	N/A	7.	Effluent loadings calculated using effluent flow.

B. FLUMES

Yes	No	N/A	1. Flow entering flume reasonably well-distributed across the channel and free of turbulence, boils, or other disturbances.
Yes	No	N/A	2. Cross-sectional velocities at entrance relatively uniform
Yes	No	N/A	3. Flume clean and free of debris and deposits.
Yes	No	N/A	4. All dimensions of flume accurate and level.
Yes	No	N/A	5. Side walls of flume vertical and smooth.
Yes	No	N/A	6. Sides of flume throat vertical and parallel.
Yes	No	N/A	7. Flume head being measured at proper location.
Yes	No	N/A	8. Measurement of flume head zeroed to flume crest.
Yes	No	N/A	9. Flume properly sized to measure range of existing flow.
Yes	No	N/A	10. Flume operating under free-flow conditions over existing range of flows.
Yes	No	N/A	11. Flume submerged under certain flow conditions.
Yes	No	N/A	12. Flume operation invariably free-flow.

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FLOW MEASUREMENT INSPECTION CHECKLIST (Continued)

C. WEIRS

Yes No N/A	1. What type of weir is being used?
Yes No N/A	2. Weir exactly level.
Yes No N/A	3. Weir plate plumb and its top and edges sharp and clean.
Yes No N/A	4. Downstream edge of weir is chamfered at 45°.
Yes No N/A	5. Free access for air below the nappe of the weir.
Yes No N/A	6. Upstream channel of weir straight for at least four times the depth of water level and free from disturbances.
Yes No N/A	7. Distance from sides of weir to side of channel at least 2H.
Yes No N/A	8. Area of approach channel at least (8 × nappe area) for upstream distance of 15H.
Yes No N/A	9. If not, is velocity of approach too high?
Yes No N/A	10. Head measurements properly made by facility personnel.
Yes No N/A	11. Leakage does not occur around weir.
Yes No N/A	12. Proper flow tables used by facility personnel.

D. OTHER FLOW DEVICES

	1. Type of flowmeter used:
	2. What are the most common problems that the operator has had with the flowmeter?
	3. Measured wastewater flow: _____ mgd; Recorded flow: _____; Error _____ %

E. CALIBRATION AND MAINTENANCE

Yes No N/A	1. Flow totalizer properly calibrated.
	2. Frequency of routine inspection by proper operator: /day.
	3. Frequency of maintenance inspections by plant personnel: /year.
Yes No N/A	4. Flowmeter calibration records kept. Frequency of flowmeter calibration: /month.
Yes No N/A	5. Flow measurement equipment adequate to handle expected ranges of flow rates.
Yes No N/A	6. Calibration frequency adequate.

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7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

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*** NOTES ***

7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

A. Objectives and Requirements

The analytical laboratory provides both qualitative and quantitative information for determining the extent of permittee compliance. To be valuable or useful, the data must be representative and accurately describe the characteristics and concentrations of constituents in the samples submitted to the laboratory. The objectives of laboratory Quality Assurance (QA) are to monitor and document the accuracy and precision of the results reported and to meet reliability requirements.

QA refers to a total program for ensuring the reliability of data by utilizing administrative and technical procedures and policies regarding personnel, resources, and facilities. QA is required for all functions bearing on environmental measurements and includes activities such as project/study definition; sample collection and tracking; laboratory analysis; data validation, analysis, reduction, and reporting; documentation; and data storage systems. Thus, the QA program is designed to evaluate and maintain the desired quality of data. Examples of QA include the use of spiked, duplicate, and performance evaluation samples. Quality Control (QC), a function of QA, is the routine application of procedures for controlling the accuracy and precision of the measurement process and includes the proper calibration of instruments and the use of the appropriate analytical procedures.

Laboratory QA is required by 40 *Code of Federal Regulations* (*CFR*) Section 122.41(e) (conditions applicable to all permits), which states that adequate laboratory and process controls, including appropriate QA procedures, must be provided. Each permittee's laboratory should have a QA/QC program. The QA program should be documented in a written QA/QC manual distributed to all personnel responsible for sample analyses. This manual should identify clearly the individuals involved in the QA program and their responsibilities and should document the laboratory's standard operating procedures that meet user requirements in terms of specificity, completeness, precision, accuracy, representativeness, and comparability. Approximately 10 to 20 percent of each laboratory's resources should be devoted to its QA/QC program.

Guidance in this chapter is broad based and may not be applicable to every laboratory. A Laboratory Quality Assurance Checklist for the inspector's use is included at the end of this chapter. For detailed information concerning laboratory QA, refer to Environmental Protection Agency's (EPA's) *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (USEPA 1979a). Further information is also available in the U.S. Environmental Protection Agency's (EPA's) *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module* (April 1990).

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7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

B. Sample Handling Procedures

Evaluation of Permittee Sample Handling Procedures

Proper sample handling procedures are necessary in the laboratory from the sample's receipt until it is discarded. Sample handling procedures for small permittees may differ from procedures for larger permittees because staff organizational structures and treatment facility designs vary from one facility to the next. However, proper sample handling procedures should be standardized, utilized and documented by all permittees to produce evidence that can be used in an enforcement action. In evaluating laboratory sample handling procedures, the inspector should verify the following:

- The laboratory has a sample custodian.
- The laboratory area is a secured area and is restricted to authorized personnel only.
- The laboratory has a sample security area that is dry, clean, and isolated; has sufficient refrigerated space; and can be locked securely.
- Samples are handled by a minimum number of people.
- All incoming samples are received by the custodian, who signs the chain-of-custody record sheet accompanying the samples and retains the sheet as a permanent record.
- The custodian has ensured that samples are properly stored.
- Only the custodian distributes samples to personnel who are to perform analyses.
- Transfer of samples is always documented.
- Care and custody records for handling samples are accurate and up-to-date.

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7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

C. Laboratory Analyses Techniques Evaluation

Evaluation of Permittee Laboratory Analytical Procedures

The methods used by the permittee's laboratories or its contract laboratories must be uniform, thus, eliminating methodology as a variable when data are compared or shared among laboratories. Procedures used by the permittee's laboratory must be selected by consulting 40 *CFR* Part 136 or EPA for approval of alternative methods. Alternative test procedures may be implemented only if the required written EPA approval has been obtained, as specified by 40 *CFR* Parts 136.4 and 136.5, and promulgated under Public Law (PL) 92-500.

Many standardized test procedures that have been promulgated under 40 *CFR* 136 are covered in *Methods for Chemical Analysis of Water and Wastes* (USEPA 1979b). Revisions and new additions to this publication are made whenever new analytical techniques or instruments are developed. These are considered accepted after final publication in the *Federal Register.* Other acceptable methods are specified in the latest accepted edition of *Standard Methods for the Examination of Water and Wastewater* [American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF)]. (The most current 40 *CFR* Part 136 may supersede any method or technique cited in this manual.)

In evaluating laboratory analytical procedures, the inspector should verify the following:

- Analytical methods specified in 40 *CFR* Part 136 are followed and any deviations allowed by 40 *CFR* Part 136 are properly performed.
- The QC system used conforms to the system specified in the permit or to that detailed in published *Standard Methods* (APHA, AWWA, and WEF).
- A QC record is maintained on reagent preparation, instrument calibration and maintenance, and purchase of supplies.
- QC checks are made on materials, supplies, equipment, instrument calibration and maintenance, facilities, analyses, and standard solutions.

- Steps and procedures stated in the method specified in 40 *CFR* Part 136 are followed.
- Documentation of any EPA-approved deviation from specified test procedures is available.

Evaluation of Permittee Laboratory Facilities and Equipment

To verify that the proper analytical procedures are being followed, the inspector should have the responsible analyst describe each of the procedures. The inspector should be alert to any deviation from the specified analytical method. Any questions regarding the proper procedures can be resolved by referring to the cited methodology. Even simple analyses can yield invalid results if the methodology cited in 40 *CFR* Part 136 is not exactly followed.

Laboratory Services

The availability of laboratory services affects data reliability. The inspector should verify that the following items are provided:

- An adequate supply of laboratory pure water, free from chemical interferences and other undesirable contaminants. Water quality should be checked routinely and documented.
- Adequate bench, instrumentation, storage, and recordkeeping space.
- Adequate humidity and temperature control.
- Adequate lighting and ventilation.
- Dry, uncontaminated, compressed air when required.
- Efficient fume hood systems.
- Necessary equipment such as hot plate, incubator, water bath, refrigerator for samples, pH meter, thermometer, and balance.
- Electrical power for routine laboratory use and, if appropriate, voltage-regulated sources for delicate electronic instruments.
- Emergency equipment, fire extinguisher, eye wash station, shower, first aid kit, gloves, and goggles.
- Vibration-free area for accurate weighings.

The inspector should also check that proper safety equipment (gloves, goggles, and fume hoods) are being used where necessary. The laboratory should be equipped with a fire

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extinguisher, eye wash station, shower, and first aid kit. Any problems noted should be documented and referred to the proper authority [e.g., Occupational Safety and Health Administration (OSHA)].

Instruments and Equipment

Instrumentation is extremely important in the analytical laboratory. To a certain extent, analytical instrumentation is always developmental; manufacturers are continually redesigning and upgrading their products, striving for miniaturization, enhanced durability and sensitivity, and improved automation. In evaluating laboratory instruments and equipment, the inspector should verify the following:

- Standard and specific procedures for cleaning glassware and containers are followed. Chapter 2 of EPA's *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module* (April 1990) contains detailed information on glassware cleaning.
- Written requirements (e.g., instruction manuals) for daily operation of instruments and equipment are provided and followed.
- Standards and appropriate blanks are available to perform standard calibration procedures. Standard concentrations that closely bracket actual sample concentrations should be used.
- Written troubleshooting procedures are available to identify common equipment malfunctions.
- Written schedules for replacement, cleaning, checking, and/or adjustment by service personnel are available and followed.
- Documentation is maintained on equipment maintenance and service checks.

Commonly used analytical instruments include analytical balances, pH meters, dissolved oxygen meters, conductivity meters, turbidimeters, spectrophotometers, atomic absorption spectrophotometers, organic carbon analyzers, selective ion analyzers, gas-liquid chromatographs, titrimetric analyses, and temperature controls. Detailed discussions on these instruments are included in Chapter 2 of EPA's *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module*. (April 1990).

Maintenance of laboratory facilities and equipment is an important factor in laboratory QA.

Supplies

Chemical reagents, solvents, and gases are available in many grades of purity, ranging from technical grade to various ultrapure grades. The purity of the materials required in analytical chemistry varies with the type of analysis. The parameter being measured, the analytical method, and the sensitivity and specificity of the detection system determine the purity of the

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reagents required. Reagents of lesser purity than that specified by the method should not be used. In evaluating laboratory supplies, the inspector should verify that:

- The required reagent purity for the specific analytical method is used
- Standard reagents and solvents are stored according to the manufacturer's directions
- Working standards are checked frequently to determine changes in concentration or composition
- Concentrations of stock solutions are verified before being used to prepare new working standards
- Laboratory supplies with limited shelf life are dated upon receipt and shelf-life recommendations, including the discard date on the container and the storage requirements, are observed
- Reagents are prepared and standardized against reliable primary standards
- Standards and reagents are labeled properly including the date of preparation and analyst's identification.
- Standards and reagents are stored in appropriate containers and under required conditions.
- Purchased solutions contain the chemicals specified by the method being used and are checked for accuracy.
- Clean containers of suitable composition with tight-fitting stoppers or caps should be used for storage.
- Reagents are discarded when signs of discoloration, formation of precipitates, or significant changes in concentrations are observed.
- Stock solutions and standards should be prepared using volumetric glassware.

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7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

D. Quality Assurance and Quality Control

Evaluation of the Precision and Accuracy of the Permittee Laboratory

The purpose of laboratory control procedures is to ensure high-quality analyses by the use of control samples, control charts, reference materials, and instrument calibration. Controls must be initiated and maintained throughout the analysis of samples. Specifically, each testing batch must contain at least one blank, standard, duplicate, and spiked (as applicable) sample analysis. When a batch contains more than 10 samples, every tenth sample should be followed by a duplicate and a spike (as applicable).

The precision of laboratory findings refers to the reproducibility or degree of agreement among replicate measurements of the same quantity. The closer the numerical values of the measurements come to each other, the more precise are the measurements. In a laboratory QC program, precision is estimated by the analysis of actual samples in duplicate. These may represent a range of concentrations and a variety of interfering materials usually encountered during the analysis. Accuracy refers to the degree of difference between observed values and known or actual values. The closer the value of the measurement comes to the actual value, the more accurate the measurement is. The accuracy of a method can be determined by analyses of samples to which known amounts of reference standards have been added (spiked samples).

In evaluating the precision of the measurement process, the inspector should verify that:

- Control samples are introduced into the train of actual samples to monitor the performance of the analytical system.
- Duplicate analyses are performed with each batch of samples to determine precision. In general, 10 percent of the samples should be duplicated.
- Precision control charts or other statistical techniques for each analytical procedure are prepared and used. Precision control charts should be developed by collecting data from a minimum of 15 to 20 duplicate samples (run in controlled conditions) over an extended period (e.g., 10 to 20 days). Statistical methods include calculation of mean, standard deviation, and variance to define the range and variability of the data.

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- Corrective actions are taken when data fall outside the warning and control limits.
- The out-of-control data or situation and the corrective action taken are fully documented.

In evaluating accuracy, the inspector should verify that:

- Spiked samples are introduced into the train of actual samples at least 10 percent of the time to monitor the performance of the analytical system.
- Spiked samples are used to monitor accuracy in each sample batch.
  - The amount of additive is appropriate to the detection limit and sample concentration.
- Accuracy control charts for each analytical procedure are prepared and used. Accuracy control charts should be developed by collecting data for a minimum of 15 to 20 samples over an extended period of time.
  - Accuracy limits are established based on standard deviations whose upper and lower control limits are established at three times the standard deviation above and below the central line.
  - The upper and lower warning limits are established at twice the standard deviation above and below the central line. Note: Some parameters have a defined warning limit required by 40 *CFR* 136.
  - Corrective actions are taken when data fall outside the warning and control limits.
  - The out-of-control data or situation and the corrective action taken are fully documented.

Evaluation of Permittee Data Handling and Reporting

An analytical laboratory must have a system for uniformly recording, processing, and reporting data. In evaluating permittee data handling and reporting, the inspector should verify that:

- Correct formulas are used to calculate the final results.
- Round-off rules are uniformly applied.
- Significant figures are established for each analysis.
- Provisions are available for cross-checking calculations.
- Control chart approaches and statistical calculations have been determined for the purposes of QC and reporting.

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- The laboratory report forms provide complete data documentation and permanent recording, and they facilitate data processing.
- The program for data handling provides data in the form/units required for reporting.
- Laboratory records are kept readily available to the regulatory agency for a minimum of 3 years (or longer if requested by EPA or the State).
- Laboratory notebooks or pre-printed data forms are bound permanently to provide good documentation, including the procedures performed and the details of the analysis, such as the original value recorded, correction factors applied, blanks used, and the reported data values. The dated notes indicate who performed the tests and include any abnormalities that occurred during the testing procedure. The notes are retained as a permanent laboratory record.
- Computer data are backed up with duplicate copies.
- Proper data handling and reporting procedures are implemented by all contract laboratories performing sample analyses.

Evaluation of Permittee Laboratory Personnel

Analytical operations in the laboratory vary in complexity. Consequently, work assignments in the laboratory should be clearly defined. All analysts should be thoroughly instructed in basic laboratory operations. Those persons performing complex analytical tasks should be qualified and properly trained. All analysts must follow specified laboratory procedures and be skilled in using the laboratory equipment and techniques required for the analyses assigned to them. In evaluating laboratory personnel, the inspector should consider the following factors:

- Adequacy of training
- Skill and diligence in following procedures
- Skill and knowledge in using equipment and analytical methods (particularly for complex equipment such as gas chromatography)
- Precision and accuracy in performing analytical tasks
- Assignment of clearly defined tasks and responsibilities.

Evaluation of Contract Laboratories

When laboratories are contracted to analyze samples, the inspector may need to ensure that the laboratory practices at the contracted laboratory are also evaluated. The practices can also be evaluated by other designated EPA inspectors. If a deficiency is identified at a contract laboratory, the permittee is responsible for the deficiency and will be notified.

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Overview of the Discharge Monitoring Report Quality Assurance Program and How It Relates to the Inspection Program

The validity of the National Pollutant Discharge Elimination System (NPDES) program depends on the quality of the self-monitoring program. The Discharge Monitoring Report Quality Assurance (DMR QA) program is an important tool used to ensure the quality of NPDES self-monitoring data. The program is designed to evaluate and improve the ability of laboratories serving NPDES permittees to analyze and report accurate self-monitoring data.

Major permittees under NPDES are sent performance evaluation samples containing constituents normally found in industrial and municipal wastewaters. They are to analyze these samples using the analytical methods and laboratory normally employed for their reporting of NPDES self-monitoring data. Responding permittees subsequently receive a report showing evaluation of their reported data.

Highlights

- The DMR QA Program has been an excellent means of focusing on and improving the quality of laboratory results used in developing DMR data. Improvements in the DMR QA data have been significant.

- This program has helped major permittees identify and correct both analytical and data handling problems in their laboratories.

- In general, permittees are receptive to the program and recognize its value, including some who challenged EPA's authority to require participation.

- Regions and States are generally supportive and have made good use of the results of this program for targeting inspections and directing other follow-up activities. This ability to concentrate corrective actions on problem permittees results in an increased efficiency in improving the self-monitoring data of all NPDES permittees.

- The program is one of the least resource-intensive methods for maintaining direct and regular technical contact with NPDES permittees. It has been recognized as a cost-effective effort.

- Utilizing computer technology, the following ways of managing and analyzing DMR QA data were started in FY 1985: compiling tracking summaries, comparing performance of the major industries, tracking multiple permittees, and regenerating past performance evaluation reports.

The DMR QA Program and the NPDES inspection programs are interdependent in several areas. First, in targeting the inspections, the DMR QA evaluations of permittee performance can be used, since the evaluations identify potential problems in laboratory analysis or data handling and reporting. This targeting helps to direct limited resources to permittees who need them most.

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The inspections and DMR QA results are tracked, and results are provided to the DMR QA coordinators at EPA Regional Offices and NPDES States. To track follow-up and complete statistical evaluations properly, a code is provided in Inspection Report Form 3560-3 to indicate when an inspection is the result of a DMR QA evaluation. (This is shown with the Code Q on the inspection form.)

Finally, inspections, particularly the Performance Audit Inspection (PAI), can be used to follow up the DMR QA. The DMR QA results should be cross-checked with the permit prior to the onsite visit, and parameters that were failed should be stressed during a laboratory inspection.

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7. LABORATORY PROCEDURES AND QUALITY ASSURANCE

E. References and Laboratory Quality Assurance Checklist

References

American Society for Testing and Materials (ASTM). *Annual Book of Standards, Part 31, Water.* ASTM, Philadelphia, PA.

APHA, AWWA, and WEF. *Standard Methods for the Examination of Water and Wastewater.* (Use the most current, EPA-approved edition.)

Brown, E., M.W. Skougstad, and M.J. Fishman. 1970. *Methods for Collection and Analysis of Water Samples for Dissolved Minerals and Gases.* U.S. Geological Survey Techniques of Water Resources Inv., Book 5.

Delfino, J.J. 1977. "Quality Assurance in Water and Wastewater Analysis Laboratories." *Water and Sewage Works*, 124(7): 79-84.

U.S. Environmental Protection Agency. 1979a. *Handbook for Analytical Quality Control in Water and Wastewater Laboratories.* EPA-600/4-79-019.

U.S. Environmental Protection Agency. 1979b. *Methods for Chemical Analysis of Water and Wastes.* EPA-600/4-79-020.

Federal Register, Vol 51. No. 125, June 30, 1986. *Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act* (also see October 26, 1986).

Plumb, R.H., Jr. 1981. "Procedure for Handling and Chemical Analysis of Sediment and Water Samples." *Technical Report EPA/CE-81-1.*

United States Geologic Survey (USGS), United States Department of the Interior (USDI), Open File Report 85-495; 1906 (see 6/30/86 *FR* for full citation).

U.S. Environmental Protection Agency. April 1990. *NPDES Compliance Monitoring Inspector Training Laboratory Analysis Module.*

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LABORATORY QUALITY ASSURANCE CHECKLIST

A. GENERAL

Yes	No	N/A	1. Written laboratory QA manual available.

B. LABORATORY PROCEDURES

Yes	No	N/A	1. EPA-approved analytical testing procedures used and on-hand. (written)
Yes	No	N/A	2. If alternate analytical procedures used, proper approval obtained.
Yes	No	N/A	3. Calibration and maintenance of instruments and equipment satisfactory.
Yes	No	N/A	4. QA procedures used.
Yes	No	N/A	5. QC procedures adequate.
			6. Duplicate samples analyzed % of time.
			7. Spiked samples used % of time.
Yes	No	N/A	8. Commercial laboratory used. Name _____ Address _____ Contact _____ Phone _____ Certification # _____

C. LABORATORY FACILITIES AND EQUIPMENT

Yes	No	N/A	1. Proper grade laboratory pure water available for specific analysis.
Yes	No	N/A	2. Dry, uncontaminated compressed air available.
Yes	No	N/A	3. Fume hood sufficiently ventilated.
Yes	No	N/A	4. Laboratory sufficiently lighted.
			5. Adequate electrical sources available.
Yes	No	N/A	6. Instruments/equipment in good condition.
Yes	No	N/A	7. Written requirements for daily operation of instruments available.
Yes	No	N/A	8. Standards and appropriate blanks available to perform daily check procedures.
Yes	No	N/A	9. Written troubleshooting procedures for instruments available.
Yes	No	N/A	10. Schedule for required maintenance exists.
Yes	No	N/A	11. Proper volumetric glassware used.
Yes	No	N/A	12. Glassware properly cleaned.
Yes	No	N/A	13. Standard reagents and solvents properly stored.
Yes	No	N/A	14. Working standards frequently checked.
Yes	No	N/A	15. Standards discarded after recommended shelf-life has expired.
Yes	No	N/A	16. Background reagents and solvents run with every series of samples.

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LABORATORY QUALITY ASSURANCE CHECKLIST (Continued)

Yes	No	N/A	17. Written procedures exists for cleanup, hazard response methods, and applications of correction methods for reagents and solvents.
Yes	No	N/A	18. Gas cylinders replaced at 100-200 psi.

D. LABORATORY'S PRECISION, ACCURACY, AND CONTROL PROCEDURES

Yes	No	N/A	1. Multiple replicates (blanks, duplicates, spikes, and splits) analyzed for each type of control check and information recorded.
Yes	No	N/A	2. Plotted precision and accuracy control methods used to determine whether valid, questionable, or invalid data are being generated from day to day.
Yes	No	N/A	3. Control samples introduced into the train of actual samples to ensure that valid data are being generated.
Yes	No	N/A	4. Precision and accuracy of the analyses are sufficient.

E. DATA HANDLING AND REPORTING

Yes	No	N/A	1. Round-off rules uniformly applied.
Yes	No	N/A	2. Significant figures established for each analysis.
Yes	No	N/A	3. Provision for cross-checking calculation used.
Yes	No	N/A	4. Correct formulas used to calculate final results.
Yes	No	N/A	5. Control chart approach and statistical calculations for QC and report available and followed.
Yes	No	N/A	6. Report forms developed to provide complete data documentation and permanent records and to facilitate data processing.
Yes	No	N/A	7. Data reported in proper form and units.
Yes	No	N/A	8. Laboratory records readily available to regulatory agency for required time of 3 years.
Yes	No	N/A	9. Laboratory notebook or pre-printed data forms bound permanently to provide good documentation.
Yes	No	N/A	10. Efficient filing system exists, enabling prompt channeling of report copies.

F. LABORATORY PERSONNEL

Yes	No	N/A	1. Enough analysts present to perform the analyses necessary.
Yes	No	N/A	2. Analysts have on hand the necessary references for EPA procedures being used.
Yes	No	N/A	3. Analysts trained in procedures performed through formal or informal training or certification programs.

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8. TOXICITY

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8. TOXICITY

A. Objectives

By definition, toxicity is a characteristic of a substance (or group of substances) that causes adverse effects in organisms. Adverse effects include an increased rate of morbidity (the rate of occurrence of disease) and mortality (the rate of occurrence of death), as well as those effects that limit an organism's ability to survive in nature, such as impaired reproductive ability. Toxicity of a substance is measured by observing the responses of organisms to increasing concentrations of that substance. One substance is more toxic than another when it causes the same adverse effects at a lower concentration.

Whole Effluent Toxicity (WET) is a National Pollutant Discharge Elimination System (NPDES) permit parameter designed to evaluate the toxicity of the entire wastestream and not individual pollutants. The WET testing may be either performed or evaluated as part of one of five NPDES inspections:

- Compliance Evaluation Inspection (CEI)
- Compliance Sampling Inspection (CSI)
- Performance Audit Inspection (PAI)
- Toxics Sampling Inspection (XSI)
- Compliance Biomonitoring Inspection (CBI).

In addition, the toxicity of a municipal treatment plant effluent should be considered as part of the Pretreatment Compliance Inspection (PCI), especially if the cause of the toxicity has been investigated and found to be from industrial or commercial dischargers contributing to the system.

The inspector should understand the permittee's WET testing requirements so that the appropriate objectives can be met:

- Assess compliance with NPDES permit conditions
- Determine compliance with State water quality standards
- Evaluate quality of self-monitoring data
- Assess adequacy of self-monitoring procedures
- Document existence or lack of toxic conditions
- Identify need to perform a Toxicity Identification Evaluation (TIE) and/or a Toxicity Reduction Evaluation (TRE)
- Develop permit limits.

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In the case of a PAI, the laboratory performing the WET tests is evaluated, as well as the NPDES permittee. This type of inspection requires more extensive information than is presented in this section. The inspector is therefore referred to Environmental Protection Agency's (EPA) *Manual for the Evaluation of Laboratories Performing Aquatic Toxicity Tests* (EPA/600/4-90/031) for the protocol to perform a PAI.

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8. TOXICITY

B. Requirements of WET Testing

Types of WET Testing

WET tests are techniques to determine the toxicity of a permittee's discharge or effluent by measuring the responses of organisms to solutions containing various percentages of effluent and dilution water. The test designs vary, depending on how the results are to be used. Test designs may vary in duration (acute or chronic) or in the way in which the effluent contacts the organism (flow-through, static, static renewal). However, WET testing is usually performed as a definitive (as opposed to a range finding or screening) test.

In a definitive test, several groups (replicates) of organisms are exposed for a predetermined length of time to solutions containing various proportions of effluent and dilution water. The response of each organism in each test concentration is observed and recorded, and the number of responses is analyzed in relation to the concentrations of effluent to which the organisms were exposed.

WET testing may be performed as either acute or chronic tests. The terms acute and chronic refer to the length of time that the organisms are exposed to the toxicant. The duration of the tests should be specified in the NPDES permit. Generally, acute tests measure short-term effects with impacts usually resulting in death or extreme physiological disorder. A response observed in 96 hours or less typically is considered acute. Chronic tests involve a stimulus that lingers or continues for a relatively long period, often one-tenth of a lifespan or more. Chronic should be considered a relative term depending on the lifespan of an organism. A chronic effect may result in death, stunted growth, or reduced reproductive rates.

Common test responses indicating the presence of toxic conditions include:

- Death — Increase in number of organisms killed by a test solution compared to the control
- Growth — Reduction in growth compared to the control
- Reproduction — Reduction in reproductive rates compared to the control
- Terata — Increase in number of gross abnormalities shown in early life stages compared to the control.

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WET tests are also described according to the way in which organisms are exposed to test solutions. The terms flow-through, static renewal, and static are most commonly used to describe how often the test solutions are renewed. In a flow-through test, effluent and dilution water are mechanically renewed continuously. This test setup requires specialized equipment (a serial or proportional dilutor or syringe pumps) and is more costly to operate than a static test. In a static renewal test, the test solutions are replaced periodically (usually daily) with fresh effluent and dilution water. In a static test, the solutions used at the start of the test are not replaced for the test's duration. Both static renewal and static tests require only basic equipment. The method of test solution renewal should be specified in the NPDES permit.

WET Test Components

WET tests consist of a number of components, as shown below:

- Effluent
- Dilution water
- Test Apparatus
- Test organisms
- Reference Toxicants
- Test results.

In simple terms, effluent and dilution water are combined in the test system with test organisms to produce test results. Each component must be of a specific quality for successful toxicity testing. It is the inspector's job to determine (insofar as possible) from the information available, that the test components adhere to the standards specified in the NPDES permit or accepted reference method. Review of the permittee's sampling logbook, chain of custody forms, and contract lab reports should provide most of the information necessary to assess the quality of the test components.

Each component has specific requirements (e.g., sample location for the effluent, dilution water constituents, choice of test apparatus materials). Accurate and reproducible test results can only be expected when the critical test components are handled properly. It is, therefore, very important to understand the relationships between these test components and the critical factors that determine the acceptability of each from a quality assurance standpoint. Critical factors that would likely be encountered during an NPDES inspection are described in the following sections.

Effluent

Effluent sampling strategy will usually be specified in the NPDES permit. Effluent samples must be representative of the entire discharge and free of contamination from other sources. If holding is necessary, the samples must be stored under strict conditions (4°C) and for limited times (less than 36 hours) so that no appreciable change in toxic characteristics occurs before testing.

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The type and frequency of samples taken (e.g., grab, composite) must be consistent with those required in the permit. For flow-through tests that are not done by pumping effluent directly into dilutors, daily sample sizes must be sufficient to supply the dilutor for periods ranging from 24 to 36 hours. This volume will depend on the type of test being conducted and the number of dilutions being run. For static renewal tests, daily sample volumes should be sufficient to replenish all dilutions in the test series and to provide separate vials of the dilutions to allow for Dissolved Oxygen (DO), pH, salinity, and other chemical analyses without contamination of the test dilutions. This volume will depend on the type of test being conducted and dilutions being run. Table 8-1 provides guidance as to representative sampling strategies for various situations.

Sample containers for large volumes of effluent should be either covered fiberglass or unsealed stainless steel tanks. Small volumes of effluent can be stored in reusable glass jugs or non-reusable Cubitainers or plastic milk jugs.

Samples for onsite tests should be used immediately when practical, but must be used within 36 hours of collection. It is usually not possible to refrigerate the large volume samples (200 liters or more) that are required for flow-through fish tests, but all other samples should be either iced or refrigerated if they are not to be used immediately.

Samples to be used for offsite tests should be iced for shipment and refrigerated (4°C) upon receipt by the testing laboratory. As a minimum requirement in all cases, tests should be initiated within 36 hours of collection. In the case of short-term chronic tests, samples taken on days one, three, and five may be held for a longer period of time to complete the test. In no case should any preservative be added to samples to be tested for toxicity.

Dilution Water

The choice of dilution water is generally specified in the NPDES permit and depends on the purpose of the toxicity test. Synthetic dilution water is used to evaluate the inherent toxicity of the effluent. Dilution water from the receiving stream or a nontoxic equivalent is used to test for interactions after discharge. Under no circumstances should the dilution water cause any toxic responses in test organisms. A lack of toxic responses in control organisms is evidence of the suitability of the dilution water. Control organisms should have less than or equal to 10 percent mortality in acute tests and less than or equal to 20 percent mortality for chronic tests. EPA manuals describe various techniques for the preparation of synthetic dilution water which may be necessary to use if the natural receiving water exhibits unacceptable levels of toxicity.

Dilution water obtained from receiving waters should be immediately used for testing. If it will not be used within 24 hours, it should be refrigerated (4°C) as soon as it is collected. In any case, the receiving water should be used within 36 hours of collection. The location from which the dilution water was obtained should be noted in the permittee's sampling log. It should be upstream and out of the influence of the outfall. The location should be free of other sources of contamination (e.g., other outfalls).

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Test System

WET tests may be performed in a fixed or mobile laboratory. Depending on the scope of the program, facilities may include equipment for rearing, holding, and acclimating organisms. Temperature control is achieved using circulating water baths, heat exchangers, or environmental chambers. Appropriate dilution water may be ground water, surface water, reconstituted water, or dechlorinated tap water. Holding, acclimation, and dilution water should be temperature controlled and aerated whenever possible. Air used for aeration must be free of oil and fumes; filters to remove oil in air are desirable. Test facilities must be well-ventilated and free of fumes. During holding, acclimating, and testing, test organisms should be shielded from external disturbances.

Any materials that come into contact with either effluent or dilution water must not release, absorb, or adsorb toxicants. A number of different choices for test equipment are available. Glass and No. 304 or 306 stainless steel are generally acceptable for freshwater holding, mixing, and test chambers. Stainless steel, however, is not acceptable for saltwater systems. Square-sided glass aquaria should be held together with small beads of silicone adhesive, with any unnecessary adhesive removed from inside the aquaria. If stainless steel containers are used, they must be welded, not soldered. Other specialized containers of NITEX or TEFLON are also acceptable. Tanks for storing effluents and dilution water may also be made of fiberglass. All containers or tubes made of these materials are reusable with appropriate cleaning (see below).

Polyethylene, polypropylene, polyvinyl chloride, polystyrene, and TYGON may also be used for containers or tubing, but should be checked for toxicity before being used. Because these materials may absorb toxicants during a test, their reuse is discouraged to prevent absorbed toxicants from leaching into new effluent or dilution water.

Copper, galvanized metal, brass, lead, and rubber must not contact the testing solutions at any time.

New plasticware (from a known nontoxic source) can be used after rinsing with dilution water. New glassware should be soaked overnight in dilute (20 percent) nitric or hydrochloric acid, rinsed in tap water, and then rinsed with dilution water before use.

Glassware and stainless steel components that must be reused should be soaked in detergent and scrubbed (or washed in a laboratory dishwasher), rinsed twice with tap water, rinsed with dilute acid, rinsed twice with tap water, rinsed with full strength acetone, rinsed twice with tap water, and then rinsed with dilution water before use. Glassware for algae tests should be neutralized in sodium bicarbonate before use.

Test Organisms

Organisms used for toxicity testing are limited to certain species for which there are established testing protocols. Species commonly used in biomonitoring include daphnids, mysids, fathead minnows, silversides, and algae. The life stage, source, acclimation and feeding procedures, presence of disease, and the number of organisms placed in test chambers all affect the degree to which organisms respond to toxicants. Therefore, it is

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important that these factors be standardized as much as possible. Appendix H summarizes test conditions for various types of tests and organisms.

The inspector should ascertain, as closely as possible, that the following procedures are being observed.

- The correct organisms must be utilized in the test (most often as specified in the NPDES permit). "Wild" organisms are rarely appropriate in WET testing. Test organisms used in toxicity testing must be of known history, free of disease, and acclimated to test conditions. Culture information should be recorded. Test organisms must also be of the appropriate age. The appropriate number of organisms must be used in each test vessel.

- Test organisms should be fed according to the requirements for the particular type of test. When feeding is necessary, excess food should be removed daily by aspirating with a pipette, to avoid problems such as food buildup leading to excessive oxygen demand.

- A daily log should be kept by the lab of feeding, reproduction, growth, mortality, and any abnormal behavioral observations.

- The following procedures are being observed (by the contract laboratory) for holding test organisms:

  - Quarantines new test organisms for at least 10 days if received from an outside source of unknown quality or for 48 hours if test organisms are obtained from a quality stock.

  - Maintains DO levels above 40-percent saturation for warm water species and above 60-percent saturation for cold water species.

- The laboratory should record the source of test organisms (hatchery, in-house, or elsewhere), as well as holding conditions (temperature, dissolved oxygen).

- Test organisms should be handled as little as possible to minimize stress:

  - Dip nets should be used for large organisms

  - Pipettes should be used for transferring small organisms such as daphnids and midge larvae.

Reference Toxicants

Reference toxicants are used to establish the relative sensitivity of the test organisms. A laboratory performs a definitive 24- or 48-hour static toxicity test with the reference toxicant to establish an average response. Reference toxicants available from the USEPA Environmental Monitoring Systems Laboratory (EMSL), Cincinnati, Ohio, include cadmium chloride and copper sulfate. Reference toxicants can also be prepared by the testing laboratory. An attempt should be made to match the type of reference toxicant used (e.g., metal or

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chlorinated organic) to the major pollutant in the wastewater tested. Reference toxicant data should be included with the contract lab report.

Recordkeeping and Data Reporting

Proper recordkeeping is essential to an effective program. Chain-of-custody procedures should consistently be used to document sample transfer. The permittee should maintain a sample log containing information as to the date, time, and type of sample taken as well as the sampler's name. Unusual conditions should be noted. When evaluating the contract lab's data reporting, the inspector should verify that the following are included:

- Summary of test results, description of test conditions, material tested, and other data for quality assurance
- Methods used for all chemical analyses
- Average and range of acclimation temperature and test temperature
- Any deviation from standard test methods
- Any other relevant information.

It may be beneficial for the contract lab to have a copy of the permittee's NPDES permit, including any modifications. By having a copy of the permit, the lab can better ensure that proper test procedures are being followed.

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Table 8-1

Recommended Sampling Strategies for Continuous and Intermittent Discharges for Flow-Through, Static Renewal, and Static Toxicity Tests

CONTINUOUS DISCHARGE

Test Type	Retention Time <14 Days	Retention Time >14 Days
Flow-through*	Two grab samples daily (early a.m. and late p.m.)	One grab sample daily
Static renewal	Four separate grab samples each day for four concurrent tests	One grab sample daily
Static.	Four separate grab samples on first day for four concurrent tests	One grab sample on first day

* For flow-through tests, it is always preferable to pump effluent directly to the dilutor.

INTERMITTENT DISCHARGE

Test Type	Continuous Discharge During 1 or 2 Adjacent 8-Hour Shifts	Discharge From Batch Treatment	Discharge to Estuary on Outgoing Tide
Flow-through	One grab sample midway through shifts daily	One grab sample of discharge daily	One grab sample of discharge daily
Static renewal	One grab sample midway through shifts daily	One grab sample of discharge daily	One grab sample of discharge daily
Static	One grab sample midway through shifts on first day	One grab sample of discharge on first day	One grab sample of discharge on first day

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8. TOXICITY

C. Analysis of Results

In general, the valid interpretation of test results requires that mortality in controls be limited, the conditions specified in the previous sections be met, and the results be consistent with response patterns normally observed in toxicity tests (e.g., increasing mortality with increasing concentrations). If any of these three general conditions are not met, the test results are invalid. However, there are exceptions, as discussed later.

In general, survival in controls must exceed survival in all other test chambers for both acute and chronic tests. If it does not, calculation of the toxicity due to increasing effluent concentration is at best an approximation of effluent toxicity. In any case, mortality in controls should not exceed 10 percent for acute toxicity tests and 20 percent for chronic test (or other values as required by States through their regulations). If control survival does not meet 90 or 80 percent for an acute or chronic test, respectively, then results should not be used for calculating summary statistics, and a determination of compliance using the test results cannot be made.

Each protocol has specified criteria to achieve acceptable ranges of control survival: temperature, dissolved oxygen concentration, salinity, pH, light intensity and duration of photoperiod, organism loading (numbers or weight per volume), feeding, and cleaning procedures. Summary tables of selected EPA methods are included as Appendix H. Tests not meeting the control criteria to achieve survival, growth, or reproduction are not valid. Tests not meeting the other acceptability criteria in these tables should be reviewed with caution and referred to the regional biologist. The inspector should review the EPA methods manual for a more extensive discussion of each of these factors. The EPA methods manuals are the following:

- *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*, EPA/600/4-89/001
- *Short-Term Methods for Measuring the Acute Toxicity of Effluent and Receiving Waters to Freshwater and Marine Organisms*, EPA/600/4-90/027F
- *Short-Term Methods for Estimates the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms*, EPA/600/4-87/028.

The expected result in all toxicity tests is a greater number of organism responses with increasing effluent concentrations. On many occasions, this increasing response is observed as one concentration eliciting no responses and the next higher concentration having 100 percent responses. This pattern is particularly obvious with acute tests. In other cases, the

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test organisms in more than one effluent dilution may exhibit a partial response (between 0 and 100 percent).

When test results do not meet the expected pattern, the test may be invalid. Questionable results in an acute test include:

- Higher mortalities in lower concentrations than in higher concentrations of effluent
- 100 percent mortality in all effluent dilutions
- Greater percent mortality in the control than in the lower dilutions of effluent.

Questionable results in a chronic test include:

- Greater growth or reproduction or fewer terata at higher concentrations of effluent than at lower concentrations
- No growth or reproduction or 100 percent terata at all effluent concentrations
- Less growth or reproduction or more terata in controls than in lower effluent concentrations.

When any of these abnormalities occur (outside of experimental error), the results and test conditions should be reviewed by the regional biologist. It should be recognized, however, that often there will be minor variations in test results. For example, *Ceriodaphnia dubia* reproduction may be higher at intermediate concentrations that are not toxic but provide a greater food resource than lower concentrations. Thus, variations should not always be used to eliminate otherwise valid results. However, if the normally expected pattern is not found, summary statistics calculated on the results should be assessed with caution.

Under some circumstances, compliance may still be determined with abnormal test results. If, for example, 100 percent responses were found in all effluent dilutions but the control was within the acceptable range, the appropriate toxicity measure would have to be below the most dilute solution tested. Similarly, if no responses are found in the toxicity test, the effluent can be deemed nontoxic at 100 percent effluent.

The test results need to be expressed such that compliance with the permittee's WET limits can be determined. The following definitions may help the inspector to interpret the results:

- The LC_{50} (for lethal concentration) is the calculated percentage of effluent (point estimate) at which 50 percent of the organisms die in the test period. Usually, the LC_{50} is calculated statistically by computer programs that fit the response curve to a mathematical function. Computer-based calculation procedures usually print an estimate of the error associated with the LC_{50} estimate.
- The EC_{50} (for effect concentration) is the calculated concentration (point estimate) at which 50 percent of the organisms show a particular effect (not necessarily death). For some species (e.g., *Ceriodaphnia dubia*) where the point of death is not certain, immobility is often used as a surrogate for death. Results for responses like the immobility responses in Daphnia may be reported as an EC_{50} (calculated in the same

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manner as the LC_{50}). Often, however, no distinction is made between the EC_{50} and the LC_{50} when the response is a surrogate for death.

- The No Observable Effect Concentration (NOEC) is the highest tested concentration at which the organisms' responses are not statistically different from the control organisms' responses. The NOEC [like the Lowest Observable Effect Concentration (LOEC) and Chronic Value (ChV) defined in the following paragraphs] is normally determined only for chronic tests.

- The LOEC is the lowest tested concentration at which organisms' responses are statistically different from controls. The ChV is the calculated geometric mean of the NOEC and LOEC (the square root of the product of the NOEC and LOEC).

- The Inhibition Concentration) (IC_{25}) is the calculated percentage of effluent (point estimate) at which the organisms exhibit a 25 percent reduction in a non-quantal biological measurement such as fecundity or growth.

- The percent response at a criterion concentration is reported. For example, the permit or standard may prohibit toxicity at 100 percent effluent or less. In this case, predicted percent response at 100 percent effluent would be reported.

There is an inverse relationship between toxicity and the effluent concentration percentage causing a toxic response. In other words, the same toxicity test response (e.g., LC_{50}) at lower percentages of effluent (i.e., more dilution) indicates higher toxicity than test results at higher percentages of effluent (i.e., less dilution). A Toxic Unit (TU), which is directly proportional to toxicity, is sometimes used to express the effluent's toxicity. TUs are defined as $100/LC_{50}$ for acute or 100/NOEC for chronic when the LC_{50} or NOEC is expressed as percent effluent. An effluent with an LC_{50} of 50 percent effluent has an acute toxicity of 2 Acute Toxic Units (TU_a). Similarly, an effluent with a NOEC of 25-percent effluent has a chronic toxicity of 4 Chronic Toxic Units (TU_c). The major advantage of using toxic units to express toxicity test results is that toxic units increase linearly as the toxicity of the effluent increases. So an effluent with a TU_a of 4 is twice as toxic as an effluent with a TU_a of 2. A second advantage of using toxic units is that they are directly analogous to constituent concentrations and can be used in waste load allocations with the same equations as individual constituents.

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9. PRETREATMENT

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9. PRETREATMENT

A. Review of the General Pretreatment Regulations

Development of 40 *CFR* Part 403

The Clean Water Act (CWA) requires Environmental Protection Agency (EPA) to promulgate regulations to control the discharge of pollutants to the Nation's waters to preserve their physical, chemical, and biological integrity. The National Pollutant Discharge Elimination System (NPDES) program is the primary regulatory mechanism developed to control point-source discharges to the surface waters of the United States. The National Pretreatment Program is the mechanism developed to regulate nondomestic users who discharge pollutants to Publicly Owned Treatment Works (POTWs) that could pass through or interfere with the treatment plant, threaten worker health and safety, or contaminate sludges.

The General Pretreatment Regulations [40 *Code of Federal Regulations (CFR)* Part 403] were promulgated on June 26, 1978. The regulations were revised and repromulgated on January 28, 1981. Since publication of the rule in 1981, the regulations have continued to be revised. Amendments have been made to the regulations to clarify some aspects and to respond to the findings of the Pretreatment Implementation Review Task Force (PIRT) study conducted in 1984. Additional regulatory changes were promulgated on July 24, 1990, (*Federal Register* 30082) in response to recommendations made in the Domestic Sewage Study (DSS). A summary of the General Pretreatment Regulations is provided in Table 9-1. Major technical changes resulting from final regulatory amendments or court decisions are noted in this table.

The purpose of the General Pretreatment Regulations is to protect POTWs and the environment from the damage that may result from discharges of pollutants to sanitary sewer systems. The three specific objectives cited in 40 *CFR* 403.2 of the General Pretreatment Regulations are to:

- Prevent the introduction of pollutants that would cause interference with the POTW or limit the use and disposal of its sludge
- Prevent the introduction of pollutants that would pass through the treatment works or be otherwise incompatible
- Improve the opportunities to recycle or reclaim municipal and industrial wastewaters and sludges.

In addition, improved POTW worker health and safety and reduction of influent loadings to sewage treatment plants are further objectives of pretreatment. Briefly stated, the definitions for interference and pass through are the following (see 40 *CFR* 403.3 for the exact definitions):

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- Interference is a discharge that alone or in conjunction with other discharges, disrupts the POTW or sludge processes, uses, and disposal, and therefore in turn causes violation of any requirement of the POTW's NPDES permit or prevents the POTW from using its chosen sludge use or disposal practice.

- Pass through is a discharge that exits the POTWs to waters of the United States in quantities or concentrations which, alone or in conjunction with other discharges, causes a POTW NPDES permit violation.

The General Pretreatment Regulations detail the procedures, responsibilities, and requirements of EPA, States, POTWs, and industries. To achieve the objectives of the regulations, implementation of the program by all regulated entities must be accomplished. In the next three sections, the specific responsibilities of each are explained.

Guidance manuals developed to assist EPA Regional Offices, States, POTWs, and industries with implementation of the General Pretreatment Program are listed in Section C, "References," of this chapter. In addition, policy memorandums from the EPA Office of Water Enforcement and Permits on pretreatment issues are listed.

Approval Authority Responsibilities

Two terms are important in understanding the General Pretreatment Regulations: "Control Authority" and "Approval Authority." Control Authority directly regulates the significant industrial users discharging to a POTW; Approval Authority oversees the development and implementation of POTW pretreatment programs and, for POTWs without an approved pretreatment program, is also the Control Authority that regulates industrial discharges to the POTW. The EPA Regional Office is the Approval Authority until a State is approved to administer the pretreatment program. However, once a State is approved, the EPA Regional Office maintains oversight responsibilities.

A pretreatment program is administered through the EPA Regional Office or a State with NPDES and pretreatment approval. The principal tasks for which an Approval Authority (EPA Regional Office or delegated State) is responsible are the following:

- Reviewing and approving POTW pretreatment programs and major modifications (see "Control Authority Responsibilities" for what Control Authority program development entails).

- Overseeing POTW program implementation, i.e., Pretreatment Compliance Inspections (PCIs), audits, and annual report reviews.

- Providing POTWs with technical assistance on the requirements of the General Pretreatment Regulations, categorical pretreatment standards, and POTW pretreatment program requirements.

- Notifying POTWs of new and existing program requirements.

- Determining SIU and POTW compliance with all applicable Federal requirements.

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- Applying and enforcing pretreatment standards and requirements at industries discharging to POTWs that do not have an approved local pretreatment program.

- Initiating enforcement action against noncompliant POTWs or industries.

Part 403.10 of the General Pretreatment Regulations identifies the requirements a State must meet to receive approval of the pretreatment program as part of its NPDES authority, that is, to become an Approval Authority. For States preferring to assume the responsibility of directly regulating industries discharging to POTWs and, hence, being considered the Control Authority in lieu of POTWs within the State, 40 *CFR* 403.10(e) provides that option.

Control Authority Responsibilities

Control Authority pretreatment program development and implementation requirements must be included in the NPDES permit of POTWs required to develop programs. Those requirements will thereby become an enforceable component of the permit. Part 403.8 of the General Pretreatment Regulations details the responsibilities of a POTW during the development of a pretreatment program. Additional information on the responsibilities of Control Authorities is provided in the EPA *Guidance Manual for POTW Pretreatment Program Development* (1993) and subsequent EPA guidance manuals.

The Control Authority program is submitted to the Approval Authority, either the EPA Regional Office or the approved State. Once approval has been received, the NPDES permit must be amended to require the Control Authority to implement the program.

Before a Control Authority pretreatment program is approved, the Approval Authority is the Control Authority for industries discharging to the POTW. After program approval, the Control Authority becomes responsible for implementing the requirements specified in the General Pretreatment Regulations [40 *CFR* 403.8(f)], the POTW pretreatment program, and the requirements of the NPDES permit (the permit must be complied with regardless of program approval). To fully implement the pretreatment program throughout the entire service area, the Control Authority has responsibilities related to several specific areas:

- Legal authority
  - Deny or condition new or increased discharges.
  - Require industrial users to comply with applicable pretreatment standards and requirements.
  - Require development of compliance schedules.
  - Carry out all inspection, surveillance, and monitoring procedures to determine industrial user compliance.
  - Enter premises of industrial users.
  - Apply Federal pretreatment standards to IUs.

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- Seek injunctive relief for noncompliance.
- Seek or assess civil or criminal penalties of at least $1,000 a day per violation.
- Immediately halt a discharge that presents or appears to present an imminent endangerment to the health or welfare of persons or to the environment or that threatens to interfere with the POTW's operation.
- Comply with confidentiality requirements.
- Develop and enforce an adequate sewer use ordinance.
- Control through permit order, or similar means, the contribution to the POTW by each industrial user. Individual control mechanisms that contain minimum required elements must be issued to significant industrial users.

• Pretreatment standards

- Identify and locate all possible industrial users that may be subject to the pretreatment program.
- Identify the character and volume of pollutants contributed to the POTW.
- Establish and periodically reevaluate local limits to ensure protection of the POTW from interference or pass through and to ensure the use or disposal of POTW sludge.
- Notify all industrial users of appropriate pretreatment standards, any changes to the regulations, and requirements of the Resource Conservation and Recovery Act (RCRA).
- Update the industrial survey to identify new industries that should be regulated by the POTW pretreatment program, and identify changes in manufacturing processes and wastewater discharge characteristics at existing facilities.
- Comply with public participation requirements.

• Industrial user compliance and enforcement

- Establish reporting, inspection, and monitoring requirements and procedures to enable evaluation of compliance.
- Inspect and sample industrial users. At a minimum, significant industrial users must be sampled and inspected at least once a year.
- Evaluate each significant industrial user at least once every 2 years for the need for a slug discharge control program.

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- Perform sampling and analysis in a manner to produce evidence admissible in enforcement proceedings or in judicial actions.

- Develop and implement an enforcement response plan to guide compliance evaluation and enforcement activities.

- Evaluate industry compliance by reviewing and analyzing self-monitoring reports and Control Authority monitoring.

- Investigate instances of noncompliance.

- Initiate appropriate enforcement action tc bring users into compliance.

- Establish other procedures as required and/or determined to be needed to regulate the significant industries discharging to the POTW.

• Public participation

- Publish at least annually, in the local newspaper with the greatest circulation, a list of the industrial users that were in significant noncompliance within the past 12 months as defined in 40 *CFR* 403.8(f)(2)(vii).

- Notify the public of any changes to the sewer use ordinance or local limits after approval by the Approval Authority.

- Submit pretreatment program modifications to Approval Authority.

• Data management

- Maintain records of pertinent industrial user activities and compliance status.

- Maintain a current understanding of the categorical pretreatment standards and General Pretreatment Regulations, and notify industries of any changes.

- Provide the Approval Authorities with any reports required.

• Resources

- Provide adequate resources and qualified personnel for program implementation.

As pretreatment needs change, the Control Authority may need to revise the approved program. When this occurs, the Control Authority should submit the modifications to the Approval Authority for review and approval.

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Industry Responsibilities

Industrial dischargers to POTWs must comply with the following:

- Prohibited discharge standards—The general and specific prohibited discharge standards (40 *CFR* 403.5) noted in Table 9-1.

- Appropriate pretreatment standards—Categorical pretreatment standards (40 *CFR* Part 405-471), State requirements, or locally developed discharge limitations as per 40 *CFR* 403.5.

- Reporting requirements—As specified in 40 *CFR* 403.12 and/or by the POTW. The requirements provided in 40 *CFR* 403.12 are summarized in Table 9-1.

The types of industrial facilities that are categorical industries are listed in Table 9-2. EPA has developed categorical pretreatment standards for these industries based on the type of wastes produced by the manufacturing processes at each type of industry, the wastewater control technologies available to the industry, and economic considerations. The categorical pretreatment standards developed apply to the wastewaters from specific manufacturing processes. The standards apply at the point of discharge from the pretreatment unit for the regulated process, or if there is no pretreatment unit, they apply at the end of the regulated process.

Where the Control Authority has determined that specific limitations for certain pollutants of concern are needed to protect the POTW from interference, pass through, and sludge contamination, the Control Authority must develop and enforce such limitations. These local limitations generally are applied at the point where the industrial facility discharges to the POTW.

An industry must meet the more stringent pretreatment standard for each pollutant. For a categorical industry, this will be the categorical pretreatment standard or a local limit for each pollutant regulated. If the point at which the Control Authority's limitation applies is not the same as the point at which the categorical pretreatment standard applies, either a calculation to adjust the categorical pretreatment standard will have to be used to compare the discharge limitations or sampling must be conducted at both points so that compliance with categorical standards and local limits can be determined.

When evaluating the pretreatment standards to determine the appropriate limitation, note that different categorical pretreatment standards were developed for each type of industry. If the industry combines the flows from more than one regulated process or combines a regulated process flow with other flows before these wastes are treated, the Control Authority and the industry must adjust the categorical pretreatment standard using the Combined Wastestream Formula (CWF). The equation is provided in 40 *CFR* 403.6(e) of the General Pretreatment Regulations. If the wastewaters are mixed after treatment, the categorical pretreatment standards must still be adjusted, in this case by flow weighted averaging of all flows introduced prior to the sample point. In either case, the resulting alternative limit cannot be set below the level of detection for that pollutant. Additional information on the combined wastestream formula and the flow weighted averaging formula is provided in EPA's *Guidance*

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Manual for Implementing Production-Based Pretreatment Standards and the Combined Wastestream Formula (1985).

Categorical industries have specific reporting requirements as per 40 *CFR* 403.12. A summary of the reports that categorical industries are required to submit is provided in Table 9-1. A Control Authority may require additional reports from all industries discharging to the system, including categorical industries.

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Table 9-1

Summary of the General Pretreatment Regulations

403.1	Purpose and Applicability
403.2	Objectives of General Pretreatment Regulations
403.3	Definitions
403.4	State or Local Law
	The Federal General Pretreatment Regulations are not meant to affect any state or local regulatory requirements as long as these requirements are at least as stringent as the Federal regulations.
403.5	National Pretreatment Standards: Prohibited Discharges
	This section specifies general and specific prohibited discharge standards that Control Authorities must incorporate into their pretreatment programs. The general prohibitions specify that pollutants introduced into POTWs by a nondomestic source shall not pass through the POTW or interfere with the operation or performance of the works. The section provides that Control Authorities required to develop local pretreatment programs and POTWs where interference and pass through are likely to recur develop and enforce specific limitations (local limits) to implement the general prohibitions against interference, pass through, and sludge contamination.
	The specific prohibitions specify prevention of discharge of pollutants that cause any of the following at the POTW:
	• Fire or explosion hazard, including no discharge with a closed-cup flashpoint of less than 60°C (140°F) using test methods in 40 *CFR* 261.21
	• Corrosive structural damage (no pH<5.0)
	• Obstruction to the flow in the POTW
	• Interference
	• Heat causing inhibition of biological activity and temperatures at the POTW treatment plant to exceed 40°C (104°F)
	• Petroleum oils, nonbiodegradable cutting oils, or products of mineral oils in amounts that will cause interference or pass through
	• Fume toxicity or reactivity
	• Trucked or hauled pollutants except at designated discharge points.
	Additionally, industrial users are provided with an affirmative defense (if specified conditions are met) for actions brought against them for alleged violations of the general or specific prohibitions contained in this section.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

403.6	National Pretreatment Standards: Categorical Standards This section discusses development and implementation of categorical pretreatment standards including, but not limited to, compliance deadlines, concentrations and mass limits, prohibition of dilution as a substitute treatment, and the Combined Wastestream Formula (CWF) to determine discharge limitations.
403.7	Revision of Categorical Pretreatment Standards to Reflect POTW Removal of Pollutants This section (referred to as the removal credits provision) provides the criteria and procedures to be used by a POTW in revising the pollutant discharge limits specified in categorical pretreatment standards to reflect removal of pollutants by the POTW.
403.8	Control Authority Pretreatment Programs: Development by Control Authority This section covers the requirements for pretreatment program development by a Control Authority. Included in this section are criteria for determining which POTWs must develop pretreatment programs, incorporation of approved programs and compliance schedules into NPDES permits, deadlines for program approvals, and program and funding requirements. 403.8(f) sets out the requirements of a POTW program. Specifically, it requires the Control Authority to have sufficient legal authority to enforce the approved pretreatment program. The section also discusses that all Control Authorities with approved programs, or programs under development, must develop and implement procedures to ensure compliance with the requirements of a pretreatment program.
403.9	Control Authority Pretreatment Programs and/or Authorization to Revise Pretreatment Standards: Submission for Approval This section discusses requirements and procedures for submission and review of Control Authority pretreatment programs. Included in this section are discussions of conditional program approval, approval authority action, and notification where submissions are defective.
403.10	Development and Submission of NPDES State Pretreatment Programs This section discusses requirements and procedures for submission and review of NPDES State pretreatment programs. Included in this section are discussions of approvals and deadlines for State programs, legal authority, program and funding requirements, and contents of program submissions.
403.11	Approval Procedures for Control Authority Pretreatment Programs and Revision of Categorical Pretreatment Standards This section provides the administrative procedures for the review and approval or denial of Control Authority pretreatment program submissions and requests for removal credit authority.
403.12	Reporting Requirements for Control Authorities and Industrial Users This section presents reporting requirements for Control Authorities and industrial users. Reports required by industrial users include the following:

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

403.12	(Continued) • Baseline Monitoring Report (BMR). Due to the Control Authority within 180 days of the effective date of the categorical pretreatment standards (40 *CFR* 403.6). In addition, new source BMR reporting requirements are discussed in this section. • Compliance schedule progress reports. Due to the Control Authority within 14 days of completion of compliance schedule milestones or due dates. • 90-day compliance report. Due to the Control Authority within 90 days of the compliance date of the categorical standards. • Periodic reports on continued compliance. Due to the Control Authority at least semiannually, usually in June and December after the compliance date. • Notices of potential problems including slug loadings. Due to the Control Authority immediately upon identification of discharges, including slug loadings that could cause problems to the POTW for both noncategorical and categorical industries. • Notice of changed discharge. Due to the Control Authority from categorical and noncategorical users in advance of any significant change in volume or character of pollutants discharged. • Notice of violation and resampling. Notification due to the Control Authority within 24 hours of noting a violation; results of resampling due within 30 days. • Notification of hazardous waste discharge. Notification to the POTW, EPA, and State Hazardous Waste authorities of the hazardous wastes discharges to the POTW. Reports required from Control Authorities include the following: • Compliance schedule (for development of pretreatment programs) progress reports • Annual POTW reports. Also discussed in detail in this section are monitoring requirements for industrial users and signatory and recordkeeping requirements for Control Authorities and industrial users.
403.13	Variances from Categorical Pretreatment Standards for Fundamentally Different Factors This provision allows an industrial user, or any interested person, to request a variance for the establishment of limits either more or less stringent than that required by a categorical pretreatment standard. The primary criterion required for approval of this variance is that the factors relating to the industrial user's discharges be fundamentally different from factors considered by EPA in establishing categorical pretreatment standards for these discharges.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

403.14	Confidentiality
	This section covers confidentiality requirements and prohibitions for EPA, States, and Control Authorities. Effluent data are available to the public without restriction.
403.15	Net/Gross Calculation
	This provision provides for adjustment of categorical pretreatment standards to reflect the presence of pollutants in the industrial user's intake water.
403.16	Upset Provision
	This provision is consistent with the NPDES regulations and allows an upset of an industry's pretreatment system (which meets the conditions of an upset as specified in this provision) to be an affirmative defense to an action brought for noncompliance with categorical pretreatment standards. The industrial user shall have the burden of proof for such a defense.
403.17	Bypass
	This provision requires industrial users to operate their treatment systems at all times and includes criteria for allowing a bypass to occur and notification procedures for both an anticipated and unanticipated bypass.
403.18	Modification of Control Authority Pretreatment Programs
	This provision specifies procedures and criteria for "minor" and "substantial" modifications to approved Control Authority pretreatment programs and incorporation of substantial modifications into the Control Authority NPDES program.

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Table 9-1

Summary of the General Pretreatment Regulations (Continued)

Appendix A	Program Guidance Memorandum This memorandum summarizes the Agency's policy on the use of construction grants for treatment and control of combined sewer overflows and storm water discharges.
Appendix B	65 Toxic Pollutants This appendix lists the 65 classes of toxic pollutants that are regulated by the pretreatment program through categorical pretreatment standards
Appendix C	Industrial Categories Subject to National Categorical Pretreatment Standards (previously titled "34 Industrial Categories") The Appendix C published on January 21, 1981, listed 34 industrial categories originally expected to be regulated by the pretreatment program through categorical pretreatment standards. Appendix C was revised on June 4, 1986, to incorporate changes to previous categorization, to delete categories that were exempted by paragraph 8 of the NRDC vs. EPA Consent Decree, and to incorporate additional categories for which standards are being developed or considered.
Appendix D	Selected Industrial Subcategories Considered Dilute for Purposes of the Combined Wastestream Formula (previously titled "Selected Industrial Subcategories Exempted from Regulation Pursuant to Paragraph 8 of the NRDC v. Costle Consent Decree" The Appendix D published on January 21, 1981, provided a list of industrial subcategories that had been exempted (pursuant to paragraph 8 of the NRDC vs. EPA Consent Decree) from regulation by categorical pretreatment standards. Appendix D was revised on October 9, 1986, to update the list of exempted industrial categories and to correct previous errors by either adding or removing various subcategories or by changing the names of some categories or subcategories. Each of the subcategories, as indicated by the revised Appendix D title, contains wastestreams that are classified as dilute for purposes of applying categorical pretreatment standards to other wastestreams and for using the combined wastestream formula to adjust these standards.
Appendix E	Sampling Procedures This appendix provides a general description of composite and grab sampling procedures.
Appendix to 403.12(p)	Hazardous Waste Authorities This appendix lists the EPA Regional and State Hazardous Waste Authority required to receive notification of hazardous wastes discharged.
Appendix G	Regulated Pollutants in Part 503 Eligible for a Removal Credit

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Table 9-2

Categorical Pretreatment Standards

Industrial Categories With Categorical Pretreatment Standards in Effect			Effluent Guidelines Currently Under Development*
	N	Aluminum Forming (Part 467)	• Pesticide Formulating, Packaging, and Repackaging
E	N	Battery Manufacturing (Part 461)	• Pulp, Paper, and Paperboard
E	N	Builder's Paper and Board Mills (Part 431)	• Pharmaceutical Manufacturing
E	N	Carbon Black Manufacturing (Part 458)	• Metal Products and Machinery (Phase I).
	N	Coil Coating (Part 465)	• Landfills and Incinerators
E	N	Copper Forming (Part 468)	• Industrial Laundries
E	N	Electrical and Electronic Components	• Transportation Equipment Cleaning
E		(Part 469)	• Two additional categories yet to be specified.
		Electroplating (Part 413)	• Centralized Waste Treatment
E	N	Fertilizer Manufacturing (Part 418)	• Coastal Oil and Gas Extraction
	N	Glass Manufacturing (Part 426)	
	N	Grain Mills Manufacturing (Part 406)	**Future Effluent Guidelines to Be Developed***
	N	Ink Formulating (Part 447)	
	N	Inorganic Chemicals (Part 415)	• Metal Products and Machinery (Phase II)
E	N	Iron and Steel Manufacturing (Part 420)	
E	N	Leather Tanning and Finishing (Part 425)	**Categories Being Studied for Possible Selection as One of the Two Additional Categories***
E	N	Metal Finishing (Part 433)	
E	N	Metal Molding and Casting (Part 464)	• Metal Finishing
E	N	Nonferrous Metals Forming and Metal	• Petroleum Refining
E		Powders (Part 471)	• Iron and Steel Manufacturing
	N	Nonferrous Metals Manufacturing (Part 421)	• Inorganic Chemicals
E	N	Organic Chemicals, Plastics, and	• Textile Mills
E		Synthetic Fibers (Part 414)	• Steam Electric Power Generating
	N	Paint Formulating (Part 446)	• Pulp, Paper, and Paperboard (portion)
N	N	Paving and Roofing Materials (Part 443)	
E	N	Pesticide Chemicals (Part 455)	
E	N	Petroleum Refining (Part 419)	
E	N	Pharmaceutical Manufacturing (Part 439)	
E	N	Porcelain Enameling (Part 466)	
E	N	Pulp, Paper, and Paperboard (Part 430)	
	N	Rubber Manufacturing (Part 428)	
	N	Soap and Detergent Manufacturing (Part 417)	
E	N	Steam Electric Power Generating (Part 423)	
E	N	Timber Products Processing (Part 429)	

E = Standards in effect for existing sources.
N = Standards in effect for new sources.

*From May 18, 1994, Effluent Guideline Plan [304(m)].

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9. PRETREATMENT

B. Pretreatment Compliance Inspections (PCIs) and Audits

Scope of PCIs and Audits

The Pretreatment Compliance Inspection (PCI), the pretreatment program audit, and the program performance report (submitted at least annually) have been developed as oversight mechanisms for Approval Authorities. They provide an opportunity for EPA and State officials to assess the Control Authority's pretreatment program. The PCI and the audit provide an opportunity for EPA and State officials to conduct an onsite review of a Control Authority pretreatment program.

The focus of the PCI is to evaluate Control Authority compliance monitoring and enforcement activities. The PCI also is designed to determine whether any changes have been made to the Control Authority program since the last PCI, audit, performance report (i.e., annual report), or Control Authority program modification request approval. The role of a NPDES inspector during a PCI is as a data gatherer to collect information on Control Authority program implementation for further evaluation by compliance personnel.

The PCI may be conducted in conjunction with other NPDES inspections to conserve travel resources and allow integration of information on the many facets of a POTW's operations. PCIs are compatible with Compliance Evaluation Inspections (CEIs), Compliance Sampling Inspections (CSIs), Performance Audit Inspections (PAIs), Diagnostic Inspections (DIs), and other nonroutine inspections, such as Toxics Sampling Inspections, and Compliance Biomonitoring Inspections. A PCI may also be combined with a site visit regarding sludge compliance as discussed in Chapter Ten.

It should be noted that the POTW personnel involved in a CSI may be different from the ones involved in a PCI. Also, PCIs and audits rely heavily on file and record reviews to evaluate the Control Authority's pretreatment program. These records may have little bearing on a technical inspection of the treatment facility. This aspect of a PCI should be addressed during planning for the inspection. Inspectors responsible for performing PCIs must be familiar enough with the goals of the program, the General Pretreatment Regulations, and EPA/State policy and guidance to conduct the inspection in a manner that will obtain information to detect noncompliance with pretreatment requirements.

Audits have been designed as a comprehensive review of all facets of the Control Authority pretreatment program. The audit addresses all of the items covered in a PCI but in greater detail. Consequently, the audit is more resource intensive than the PCI.

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Procedures for conducting PCIs and audits are similar. In general, there are three major components:

- Pre-visit preparation for the PCI or audit
  - Coordination with the EPA Regional or State Pretreatment Coordinator
  - Review of background information: approved program, Control Authority annual reports (if available), NPDES permit compliance status, Control Authority fact sheet, previous inspection reports, and program modification requests from the Control Authority
  - Notification of Control Authority (if appropriate).
- Onsite
  - Entry (presenting credentials)
  - Opening conference with Control Authority officials
  - Review of pretreatment files
  - Industrial inspections (optional)
  - Interview of officials using PCI or audit checklist
  - Tour of POTW (optional)
  - Closing conference.
- Follow-up
  - Preparation of report
  - Water Enforcement National Data Base (WENDB) data entry into PCS
  - Reportable Noncompliance/Significant Noncompliance (RNC/SNC) determination
  - Follow-up letter to the Control Authority
  - Enforcement action (when necessary)
  - NPDES permit or program modifications (when necessary).

If a PCI is conducted with an unannounced NPDES inspection, it also may be unannounced, but the Control Authority officials should be notified of the PCI upon arrival of the inspection team. At many POTWs, personnel responsible for implementing the program may not be the same as those operating the treatment plant.

The protocol involved in the onsite portion of the inspection is comparable to that of other NPDES inspections. One aspect of a PCI or an audit that differs from other NPDES compliance inspections is inclusion of a tour of industrial facilities discharging to the POTW. This aspect may be included as an optional component of both PCIs and audits to evaluate the Control Authority's procedures for monitoring and inspecting industries. For more detailed information on conducting PCIs and audits, refer to EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991), and *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992).

Detailed checklists intended for use during PCIs and audits are provided in the PCI and audit guidance manuals, respectively. The organization and focus of the detailed checklist are discussed in the following section.

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PCI Checklist Components

The PCI checklist was developed to assist NPDES inspectors in conducting and documenting the PCI. The checklist is organized into the following sections:

- Cover page—Provides space for Control Authority name, address, and representatives present, as well as the date(s) of the inspection and inspectors' names, titles, and telephone numbers.

- Section I: Industrial User File Evaluation—This section documents problems or deficiencies noted during review of industrial user files. Generally, files are reviewed to determine whether the Control Authority has notified the industrial user of applicable categorization and requirements, issued an adequate control mechanism, properly applied pretreatment standards, conducted sufficient compliance monitoring activities, and taken appropriate enforcement actions for violations.

- Section II: Supplemental Data Review/Interview—This section is completed by interviewing the appropriate Control Authority personnel and enables the inspector to determine compliance with program requirements not easily determined by the file review or to acquire additional information. This section contains questions on the following six pretreatment program areas:

  - Control Authority Pretreatment Program Modifications
  - Industrial User Characterization
  - Control Mechanism Evaluation
  - Application of Pretreatment Standards and Requirements
  - Compliance Monitoring
  - Enforcement.

- Section III: Evaluation and Summary—This section consists of the same six pretreatment program areas listed above and allows the inspector to summarize deficiencies noted and any corresponding required and/or recommended corrective actions.

- Attachment A: Pretreatment Program Status Update—This section provides an update of the pretreatment program's status. It should be updated prior to the PCI, based on information from the most recent PCI or audit and latest pretreatment program performance report and should be revised based on information obtained during the PCI, if necessary.

- Attachment B: Pretreatment Program Profile—This section provides information on the Control Authority's approved pretreatment program, NPDES permit conditions, and applicable pretreatment regulations.

- Attachment C: Worksheets

  - WENDB Data Entry Worksheet—The WENDB data elements provide information to be entered in the Pretreatment Permits and Enforcement Tracking System

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(PPETS). This management information system tracks the permit compliance and enforcement status of approved pretreatment programs.

- Reportable Noncompliance (RNC) Worksheet—This worksheet evaluates whether the Control Authority is in RNC for failure to implement its approved pretreatment program.

- IU Site Visit Report—This report documents any industrial user site visits that were conducted as part of the PCI.

- IU File Evaluation Worksheets—These optional worksheets assist the inspector in documenting and quantifying the Control Authority's performance in applying standards, compliance monitoring, and enforcement activities.

In addition to the completed checklist, other materials collected during the PCI may be included in the final report as appendices, such as the following:

- Example of Control Authority control mechanism or enforcement actions
- Names of industries that were not sampled or inspected in the past year
- Control Authority's Enforcement Response Plan (ERP)
- Annual list of industrial users in significant noncompliance.

The PCI checklist can be found in EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991). The manual goes through each checklist section individually and explains the intent of the questions. As noted earlier, the manual provides more detailed information concerning the procedures for conducting the PCI.

Summary of Audit Checklist Components

The audit checklist has been developed to assist with a detailed review of a POTW pretreatment program, including pretreatment program modification, legal authority, industrial user characterization, control mechanism evaluation, application of pretreatment standards and requirements, compliance monitoring, enforcement, data management/public participation, resources, and environmental effectiveness/pollution prevention. The audit checklist is divided into the following sections:

- Cover page
- Section I: Industrial User File Evaluation
- Section II: Data Review/Interview/Industrial User Site Visits
- Section III: Findings
- Attachment A: Pretreatment Program Status Update
- Attachment B: Pretreatment Program Profile
- Attachment C: Worksheets

  - Industrial User Site Visit Data Sheet
  - WENDB Data Entry Worksheet
  - RNC Worksheet.

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The sections of the audit checklist have been developed to collect more detailed information than the PCI checklist and, as with the completed PCI checklist, also may be augmented by additional audit data:

- NPDES pretreatment permit conditions
- Control Authority enforcement documents with pretreatment requirements (i.e., administrative order, consent decree)
- Locally developed discharge limitations as included in the approved program (or any limits that have been changed by the Control Authority)
- Copy of sewer use ordinance if different from that in the approved program
- Control Authority sampling and inspection schedule for regulated industries
- List of industries not sampled or inspected in the past year
- Control Authority chain-of-custody form
- List of noncompliant industries and history of enforcement actions taken
- Annual list of industrial users in significant noncompliance.

The audit checklist is incorporated as part of the *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992). The manual provides specific guidance on conducting an audit and using the checklist.

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C. References

EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991) contains a comprehensive list of reference materials (publications and memorandums) available from U.S. EPA or the Pretreatment Coordinator in your Region. **References that have been published since the publication of the Pretreatment Guidance are listed below.**

Checklists for conducting pretreatment compliance inspections and audits are provided in EPA's *Guidance for Conducting a Pretreatment Compliance Inspection* (September 1991) and *Control Authority Pretreatment Audit Checklist and Instructions* (May 1992). The checklist provides a list of questions that should be considered during an audit or PCI, and is available from EPA Regional offices. The Regional or State Pretreatment Coordinator should be contacted before a PCI or an audit is done.

References

Memoranda

Determining Industrial User Significant Noncompliance (January 17, 1992).

Determining Industrial User Compliance Using Split Samples (January 21, 1992).

Statistical Assessment of National Significant Industrial User Noncompliance (July 23, 1992).

Use of Grab Samples to Detect Violations of Pretreatment Standards (October 1, 1992).

Using Split Samples to Determine Industrial User Noncompliance (April 12, 1993).

EPA Guidance

U.S. Environmental Protection Agency. May 1991. *Supplemental Manual on the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program.*

U.S. Environmental Protection Agency. June 1992. *Guidance to Protect POTW Workers from Fume Toxic and Reactive Gasses and Vapors.* EPA 812-B-92-001.

U.S. Environmental Protection Agency. April 1994. *Industrial User Inspection and Sampling Manual for POTWs.* EPA 831-B-94-001.

U.S. Environmental Protection Agency. June 1994. *Multijurisdictional Pretreatment Programs Guidance Manual.* EPA 833-94-005.

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10. SEWAGE SLUDGE

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10. SEWAGE SLUDGE

A. Review of the Sewage Sludge Regulations

Section 405 of the Clean Water Act (CWA) mandated the development of a Federal sludge management program. On February 19, 1993, Environmental Protection Agency (EPA) promulgated technical standards for the use or disposal of sewage sludge [see 40 *Code of Federal Regulations (CFR)* Part 503, 58 *Federal Regulation (FR)* 9248]. These regulations contain technical standards for three sewage sludge use or disposal practices: land application, surface disposal, and incineration. The National Pollutant Discharge Elimination System (NPDES) regulations had previously been changed in preparation for the issuance of the final technical standards. As NPDES permits are being reissued, they are being written to include sludge use or disposal requirements. However, the Federal 503 sludge regulations are constructed so that they apply to and are enforceable against a facility engaged in a regulated sludge use or disposal practice, regardless of whether that facility's NPDES permit contains sludge use or disposal conditions. Thus, the NPDES permit is not a shield in the case of compliance with sludge requirements. This means that as of February 19, 1994, inspectors will be expected to identify and issue notices for those violations of Part 503 requirements, whether or not specifically included in a facility's NPDES permit.

The Federal sludge management program currently regulates the use and disposal of sewage sludge, which is the residual generated from the treatment of domestic sewage. Facilities, such as Publicly Owned Treatment Works (POTWs), which are subject to NPDES permit conditions for aqueous discharges to surface waters are now, as generators and preparers of sewage sludge, subject to the 503 regulations. In addition, the sludge program includes other facilities that have not been a part of the NPDES program because they were not point sources of discharge to waters of the United States. Examples of facilities that are now regulated and that may eventually receive permits for the use and disposal of sewage sludge include sewage sludge incinerators, composting facilities, and sewage sludge surface disposal sites.

While EPA was in the process of finalizing more comprehensive regulations to address the use or disposal of sewage sludge, there were existing Federal regulations that applied to the land application and landfilling of sludge. These regulations, issued as interim final criteria in 40 *CFR* Part 257, were promulgated jointly under the authority of the CWA and the Resource Conservation and Recovery Act (RCRA) in 1979. They have since been replaced for the most part by regulations promulgated in 40 *CFR* Part 258 for disposal of sewage sludge in Municipal Solid Waste Landfills (MSWLFs) and 40 *CFR* Part 503 for sewage sludge use or disposal by land application, surface disposal, or incineration. The application of industrial sludge to the land continues to be regulated by 40 *CFR* Part 257. In addition, the Clean Air Act (CAA) regulates the operations and air emissions of sewage sludge incinerators under 40 *CFR* Parts 60 and 61. The relevant requirements in 40 *CFR* Part 258 and 40 *CFR* Part 60 and 61 are described below.

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40 *CFR* Part 258—On October 9, 1991, EPA promulgated regulations under Part 258 that established criteria for MSWLFs and standards for the co-disposal of sewage sludge with municipal solid waste. Part 503 requires that sewage sludge be sent to a MSWLF to comply with the appropriate Part 258 requirements. Because the material that is disposed of in MSWLFs is very diverse (e.g., household garbage, sanitary septic tank waste, commercial solid waste and sewage sludge), the approach to regulating solid waste is different. Instead of regulating pollutants in the solid waste, Part 258 imposes design, operation, and maintenance requirements on the final disposal site. Although pollutant limits are not imposed, sludge to be disposed of must be nonhazardous, as demonstrated by using the Toxicity Characteristic Leaching Procedure (TCLP) and passing a paint filter test.

40 *CFR* Part 60, Subpart O—Emission standards for particulates and opacity and operational standards are specified for new source sewage sludge incinerators. New source incinerators are those constructed after June 11, 1973. If mixed municipal waste is being incinerated, then Subpart Ea—Standards of Performance for Municipal Waste Combustors—apply.

40 *CFR* Part 61—Standards were promulgated under authority of the CAA that limit the emission of beryllium and mercury from sewage sludge incinerators. The Part 503 sludge regulations require compliance with the Part 61 beryllium and mercury emission standards.

In general, the Part 503 regulations are structured to apply the following types of requirements to the three sewage sludge use or disposal practices:

- Pollutant limits (10 pollutants regulated under land application, 3 under surface disposal, and 7 under incineration)
- Pathogen and vector attraction reduction requirements
- Management practices for siting and operation of sludge use or disposal activities
- Minimum monitoring requirements
- Specific recordkeeping and reporting requirements.

A brief explanation of the requirements that apply to each sewage sludge use or disposal practice is provided below.

Land Application Requirements

Pollutant Limits

Four types of limits have been established that regulate 10 pollutants. Figure 10-1 illustrates which limits apply, based on the final sludge use.

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- Ceiling Concentration Limits—These limits are expressed as milligram of pollutant per kilogram of sludge on a dry weight basis. They apply to all sewage sludge land applied.

- Cumulative Pollutant Loading Rates (CPLRs)—These limits are expressed as the total amount of pollutant (kilograms) that can be applied to an area (hectare) of land. When this loading rate is reached, no further sludge can be applied to the site. These rates apply to bulk sewage sludge.

- Pollutant Concentration Limits—These limits are expressed as the monthly average concentration of pollutant milligram per kilogram of sludge on a dry weight basis. They apply to sewage sludge sold or given away in a bag or other container and as an alternative limit to CPLRs for bulk sewage sludge.

- Annual Pollutant Loading Rates—These limits are expressed as the amount of pollutant (kilogram) that can be applied in a 365-day period on an area (hectare) of land. This loading rate limits the amount of sludge on a dry weight basis that can be applied each year. These rates apply as an alternative limit for sewage sludge sold or given away in a bag or other container if it cannot meet the monthly average pollutant concentration limits.

In summary, bulk sewage sludge is subject to two sets of limits:

- Ceiling Concentration Limits and

- Pollutant Concentration Limits or Cumulative Pollutant Loading Rates, depending upon sludge quality.

Sewage sludge sold or given away in a bag or other container is subject to two sets of limits:

- Ceiling Concentration Limits and

- Pollutant Concentration Limits or Annual Pollutant Loading Rates, depending upon sludge quality.

Management Practices

The five management practices are intended to supplement the pollutant limits and provide additional protection to endangered species or their habitat, surface water, wetlands, ground water, and human exposure to the sludge. Four are applicable to bulk sludge; one is applicable to bagged or containerized sludge.

Operational Standards: Pathogen and Vector Attraction Reduction Requirements

There are two categories of pathogen reduction requirements: Class A and Class B (with associated site restrictions on the use of Class B sludge).

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- Class A requirements result in essentially pathogen-free sludge that may be used immediately with unrestricted public access.

- Class B requirements significantly reduce (but do not eliminate) the pathogen count in the sludge and require a waiting period before the land on which the sludge was applied may be used for certain activities.

Sludge that is sold or given away in a bag or other container must meet Class A requirements. Bulk sludge that goes to lawn or home garden use must also meet Class A requirements. Bulk sewage sludge applied elsewhere (i.e., agricultural land, forest, public contact sites, or reclamation sites) must meet either Class A or Class B requirements.

Under Part 503, six treatment alternatives are available for achieving Class A sludge. Three treatment alternatives (with specific site restrictions for use of the treated sludge) are provided for achieving Class B sludge.

The Part 257 interim regulation established specific sludge treatment processes and their operating parameters to be used to achieve the appropriate level of pathogen reduction. EPA retained substantially the same pathogen reduction treatment processes from Part 257 in the Part 503 regulations. Therefore, among the alternatives to achieve Class B sludge is treatment using one of the Processes to Significantly Reduce Pathogens (PSRP). Similarly, Class A sludge may be achieved by using one of the Processes to Further Reduce Pathogens (PFRP).

Land applied sludge is subject under the Part 503 regulations to vector attraction reduction requirements to reduce the characteristics of the sludge that attract disease vectors (i.e., insects and mammals that are capable of transporting infectious agents, ultimately to humans). Part 503 requires compliance with one of eight vector attraction reduction treatment alternatives if the sludge will be sold or given away in a bag or other container. Bulk sewage sludge applied to lawns or home gardens must also meet one of eight vector attraction reduction treatment alternatives. Bulk sewage sludge applied elsewhere must meet one of 10 treatment alternatives.

Monitoring, Recordkeeping, and Reporting Requirements

Minimum self-monitoring frequencies, which range from once per year to monthly, are specified in Part 503 based on the volume of sludge to be applied. More (or less) stringent monitoring frequencies may also be imposed through a permit mechanism.

Part 503 recordkeeping requirements differ depending on the type of pollutant limits applied. Recordkeeping requirements, including the certification statements specified in Part 503, are imposed on generators/preparers, while other specific recordkeeping requirements are imposed on appliers. Most of the specific information is required to be retained for 5 years, except that some information for sludge regulated by cumulative pollutant loading rates must be retained indefinitely.

Only a subset of the facilities required to maintain records is required to report under the Part 503 regulations. Those facilities that must report at least once per year are listed below.

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- Class I sludge management facilities
- POTWs with a design capacity equal to or greater than 1 Million Gallons per Day (MGD)
- POTWs serving a population of 10,000 or more.

Surface Disposal Requirements

Pollutant Limits

Three pollutants are regulated. Limits apply to sewage sludge that is placed on or in a surface disposal site that does not have a liner and leachate collection system. There are no limits on sewage sludge placed in sewage sludge units equipped with a liner and leachate collection system. The distance between the active sewage sludge unit and the site property line/boundary determine the specific pollutant limits that apply; the closer the distance to the boundary, the more stringent the limits (see Figure 10-2). An owner/operator can request site-specific pollutant limits; these limits would be established by the permitting authority through a permit.

Management Practices

A total of 14 management practice requirements are established in Part 503. Many are one-time surface disposal site location restrictions. Others address operational activities (e.g., leachate and runoff collection systems, methane gas monitoring) and post-closure activities.

Operational Standards

Sewage sludge must meet one of the Class A or Class B pathogen reduction treatment alternatives, but need not meet any of the Class B site restrictions (since they are only applicable to land applied sewage sludge). Surface disposed sludge must also meet one of eleven vector attraction reduction alternatives. However, if the sewage sludge is covered at the end of each day (one of the vector attraction reduction alternatives), the sludge is deemed to have met pathogen reduction requirements.

Monitoring, Recordkeeping, and Reporting Requirements

Monitoring and recordkeeping requirements, including the certification statements specified in Part 503, are imposed on the sludge generator or final preparer and/or the owner/operator of the surface disposal site. Minimum monitoring frequencies are established based on the volume of sludge disposed of. All records are required to be maintained for 5 years. The same classes of facilities identified under the land application section are required to report at least once per year.

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Incineration Requirements

Pollutant Limits

A total of seven pollutants are regulated. Limits for five metals are calculated by the permitting authority based on site-specific factors using the equations specified in the Part 503 regulations. Limits for the other two pollutants (mercury and beryllium) are derived from air emission standards promulgated under 40 *CFR* Part 61. These limits appear in the permit issued to the owner/operator of the sewage sludge incinerator.

Operational Standards

The regulations establish a monthly standard on the total hydrocarbons concentration in the exit gases of an incinerator to protect from excessive emissions of organic pollutants.

Management Practices

Seven management practices ensure that certain instruments are correctly installed, calibrated, operated, and maintained; that incinerator maximum combustion temperature and air pollution control equipment operating standards are established; and that endangered species and their habitats are protected. The specific management practice requirements should be established by the permitting authority based on site-specific factors and should appear in the incinerator's permit.

Monitoring, Recordkeeping and Reporting Requirements

Monitoring Requirements. In general, monitoring requirements for sewage sludge to be incinerated are imposed on the owner/operator of the incinerator. Part 503 requires monitoring (a) of sewage sludge for pollutant (i.e., metals) concentrations; (b) of incinerator stack exit gases for total hydrocarbon or, alternatively, carbon monoxide (CO), oxygen concentrations, and moisture content; and (c) of incinerator combustion temperatures and air pollution control equipment operating parameters. Monitoring requirements to demonstrate compliance with Part 61 beryllium and mercury standards are also likely to be imposed on owners/operators of sewage sludge incinerators.

Recordkeeping Requirements. Records required to be maintained by owners/operators of incinerators are specified both in Part 503 and site-specific conditions in the NPDES or sludge permit.

Reporting Requirements. The same classes of facilities identified under the land application section are required to report at least once per year. In this case, reporting requirements are imposed on owners and operators of sewage sludge incinerators.

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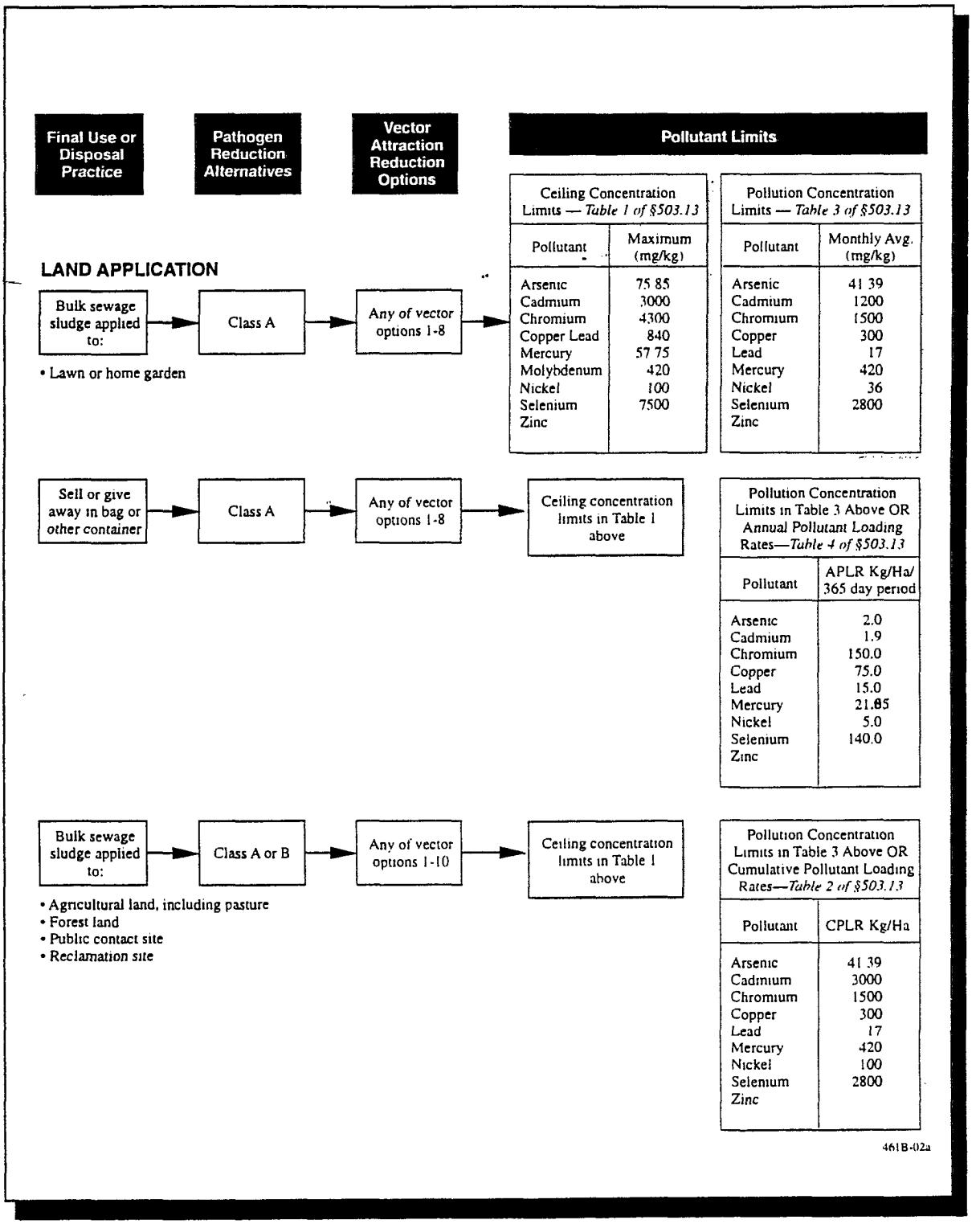
Figure 10-1

Sludge Quality Requirements for Land Application Uses



Ceiling Concentration Limits — *Table 1 of §503.13*

Pollutant	Maximum (mg/kg)
Arsenic	75 85
Cadmium	3000
Chromium	4300
Copper Lead	840
Mercury	57 75
Molybdenum	420
Nickel	100
Selenium	7500
Zinc	

Pollution Concentration Limits — *Table 3 of §503.13*

Pollutant	Monthly Avg. (mg/kg)
Arsenic	41 39
Cadmium	1200
Chromium	1500
Copper	300
Lead	17
Mercury	420
Nickel	36
Selenium	2800
Zinc	

Pollution Concentration Limits in Table 3 Above OR Annual Pollutant Loading Rates—*Table 4 of §503.13*

Pollutant	APLR Kg/Ha/ 365 day period
Arsenic	2.0
Cadmium	1.9
Chromium	150.0
Copper	75.0
Lead	15.0
Mercury	21.85
Nickel	5.0
Selenium	140.0
Zinc	

Pollution Concentration Limits in Table 3 Above OR Cumulative Pollutant Loading Rates—*Table 2 of §503.13*

Pollutant	CPLR Kg/Ha
Arsenic	41 39
Cadmium	3000
Chromium	1500
Copper	300
Lead	17
Mercury	420
Nickel	100
Selenium	2800
Zinc	

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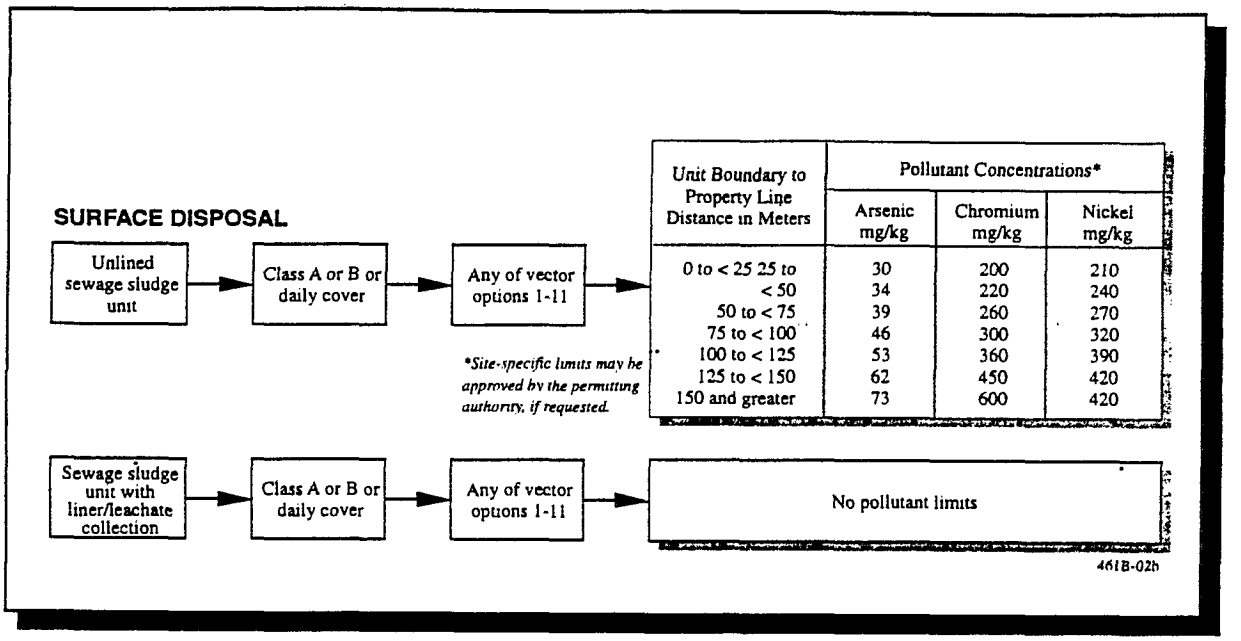
Figure 10-2

Sludge Quality Requirements for Surface Disposal



Unit Boundary to Property Line Distance in Meters	Pollutant Concentrations*		
	Arsenic mg/kg	Chromium mg/kg	Nickel mg/kg
0 to < 25	30	200	210
25 to < 50	34	220	240
50 to < 75	39	260	270
75 to < 100	46	300	320
100 to < 125	53	360	390
125 to < 150	62	450	420
150 and greater	73	600	420

10. SEWAGE SLUDGE

B. Sludge Inspection Procedures

Scope of Inspection Activities

Inspectors should verify compliance with the following general activities:

- Sludge monitoring, recordkeeping, and reporting
- Sludge treatment operations
- Sludge sampling and laboratory Quality Assurance (QA).

EPA intends for the evaluation of sludge management activities to be incorporated into the existing inspection structure so that inspection resources can be used most efficiently. The inspector can identify and investigate problems that might contribute to noncompliance with sludge requirements during any inspection site visit. The Pretreatment Compliance Inspection (PCI), the Compliance Evaluation Inspection (CEI), and the Performance Audit Inspection (PAI) are the most likely vehicles for evaluating compliance with sludge requirements. However, the NPDES inspector may use any of the following existing NPDES inspections when evaluating sludge requirements:

- CSI—The Compliance Sampling Inspection (CSI) may be used if the inspector decides that sludge sampling is necessary to determine compliance with applicable requirements.

- CEI—The inspector has historically looked at sludge treatment as part of the CEI because of its effect on wastewater treatment. This evaluation of sludge treatment should be expanded to include a review of sludge monitoring, reporting, and record-keeping, and a more comprehensive evaluation of the Operation and Maintenance (O&M) of sludge treatment processes, to evaluate compliance with sludge permit requirements.

- PAI—The PAI may be expanded to evaluate compliance with sludge monitoring requirements, and evaluate the permittee's sludge sampling and analytical procedures.

NPDES inspectors are not required to conduct an in-depth compliance assessment of sludge final use and disposal practices when such practices occur away from the treatment plant. In situations where final use and disposal requirements have been established in the facility's NPDES permit (e.g., management practices such as 10-meter buffer zones between the sludge application site and surface waters) and the activity is offsite, the inspector should verify compliance with those requirements through a records review at the facility. As part of a sampling inspection, the inspector may need to sample the sludge to determine compliance with pollutant limits.

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EPA intends to focus sludge inspection activities on those aspects of sludge management that can easily be evaluated during an existing NPDES compliance or pretreatment inspection. Inspectors will rely on an evaluation of sludge treatment operations, the observation of onsite sludge storage and disposal activities, and the review of sludge monitoring and disposal records to identify actual and potential noncompliance with sludge requirements. Inspectors should document compliance or noncompliance with sludge final use or disposal requirements in accordance with standard NPDES compliance inspection procedures.

An inspection checklist is an essential field tool for documenting that all necessary information has been collected. Inspection checklists are included in Appendix I of this manual. These checklists are based on the checklists in EPA's *Guidance for NPDES Compliance Inspector: Evaluation of Sludge Treatment Processes* (USEPA November, 1991) and *Guidance for NPDES Compliance Inspector: Verifying Compliance with Sludge Requirements* (USEPA November, 1991), as modified by EPA Region 8. The checklists should be used in conjunction with the checklist questions found in the 1991 guidance manuals. However, sludge permits may contain additional sludge permit conditions, based on case-by-case considerations, that are not included on the checklist. The inspector should identify additional permit requirements and verify compliance with these conditions as well. To accomplish this, it is recommended that the inspector expand the checklist, if necessary, to ensure that it is specific to the NPDES permit and the sludge final use or disposal activity. The inspector should complete the checklist and should incorporate his/her findings and conclusions in the final inspection report prepared for the facility.

The NPDES compliance inspector should consult EPA's 1991 *Guidance for NPDES Compliance Inspector: Evaluation of Sludge Treatment Processes* when preparing to conduct a sludge inspection. This technical reference presents a detailed examination of sludge unit processes and also contains extensive technical checklists that summarize the most critical elements of sludge thickening, stabilization, conditioning, dewatering, and disinfection. A technical understanding of the proper design and operation of the sludge treatment processes is essential for conducting thorough and informed sludge inspections.

Inspection Preparation

On preparing for the inspection, the inspector should:

- Review the NPDES Permit (or the facility's sludge permit, if applicable). When reviewing the NPDES permit file in preparation for the inspection, identify:
  - Permit conditions applicable to sludge including treatment; general requirements; management practices; and monitoring, reporting, and recordkeeping requirements.
  - Any additional requirements in the NPDES permit that may reflect State regulations. Additionally, the NPDES permit may incorporate a separate State permit by reference, in which case the State permit is also enforceable under the Federal CWA.
- Review sludge self-monitoring data.
- Become familiar with the sludge disposal practices used.

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- Review appropriate Federal regulations (i.e., 40 *CFR* Part 503 Regulations, or Part 258 if sludge is disposed of in a municipal solid waste landfill, and any other applicable State or local regulations).

- Review relevant guidance for background information and implementation procedures (e.g., guidelines on calculating agronomic rate, EPA's Process Design Manuals for Land Application of Municipal Sewage Sludge and Municipal Sludge Landfills, Control of Pathogens in Municipal Sewage Sludge).

- Verify that records kept by the permittee facilitate evaluation of compliance with sludge requirements.

Records Review

The Part 503 sludge regulations contain recordkeeping and reporting requirements. The facility's NPDES or sludge permit may have additional recordkeeping or reporting requirements. An evaluation of the sludge records and reports found at the facility should be conducted to determine compliance with these recordkeeping and reporting requirements. The procedures listed below should be used for these routine inspections. If suspected violations are uncovered during the routine evaluation, a more intensive investigation should be conducted.

In the records review process, the evaluation of compliance with sludge recordkeeping requirements should consider the following:

- Is all required information available for review?

- Are all regulated pollutants and sludge use and disposal practices addressed?

- Is all sludge information current?

- Are sludge records maintained for at least 5 years (commencing July 20, 1993)?

- Does the information contained in sludge records support the data submitted to the permitting authority?

- Do the records indicate areas needing further investigation?

The inspector should also identify whether violations of sludge-related permit requirements (e.g., concentration limits and/or management practices) have been reported, as required by the permit. Finally, the inspector should verify that the permittee has notified EPA of any changes to sludge use or disposal practices.

Evaluation Procedures

The inspector should first review the permit and fact sheet and list all sludge recordkeeping requirements. Table 10-1 is a list of records that may be relevant for sludge. This list is

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supplemented by Table 10-2, which describes records relevant to the operation of specific sludge treatment unit processes. Throughout the inspection, the facility's operations should be compared with the permit conditions to verify that required permit activities for sludge are correct, current, and complete.

An evaluation of sludge self-monitoring records and/or procedures involves the same elements as an evaluation of their wastewater monitoring data; however, there are some special considerations inherent in sludge sampling. In evaluating the permittee's records, inspectors should look for documentation regarding:

- Regulated Pollutants—As identified in the NPDES permit or applicable Federal or State regulations.
- Monitoring Frequency—As identified in the NPDES permit or applicable Federal or State regulations. Note that Part 503 establishes minimum monitoring frequencies based on the quantity of sewage sludge used or disposed of.
- Sample Location—The appropriate sampling point is the last treatment process the sludge goes through before leaving the treatment plant for use or disposal. For example, if a composted sludge is land applied, the compost pile should be sampled. If digested sludge is land applied, the sludge should be sampled as it is transferred from the digester to the truck prior to being hauled off site. Table 10-3 identifies sludge sampling points appropriate for the various types of treated sludge.
- Sample Types—Grabs or composites may be appropriate depending on the situation, but note that a grab sample from a lagoon, drying bed, compost pile, or truck must consist of numerous samples collected from various places in the lagoon, bed, pile, or truck and must be combined to make a representative sample.
- Sample Volume—If evaluating the sample collection process or taking samples, be sure that the container is not filled completely. Some space should be left to allow for expansion of the sample due to gas production. Refer to Appendix J for specific sample volumes.
- Sample Containers—Sample containers are generally the same types as those used for collection of wastewater samples, except that sludge sampling containers should be wide mouth bottles. Refer to Appendix J for a description of the appropriate container material.
- EPA Sample Identification Methods—Same as for wastewater sampling.
- Preservation and Holding Times—The primary difference in sludge preservation is that samples should not be chemically preserved in the field because the sludge matrix makes it difficult to thoroughly mix the preservative into the sample. However, samples should be iced. Refer to Appendix J.
- Chain-of-custody—Same as for wastewater sampling.
- Quality Control—Same as for wastewater sampling.

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- Analytical procedures used by lab—The analytical methods used for sludge are different from those used for wastewater. Approved analytical methods are listed in Part 503 (40 *CFR* 503.8). For example, Part 503 requires that analyses for inorganic pollutants use the procedures in *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, EPA publication SW-846. The inspector should note the information recorded regarding sample handling and analysis at the laboratory and verify that it is correct. If evaluating the laboratory, the procedures are the same as those followed in a PAI. The inspector should look at:

  - Analytical procedures
  - Laboratory services
  - Instruments and equipment
    - -- Calibration
    - -- Maintenance
  - Supplies
  - Quality Assurance/Quality Control (QA/QC)
    - -- Precision and accuracy of measurement process
    - -- Data handling and reporting
    - -- Records retention
    - -- Personnel qualifications.

- Analytical Results—Verify that results documented in the files are consistent with those reported.

The inspector should verify that reporting requirements are fulfilled according to the permit and applicable regulations. The NPDES permit may or may not have specific reporting requirements; however, the Part 503 sludge standards have specific reporting requirements that apply regardless of whether they appear in the NPDES permit. The May 1989 revisions to the NPDES regulations established required permit conditions regarding notification of change and at least annual reporting of sludge monitoring results. As NPDES permits are reissued, they will contain, at a minimum, these standard conditions as well as conditions specified in Part 503. Based on the applicable requirements, the inspector should verify that:

- Reports contain all required information
- Reports are submitted at the required frequency
- Data are reported in Discharge Monitoring Report (DMR) or other approved form.

Inspectors should review unit operation records to verify compliance with pathogen and vector attraction reduction requirements. Tables 10-4, 10-5, and 10-6 list the records and operating requirements for the Part 503 Class A pathogen reduction alternatives, the Class B pathogen reduction alternatives, and the vector attraction reduction options, respectively. Inspectors are not expected to review each monitoring record, but rather to verify that records are being maintained and are available for review. If a permittee has problems meeting either its pathogen or vector attraction reduction requirements (e.g., fecal coliform or percent volatile solids reduction), the inspector should review treatment operating records to identify potential noncompliance with the particular operating requirements specified in Part 503 for the particular pathogen and vector reduction process employed by the permittee. For example, an inspector might check a treatment facility's pH or temperature records to determine

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whether the sludge has been maintained at the appropriate pH or temperature for the required duration during treatment.

The inspector should verify that records are available for all disposal practices:

- Volume of sludge disposed of
- Sludge quality data
- Specific records appropriate for demonstrating compliance with the general requirements, management practices, and operational standards.

Verify whether records are maintained in accordance with permit requirements. The May 1989 NPDES regulatory revisions created a mandatory permit condition requiring that sludge records be kept for 5 years. However, many NPDES permits do not yet include this requirement. The Part 503 regulations establish specific recordkeeping requirements for each party involved in the sewage sludge use or disposal process.

Facility Site Review

Inspection of Solids Handling Unit Processes

To evaluate compliance with applicable sludge requirements, the inspector should fully understand the sludge treatment processes used at the facility and how each process fits into the overall treatment scheme. Sludge processing arguably poses the greatest challenges in wastewater treatment from the standpoints of design, operation, and maintenance. Typically, solids handling accounts for between 30 and 40 percent of the capital costs, 50 percent of the operating costs, and 90 percent of the operational problems at sewage treatment plants. These problems can not only prevent compliance with applicable Federal or State sludge disposal regulations, but can also contribute to a treatment plant's noncompliance with its NPDES permit effluent limits.

When conducting the walk-through visual inspection of the facility, the inspector should be aware of, and look for, physical conditions that are indicative of potential or existing problems. Some of the more common indicators of potential problems are listed in Table 10-7. The presence of these conditions may warrant a more in-depth inspection of the sludge treatment processes. A checklist is provided in Appendix I to assist the inspector during the facility site review. The questions on this checklist are sludge-specific and should be asked in conjunction with the Facility Site Review checklist. In addition, many of the questions in the NPDES checklist relate to the overall operation of the facility and, therefore, can also be applied to sludge evaluations (e.g., treatment units properly operated and maintained). The inspector should look for conditions that indicate potential or existing problems. If the inspector finds conditions that are a potential problem, this may trigger a more detailed evaluation. EPA has developed guidance and checklists for conducting in-depth evaluations of each of the most common sludge treatment unit processes, *Guidance for NPDES Compliance Inspectors: Evaluating Sludge Treatment Processes*, November 1991.

The inspector should determine whether the facility is operating its sludge treatment and disposal processes in a manner consistent with the requirements established in its NPDES permit. If the inspector discovers conditions at the facility that threaten public health or the

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environment (e.g., contaminating ground water or surface water, exposing the public to pathogens or disease vectors, or compromising public safety), the inspector should inform the enforcement staff so that appropriate action can be taken. If knowing endangerment is discovered, the criminal investigations unit should be informed.

Many large-scale operations are conducted outside, such as sludge drying, composting, temporary and long-term storage, and loading and hauling. Inspectors should note these outside operations' exposure to rainfall and runoff collection and treatment methods. If storm water collection devices have been constructed, the inspector should evaluate the performance and maintenance of these devices as well as their design capacity (e.g., the 10-year 24-hour storm event or the 25-year 24-hour storm event). Visual observations can detect obvious problems that may contribute to the contamination of surface water or ground water such as erosion, breaches of dikes or berms, or cracks in the concrete or asphalt. The inspector should inquire as to whether the capacity of the collection devices has ever been exceeded during any storm event.

The sludge loading area should be inspected to determine how the sludge is being hauled or transported. The inspector should note the size of the truckloads and the number of truckloads hauled over a 1-day period (or another time period). These figures are useful to the inspector in verifying the permittee's records and reports on the volume of sludge generated and disposed of.

Sludge Storage

The inspector should also verify that the permittee has adequate storage capacity for its sludge in the event that its preferred disposal method is interrupted for any reason (e.g., noncompliance with cumulative loading rates on the land application site). There are no Federal requirements specifying a minimal storage capacity; the appropriate capacity will vary depending on the amount of sludge generated and the facility's use or disposal option(s). Storage capacity should address normal, routine storage prior to disposal and should anticipate emergency conditions, such as:

- Equipment malfunction
- Inclement weather
- Unanticipated loss of disposal site.
    - Farmer decides to discontinue use of sewage sludge
    - Landfill violates requirements and may no longer accept sludge or is required to close.

Some States have developed storage capacity requirements. If the permittee cannot dispose of its sludge in the preferred manner, it should have either adequate storage capacity for its sludge or clearly established plans for alternative methods of disposal.

R0014708

Again, many of these elements are evaluated according to the same criteria regardless of the sample being analyzed. The inspector is referred to Chapter 7 and the 1990 *NPDES Compliance Monitoring Inspector Training Module on Laboratory Analysis* for general guidance on inspecting the permittee's laboratory procedures. There are some differences in sample preparation and analytical techniques for sludge with which the inspector should be familiar.

In conducting the sludge component of the PAI, the inspector should closely evaluate the permittee's sample preparation procedures. The sludge matrix is more complex and variable than the wastewater matrix; therefore, the laboratory's development of sample preparation techniques is of particular concern.

The NPDES permit may require the permittee to analyze sludge for conventionals, inorganic pollutants, metals, and pathogens (depending on the ultimate sludge disposal practice). For example, sludge that is going to be land applied will be analyzed for 10 metals and nitrogen to determine the appropriate application rate. Table 10-8 lists the constituents required to be monitored by Part 503. 40 *CFR* 503.8 contains a listing of approved analytical methods and volatile solids reduction calculations that must be used for monitoring sludge quality. The analytical methods for metals are not the same as those used for the analysis of wastewater.

Appendix J contains the required analytical method, the maximum allowable sample holding times, sample preservation techniques, sample containers, sample preparation methods, and additional comments that may be pertinent to the analytical method.

The inspector should keep the following points in mind when reviewing the permittee's lab and analytical results:

- The Part 503 standards are expressed on a dry weight basis. Laboratory results for sludge are typically reported in one of two forms, wet weight (i.e., mg/L) or dry weight (i.e., mg/kg). The laboratory should be providing the results on a dry weight basis. In the event that the laboratory results are reported on a wet weight basis (i.e., in mg/L), the results for each pollutant in each sample must be recalculated to determine the dry weight concentration. To accomplish this conversion, the percent total solids in the sludge sample must be known. Thus, the lab must analyze the sample for percent solids using Method 2540G of *Standard Methods*, 18th Edition.

  The following equation can be used to determine the dry weight concentration because the equation uses the assumption that the specific gravity of water and sewage sludge are both equal to one. However, this assumption holds true only when the solids concentration in the sludge is low. The calculated dry weight concentration may vary slightly from the actual concentration as the solids content increases because the density of the sewage sludge may no longer be equal to that of water. Typically, this concern does not arise because the solids content of sludge is usually low. EPA is aware of this potential problem and may make a determination regarding this matter at a later date.

R0014709

Determine the pollutant concentration on a dry weight basis using the following abbreviated conversion:[1]

$$\text{PC (dry, mg/kg)} = \frac{\text{PC (wet, mg/L)}}{\text{(\% total solids)}}$$

where PC = Pollutant concentration

A unit conversion is incorporated into the equation.

- For metals, a common analytical error is that labs conduct the metals analyses using analytical methods developed for water and wastewater. Analytical methods for water and wastewater are found in *Standard Methods*, while the solid waste analytical methods are found in *Test Methods for Evaluating Solid Wastes* (EPA SW-846). For sludge samples, all metals must be analyzed by SW-846 methods.

- Also for metals, note that more than one SW-846 method is provided for each pollutant. The difference between the methods is usually the equipment used [i.e., direct aspiration, furnace, or Inductively Coupled Plasma (ICP) scan] and the level of detection desired. Each of the three methods is EPA-approved, but certain sample characteristics may require one to be used instead of another.

- SW-846 Method 3050 is the required preparation method for all metals except mercury (using equivalent to 1 gram dry weight).

- In contrast to the metals, many of the additional inorganic parameters [e.g., nitrite, Total Kjeldahl Nitrogen (TKN), etc.] require methods that are found in *Standard Methods for Water and Wastewater*. There are several reasons for this, one being that there is no method for the parameter that is specific to solid waste.

[1] *Analytical Methods Used in the National Sewage Sludge Survey.* August 1988. U.S. EPA Office of Water Regulations and Standards (WH-552), Industrial Technology Division, Washington, DC.

R0014710

Table 10-1

Records Relevant for Sludge Operations

Sludge Use/Disposal Records

- Volume
- Type of use and/or disposal options used
- Use/disposal sites
- Loading rates of pollutants (e.g., cadmium and nitrogen) at each land-application site

Sludge Operating Records

- Daily operating log
- Equipment maintenance scheduled and completed
- Detention time, operating temperature, or pH to evaluate pathogen reduction

Sludge Monitoring Records

- Constituents/pollutants in sludge
- Mass of sludge generated and disposed of (in dry metric tons per year)

Sludge Sampling and Analytical Data

- Dates, times, and locations of sampling
- Sampling protocols and analytical methods
- Results of analyses
- Dates and times of analyses
- Name(s) of analysis and sampling personnel

Sludge Laboratory Records

- Calibration and maintenance of equipment
- Laboratory bench sheets or logs and calculations
- Quality Assurance/Quality Control (QA/QC) records

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Table 10-2

Operating Records for Specific Unit Processes

THICKENING PROCESSES		
Gravity Thickening	Dissolved Air Flotation	Centrifuge
• Overflow volume • Influent flow • Percent solids - Sludge feed - Thickened sludge - Overflow • Sludge blanket depth	• Sludge feed rate • Recycle flow • Daily operating time • Percent solids - Sludge feed - Thickened sludge - Subnatant • Floating sludge depth • Air flow rate • Retention tank pressure • Percent solids capture • Detention time • Air to solid ratio	• Influent sludge flows • Volume cake produced • Percent solids - Sludge feed - Centrate - Sludge cake • Daily operating time
STABILIZATION PROCESSES (Pathogen and/or Vector Attraction Reduction)		
Aerobic Digestion	Anaerobic Digestion	Incineration
• Air supply • Solids retention time • Temperature • DO level • pH • Feed sludge - TS, TVS, and pH - Flow rate • Digested sludge - SOUR - TS, TVS, and pH - Flow rate • Supernatant - Flow rate and BOD - TSS and pH	• Detention time • Temperature • pH and alkalinity • Gas production and quality • Volatile acids • Feed sludge - TS, TVS, and pH - Flow rate • Digested sludge - TS, TVS, and pH - Flow rate • Supernatant - Flow rate and BOD - TSS and pH • Cleaning frequency	• Operating schedule • Sludge feed - Solids content - Feed rate - Volatile solids • Combustion temperature • Sludge residence time • Fuel flow • Off-gas oxygen content • Air feed rate • Emission control equipment - Pressure drop • Type of fuel • Volume of ash produced • Stack gas monitoring
Wet Air Oxidation	Heat Treatment	Composting
Temperature • Pressure • Detention time • Sludge feed - Percent solids - Volatile solids - Feed rate • End product volatile solids	Temperature/time • Pressure • Feed sludge - TS and TVS - Flow Rate - Percent solids	Oxygen concentration • Temperature and time • Turning frequency • Percent sludge solids • Type and amount of bulking agent(s) • Header pressure
Chemical Conditioning/Stabilization	Electron Irradiation	Gamma Irradiation
• Chemical types and dosage • Mixing • pH	• Sludge feed rate • Electron dosage • Temperature	• Sludge feed rate • Gamma ray source strength

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Table 10-2

Operating Records for Specific Unit Processes (Continued)

DEWATERING PROCESS		
Vacuum Filter	**Pressure Filter**	**Belt Filter Press**
• Sludge feed - Total solids • Sludge cake - Total solids • Filtrate - Flow - BOD - TSS • Maintenance • Spare parts	• Sludge feed percent solids • Sludge cake percent solids • Volume of sludge processed • Cycle length • Volume conditioning chemicals • Filtrate - Flow - BOD - TSS	• Loading rate • Operating speed • Feed slurry - Total solids and flow • Dewatered sludge - Total solids - Flow • Filtrate and wash water - BOD and SS - TSS and flow • Preventive maintenance • Polymer
Drying Bed	**Drying Lagoons**	**Heat Drying**
• Sludge loading rate • Quantity in bed • Depth of sludge in bed • Date deposited • Detention time • Ambient temperature • Drying bed construction (i.e., lined) • Undertrain destination • Percent solids of the sludge feed and of the dewatered sludge	• Sludge loading rate • Percent solids - Sludge - Decant • Quantity in lagoon • Depth in lagoon • Date deposited • Drying time • Rainfall	• Operating schedule - Start-up - Shut-down • Sludge feed rate • Percent solids - Sludge feed - Dewatered sludge • Fuel consumption • Air flow • Drying temperature • Detention time • Stack gas monitoring - Oxygen - Particulates - Carbon monoxide - Carbon dioxide

LEGEND:

DO = Dissolved Oxygen
TS = Total Solids
TVS = Total Volatile Solids
BOD = Biochemical Oxygen Demand
TSS = Total Suspended Solids
SS = Suspended Solids
SOUR = Specific Oxygen Uptake Rate

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Table 10-3

Sludge Sampling Points

Sludge Type	Sampling Point
Anaerobically digested	Sample from taps on the discharge side of positive displacement pumps.
Aerobically digested	Sample from taps on the discharge lines from pumps. If batch digester is used, sample directly from the digester. Two cautionary notes regarding this practice: • If aerated during sampling, air entrains in the sample. Volatile organic compounds may purge with escaping air. • When aeration is shut off, solids separate rapidly in well-digested sludge.
Thickened	Sample from taps on the discharge side of positive displacement pumps.
Heat treated	Sample from taps on the discharge side of positive displacement pumps after decanting. Be careful when sampling heat treatment sludge because of: • High tendency for solids separation • High temperature of samples (frequently >60°C) can cause problems with certain sample containers due to cooling and subsequent contraction of entrained gases.
Dewatered by belt filter press, plate and frame press, centrifuge, or vacuum filter press	Sample from sludge cake discharge chute and conveyor. Alternatively, sample from collection container or storage bin for the dewatered sludge; sample from many locations within the storage bin and at various depths, collect equal samples from each point, and combine them to form one sample of the total storage bin.
Dewatered or air dried in drying beds, or bin or truck bed	Divide bed into four quadrants, collect equal sample volume from the center of each quadrant, and combine them to form one sample of the total bed. Each grab sample should include the entire depth of the sludge (down to the sand).
Composted	Collect full core samples from randomly selected sites in the pile. Sample directly from front-end loader or other conveyance device as the sludge is being loaded into trucks to be hauled away.

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Table 10-4

Recordkeeping Requirements for Class A Pathogen Reduction Alternatives

Alternative A1—Time and Temperature
• Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) • Sludge temperature • Time (days, hours, minutes) temperature maintained
Alternative A2—Alkaline Treatment
• Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) • Sludge pH • Time (hours) pH maintained above 12 (at least 72 hours) • Sludge temperature • Percent solids in sludge after drying (at least 50 percent)
Alternative A3—Analysis and Operation
• Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) • Analytical results for density of enteric viruses (plaque forming unit/4 grams total solids) prior to pathogen reduction and, when appropriate, after treatment • Analytical results for density of viable helminth ova (number/4 grams total solids) prior to pathogen reduction and, when appropriate, after treatment • Values or ranges of values for operating parameters to indicate consistent pathogen reduction treatment
Alternative A4—Analysis Only
• Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) • Analytical results for density of enteric viruses (plaque forming unit/4 grams total solids) • Analytical results for density of viable helminth ova (number /4 grams total solids)

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Table 10-4

Recordkeeping Requirements for Class A Pathogen Reduction Alternatives (Continued)

Alternative A5—Processes to Further Reduce Pathogens (PFRP)	
• Heat Drying - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Moisture content of dried sludge <10 percent - Logs documenting temperature of sludge particles or wet bulb temperature of exit gas exceeding 80°C • Thermophilic Aerobic Digestion - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Dissolved oxygen concentration in digester ≤1 mg/L - Logs documenting temperature maintained at 55-60°C for 10 days • Heat Treatment - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Logs documenting sludge heated to temperatures greater than 180°C for 30 minutes • Pasteurization - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Temperature maintained at or above 70°C for at least 30 minutes	• Composting - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Description of composting method - Logs documenting temperature maintained at or above 55°C for 3 days if within vessel or static aerated pile composting method - Logs documenting temperature maintained at or above 55°C for 15 days if windrow compost method - Logs documenting compost pile turned at least five times per day, if windrow compost method • Gamma Ray Irradiation - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Gamma ray isotope used - Gamma ray dosage at least 1.0 megarad - Ambient room temperature log • Beta Ray Irradiation - Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number) - Beta ray dosage at least 1.0 megarad - Ambient room temperature log
Alternative A6—PFRP Equivalent	
• Operating parameters or pathogen levels as necessary to demonstrate equivalency to the PFRP • Analytical results for density of Salmonella sp. bacteria or fecal coliform (most probable number)	

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Table 10-5

Recordkeeping Requirements for Class B Pathogen Reduction Alternatives

Alternative B1—Fecal Coliform Count
• Number of samples collected during each monitoring event • Analytical results for density of fecal coliform for each sample collected
Alternative B2—Processes to Significantly Reduce Pathogens (PSRP)
• Aerobic Digestion - Dissolved oxygen concentration - Volatile solids content before and after digestion - Mean residence time of sludge in digester - Logs showing temperature was maintained for sufficient period of time (ranging from 60 days at 15°C to 40 days at 20°C) • Air Drying - Description of drying bed design - Depth of sludge on drying bed - Drying time in days - Daily average ambient temperature • Anaerobic Digestion - Volatile solids content before and after digestion - Mean residence time of sludge in digester - Temperature logs of sludge in digester • Composting - Description of composting method - Daily temperature logs documenting sludge maintained at 40°C for 5 days - Hourly readings showing temperature exceeded 55°C for 4 consecutive hours • Lime Stabilization - pH of sludge immediately and then 2 hours after addition of lime
Alternative B3—PSRP Equivalent
• Operating parameters or pathogen levels as necessary to demonstrate equivalency to PSRP

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Table 10-6

Recordkeeping Requirements for Vector Attraction Reduction Sludge Processing Options

Option 1—Volatile Solids (VS) Reduction	**Option 5—Aerobic Processing(Thermophilic Aerobic Digestion/Composting)**
• Volatile solids concentration of raw and final sludge streams (mg/kg) • Calculations showing 38 percent reduction in volatile solids	• Sludge detention time in digester/composting • Temperature logs showing average temperature above 45°C and minimum temperature above 40°C for 14 consecutive days
Options 2 and 3—Bench-Scale VS Reduction	**Options 6—Alkaline Treatment**
• One-time description of bench-scale digester • Time (days) that sample was further digested in bench-scale digester (30 days for aerobically and 40 days for anaerobically digested sludge) • Temperature logs showing temperature maintained at 20°C for aerobically or between 30°C and 37°C for anaerobically digested sludge • Volatile solids concentration of sludge (mg/kg) before and after bench-scale digestion	• Logs demonstrating hours pH of sludge/ alkaline mixture was maintained (12 for 2 hours and 11.5 for an additional 22 hours) • Amount of alkaline added to sludge (lbs or gals) • Amount of sludge treated
Option 4—Specific Oxygen Uptake Rate	**Options 7 and 8—Drying**
• Dissolved oxygen readings for sludge sample over 15-minute intervals (mg/L) • Temperature logs showing test was conducted at 20°C • Total solids for sludge sample (g/L) • SOUR calculations (mg/g)	• Results of percent solids (dry weight) test • Presence of unstabilized solids generated during primary treatment

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Table 10-7

Sludge Handling Process Evaluation

General Indicators

- Inadequate sludge removal from clarifiers or thickeners
- Substantial down-time of sludge treatment units/solids handling
- Sludge disposal inadequate to keep treatment system in balance
- Mass balance inappropriate (ratio of sludge wasted should be 0.65-0.85 lbs of sludge per lb of BOD removed)

Sludge Thickening Problems

- Sludge decant or return flows high in solids*
- Thickened sludge too thin
- Fouling of overflow weirs on gravity thickeners
- Air flotation skimmer blade binding on beaching plate

Anaerobic Digestion Problems

- Sludge heater inoperative*
- Supernatant exuding sour odor*
- Inadequate gas production*
- Mechanical or gas mixers inoperative
- Floating cover of anaerobic digester tilting
- Gas burner inoperative
- pH problems*
- Excessive suspended solids in supernatant

Aerobic Digestion Problems

- Excessive foaming in tank*
- Objectionable odor in aerobically digested sludge*
- Insufficient DO in digester
- Digester overloaded
- Clogging of diffusers in digester
- Mechanical aerator failure in digester
- Inadequate supernatant removal

Drying Beds/Lagoons Problems

- Dry sludge stacked around drying beds where runoff may enter waters
- Broken dikes between sludge drying lagoons
- Poor sludge distribution on drying beds
- Vegetation in drying beds (unless reed design)
- Inadequate drying time on drying beds
- Dry sludge remaining on drying beds
- Objectionable odor from sludge lagoon
- Unlined sludge lagoons

Sludge Dewatering Problems

- Excessive solids present in dewatering filtrate*
- Inadequate dryness of sludge cake*
- Sludge build-up on belts, rollers, or conveyors of dewatering equipment
- Insufficient run time for sludge dewatering equipment

*Indicates serious problems with the sludge handling process.

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Table 10-7

Sludge Handling Process Evaluation (Continued)

Disposal
• Sludge constituents not analyzed before disposal • Sludge not transported in appropriate approved vehicle • Objectionable odors generated at sludge disposal site* • Inadequate runoff control at landfill or land application sites • Inadequate coverage of sludge in subsurface injection system • Slow drying of soil-sludge mixture in subsurface injection system • Sludge ponding at land application sites • Inadequate burial of sludge at landfill site • Liquid sludge applied to landfill site or sludge fails paint filter test • Excessive erosion at sludge sites • Sludge disposed of in nonpermitted sites • Sludge lagoons full and overflowing*

*Indicates serious problems with the sludge handling process.

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Table 10-8

Pollutants Monitored for Land Application, Surface Disposal, and Incineration

Pollutant	Land Application	Surface Disposal (unlined units)	Incineration
Arsenic	✓	✓	✓
Beryllium			✓
Cadmium	✓		✓
Chromium	✓	✓	✓
Copper	✓		
Lead	✓		✓
Mercury	✓		✓
Molybdenum	✓		
Nickel	✓	✓	✓
Selenium	✓		
Zinc	✓		
Nitrogen	✓		

Organism to Be Monitored	Allowable Level in Sludge
Fecal Coliform[1]	1,000 Most Probable Number (MPN) per gram (Class A) of total solids (dry weight)
Salmonella sp.[1] bacteria (in lieu of fecal coliform)	3 MPN per 4 grams total solids (dry weight)
Enteric Viruses[2]	Less than one plaque-forming unit per 4 grams total solids (dry weight)
Viable Helminth[2] Ova	Less than one viable helminth ovum per 4 grams of total solids (dry weight)
Fecal Coliform[3]	Less than 2×10^6 MPN or less than 2×10^6 colony-forming units per gram of total solids (dry weight) (expressed as geometric mean of the results of 7 individual samples)

[1] All Part 503 Class A Alternatives 1, 2, 3, 4, 5, 6

[2] Class A Alternatives 3 and 4 only

[3] Class B, Alternative 1

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10. SEWAGE SLUDGE

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11. STORM WATER

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11. STORM WATER

A. Review of the Storm Water Regulations

Development of Storm Water Regulations (40 *CFR* §122.26)

The 1972 amendments to the Federal Water Pollution Control Act (also known as the Clean Water Act or CWA) prohibited the discharge of any pollutants to navigable waters from a point source unless the discharge is authorized by a National Pollutant Discharge Elimination System (NPDES) permit. At the time of the 1972 amendments to the CWA, sewage treatment plant outfalls and industrial process wastewater were easily identified as point sources responsible for contributing to the degradation of water quality. However, as pollution control measures were instituted, it became evident that more diffuse sources, such as agricultural and urban storm water runoff, were also contributing to the problem. In response to this concern, the Water Quality Act (WQA) of 1987 added section 402(p) to the CWA and required the Environmental Protection Agency (EPA) to establish a comprehensive two-phased approach to address storm water discharges.

In response to section 402(p)(2) of the CWA, EPA finalized Phase I storm water regulations, published on November 16, 1990 (57 *FR* 47990). The regulations specify that by October 1, 1992, the following point source[1] storm water discharges must apply for a NPDES permit: (i) a discharge with respect to which a permit has been issued prior to February 4, 1987; (ii) a discharge associated with industrial activity (see §122.26(a)(4)); (iii) a discharge from a large municipal separate storm sewer system; (iv) a discharge from a medium separate storm sewer system; and (v) a discharge that the Director, or in States with approved NPDES programs, either the Director or the EPA Regional Administrator determines is contributing to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States. The regulations exempt "discharges of storm water runoff from mining

[1]Point source storm water discharge does not include "sheet flow" (SFL) off of an industrial facility. A point source is defined at 40 *Code of Federal Regulations* §122.2 as "any discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural storm water runoff." Further, any discharge from an industrial facility through a municipal separate storm sewer system is considered to be a "discharge associated with industrial activity" and, therefore, covered by the storm water permitting requirements. In most court cases, the term "point source" has been interpreted broadly. For example, the holding in *Sierra Club* v. *Abston Construction Co., Inc.*, 620 F.2d 41 (5th Cir. 1980) indicates that changing the surface of land or establishing grading patterns on land will result in a point source where runoff from the site is ultimately discharged to waters of the United States. The CWA does not relieve the discharger from liability simply because the facility did not actually construct conveyances for the storm water. Conveyances formed by erosion or other natural means may fit the CWA definition of point source and thereby subject the dischargers to liability.

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operations or oil and gas exploration, production, processing or treatment operations or transmission facilities, composed entirely of flows which are from conveyances or systems of conveyances used for collecting and conveying precipitation runoff and which are not contaminated by contact with or that has not come into contact with, any overburden, raw material, intermediate products, finished product, byproduct or waste products located on the site of such operations" [40 *CFR* §122.26(a)(2)]. An outline of these regulations, found in 40 *CFR* §122.26 (Storm water discharges), is presented in Table 11-1.

To incorporate the storm water regulations, EPA also had to revise language in 40 *CFR* §§122.1, 122.21, 122.22, 122.28, 122.42, 123.25, and 124.52. In general, revisions to these sections were to incorporate references to specific storm water requirements, as identified in 40 *CFR* §122.26.

Phase II of the storm water program is currently under development and has not yet been proposed. Therefore, the remainder of this chapter will focus on Phase I storm water discharges.

Applicability of Storm Water Discharges Associated With Industrial Activity

First, the inspector must determine whether an industrial facility is subject to the storm water permitting regulations. The storm water regulations identify 10 different major industrial categories that are associated with industrial activity (40 *CFR* §122.26(b)(14)(i)-(x)), including construction sites larger than 5 acres. EPA identified an eleventh category for "light" industries, to be subject to the regulations only if there was an exposure of industrial pollutants to storm water.[1] A description of these 11 categories is provided in Figure 11-1. It has been estimated that more than 100,000 facilities are covered by the regulations. The discharges associated with these industrial activities are regulated pursuant to 402(p)(2)(B) of the CWA, requiring the facility to apply for and obtain a permit to discharge storm water.

Point source discharges directly to waters of the United States and to municipal separate storm sewer systems are covered by the storm water regulations; discharges to Publicly Owned Treatment Works (POTWs) or combined sewer systems are not covered. The inspector should be aware that on any given site, storm water may discharge at several points: overland flow directly to a river or creek, though an inlet to a separate storm sewer collection system, or to a combined sewer collection system that ultimately discharges to a POTW.

For the light industries identified in 122.26(b)(14)(xi), "storm water discharges associated with industrial activity," the regulations include only storm water discharges where material handling

[1]On June 4,1992, the U.S. Court of Appeals for the Ninth Circuit issued its opinion generally affirming EPA's November 16, 1990, Storm Water Application Regulations. *Natural Resources Defense Council v. EPA*, 966 F.2d 1292 (9th Cir. 1992)(NRDC). The Court in NRDC did invalidate and remand for further rulemaking the exemption of construction sites smaller than 5 acres and the exemption of certain "light" industries whose industrial activities are not exposed to rain water. EPA is not requiring permit applications for these activities until further rulemaking is completed.

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equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, or industrial machinery are exposed to storm water. Material handling activities include the storage, loading and unloading, transportation, or conveyance of any raw material, intermediate product, by-product or waste product. The term excludes areas located on plant lands separate from the plant's industrial activities, such as office buildings and accompanying parking lots as long as the drainage from the excluded areas is not mixed with storm water drained from the above described areas.

A light industrial facility that determines that there is no exposure to storm water should document the facility evaluation that led to this conclusion. A copy of this documentation should be retained onsite. (Some States may have specific requirements for documenting and retaining this information onsite.)

Operators of industrial facilities that are Federally, State, or municipally owned or operated that meet the descriptions of the facilities listed in 40 *CFR* §122.26(b)(14)(i)-(xi) must also submit applications.

The regulations, at 40 *CFR* 122.26(b)(14), define "storm water discharges associated with industrial activity." Specifically, the phrase means "the discharge from any conveyance which is used for collecting and conveying storm water and which is directly related to manufacturing, processing or raw materials storage areas at an industrial plant." The inspector will need to determine which areas are included in this definition. For the 10 categories of industries identified in 40 *CFR* §122.26(b)(14)(i)-(x), the term includes, but is not limited to, storm water discharges from the following:

- Industrial plant yards
- Immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility
- Material handling sites
- Refuse sites
- Sites used for the application or disposal of process wastewaters (as defined at 40 *CFR* Part 401)
- Sites used for the storage and maintenance of material handling equipment
- Sites used for residual treatment, storage, or disposal
- Shipping and receiving areas
- Manufacturing buildings
- Storage areas (including tank farms) for raw materials and intermediate and finished products

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- Areas where industrial activity has taken place in the past and significant materials remain and are exposed to storm water.

Also, the inspector must know which materials are considered significant. Significant materials, defined at 40 *CFR* §122.26(b)(12), include, but are not limited to:

- Raw materials
- Fuels
- Materials such as solvents, detergents, and plastic pellets
- Finished materials such as metallic products
- Raw materials used in food processing or production
- Hazardous substances designated under section 101(14) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)
- Any chemical the facility is required to report pursuant to section 313 of Title III of Superfund Amendments and Reauthorization Act (SARA)
- Fertilizers
- Pesticides
- Waste products such as ashes, slag, and sludge that have the potential to be released with storm water discharges.

Identifying whether or not a facility actually performs activities that are subject to storm water permitting requirements can be a complicated task. To allay concerns, EPA prepared two guidance documents to provide interested parties with answers to many commonly asked questions about storm water permitting requirements, *NPDES Storm Water Program Question and Answer Document* (March 1992) and *NPDES Storm Water Program Question and Answer Document, Volume II* (July 1993).

These two documents address:

- Facilities subject to storm water effluent guidelines, toxic pollutant effluent standards, and new source performance standards
- Evaluating the applicability of storm water regulations to process operations in categories (iii) mining and oil and gas operations, (iv) hazardous waste treatment, storage, and disposal facilities, (v) landfills, land application sites, and open dumps, (vi) recycling facilities, (vii) steam electric power generating facilities, (viii) transportation facilities, (ix) sewage treatment facilities, (x) construction activities, and (xi) light manufacturing facilities
- Individual, group, and general storm water discharge permits and permit applications

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- Sampling protocols
- Phase II storm water regulations
- General storm water information such as EPA and State contacts, definitions, and program status.

It is strongly recommended that the inspector either have copies or be familiar with the contents of these documents to support storm water permitting applicability decisions.

One of the first questions that must be answered when evaluating the applicability of the storm water permitting regulations is whether the facility performs any industrial activities subject to the storm water permitting requirements. Often, this decision hinges upon the facility's primary Standard Industrial Classification (SIC) code, which is based on the primary activity occurring at the site. Where multiple activities are conducted at a site, with each activity having a distinct SIC code, EPA recommends using the value of receipts or revenues with the activity generating the most revenue or employing the most people being the primary activity of the facility. If this primary activity is identified in 40 *CFR* §122.26(b)(14), then the facility is subject to the storm water permitting requirements. If, however, the facility's primary activity is not included in 40 *CFR* §122.26(b)(14), the facility is not subject to the permitting requirements even if the facility conducts secondary activities that are identified therein.

Permit Applications for Storm Water Discharges Associated With Industrial Activity

The November 16, 1990, regulations specify three types of permit applications for storm water discharges associated with industrial activity: individual permit applications, group permit applications, and general permit applications. (Later, EPA published a series of general permits in States, in Federal facilities, and on Indian lands, where EPA is the NPDES permitting authority—57 *FR* 41176, 57 *FR* 41236 for industrial activities [September 9, 1992]; 57 *FR* 44412, 57 *FR* 44438 for construction activities [September 25, 1992].) Facilities subject to the storm water permitting regulations had the opportunity to apply for any of the three types of permits. The due date for group applications has since passed, leaving new facilities with two options, general or individual permits.

Individual permit application requirements are identified in 40 *CFR* §122.26(c)(1) and require the applicant to provide comprehensive facility-specific information and quantitative storm water sampling data on Forms 1 and 2F. Individual permit applications were due on October 1, 1992 for existing facilities. New facilities must submit this application 180 days prior to commencement of industrial activity that may cause a storm water discharge; new construction facilities must submit an application 90 days prior to commencement of construction.

Group permit application requirements are identified in 40 *CFR* §122.26(c)(2) and allow facilities with similar operations and storm water discharges to file a single two-part permit application. Part 1 group permit applications were due to EPA on September 30, 1991, for all industrial activities except those owned and operated by a municipality with a population of less than 250,000. Municipalities with populations of less than 250,000 were required to submit this application no later than May 18, 1992. Part 2 applications were due to EPA on

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October 1, 1992, for all industrial activities except those owned and operated by a municipality with a population of less than 250,000. Municipalities with populations of less than 250,000 were required to submit this application no later than May 17, 1993.

Industrial facilities wishing to be covered under a general permit, which is the most common permit choice by far, must file a Notice of Intent (NOI). The NOI is a simple one-page form that notices EPA (or the NPDES-approved State) of the facility's intent to be covered under the baseline general permitting requirements. Typically, coverage under the permit is automatic two days after the post-marked date of the NOI. (Some delegated States have varying time frames and some do not offer automatic coverage.) All NOIs for existing industrial facilities were due on October 1, 1992; however, EPA is accepting NOIs after that date (although, acceptance does not preclude EPA from taking enforcement action against the permittee for failure to submit). The NOI requires general facility operator and site information, site activities, and a signed certification attesting to the truth, accuracy, and completeness of the NOI. Most facilities submitting NOIs do so assuming that the general permit will be less stringent and cheaper (i.e., fewer pollutant limitations, monitoring requirements, and reporting requirements) to comply with than an individual permit. Also, preparing an NOI is less costly than completing a Form 2F (i.e., no sampling is required). Many facilities submitting individual permit applications believe that their facility is cleaner than the "general facility" and are looking for less stringent requirements than those in the general permit. EPA and NPDES-approved states do have the right to refuse issuance of a general permit and require submission of an individual permit application based on a review of the NOI or other information.

As described above, EPA established October 1, 1992, as the latest date for any facility with a discharge associated with industrial activity to submit either an individual or group application, or to be covered by a promulgated general permit.

Also, operators of storm water discharges associated with industrial activities that discharge through a large or medium separate storm sewer system must provide the operator of the large or medium municipal separate storm sewer system with basic information on the facility and its discharge (40 *CFR* §122.26(a)(4). This information includes:

- The name of the facility
- A contact person and phone number
- The location of the discharge
- A description, including SIC code, which best reflects the principal products or services provided by each facility
- Any existing NPDES permits.

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Applicability of Storm Water Discharges From Municipal Separate Storm Sewer Systems

In addition to regulating discharges from the 11 categories of sites with industrial activities, the storm water program regulates discharges from medium and large municipal separate storm sewer systems.

The November 16, 1990, regulations identify a two-part storm water permit application process for medium (serving a population of 100,000 or more, but fewer than 250,000) and large (serving a population of more than 250,000) municipal separate storm sewer systems in 40 *CFR* §122.26(d), pursuant to 402(p)(2)(C)-(D) of the CWA. The regulations identify 220 cities and counties that meet this requirement (and allow for case-by-case designations of other municipal storm sewers to be included in these systems). In addition to the designated counties and cities, other entities may be regulated such as Departments of Transportation or flood control districts. To date, a total of approximately 815 entities (cities, counties, DOTs, etc.) will be covered under 263 permits nationwide. Part 1 applications for municipal storm sewer systems were due to EPA on November 18, 1991, (large systems) and May 18, 1992, (medium systems). Part 2 applications for these permittees were due to EPA on November 16, 1992, (large systems) and May 17, 1993, (medium systems).

Permit Applications for Storm Water Discharges From Municipal Separate Storm Sewer Systems

Operators of large and medium municipal separate storm sewer systems (and others as designated by the Director) are required to submit a two-part jurisdiction- or system-wide permit application. Part 1 of the application should include general applicant information (including legal authorities), characterization of storm water and the source area, a description of existing management programs, and available resources. Part 2 of the application requires demonstration of adequate legal authority, a proposed program to monitor storm water discharges and estimate pollutant loads, refinement of the source characterization, a proposed management program and its anticipated effects, and an analysis of the fiscal expenditures to implement and enforce storm water provisions.

The permitting authority may issue one system-wide permit covering all discharges from municipal separate storm sewer systems or issue distinct permits for appropriate categories of discharges. Also, the permitting authority may issue permits for other municipal separate storm sewer systems on a system-wide or categorical basis. In many instances, these permits will be unique to the individual permittee; therefore, a definitive discussion of the permit requirements for the municipal separate storm sewer system permittees is not possible.

Storm Water Application and Permitting Deadlines

Section 402(p)(4) of the CWA identifies specific deadlines for the issuance or denial of all storm water permits. However, since EPA was unable to promulgate its regulations by the statutory deadline, the regulations require issuing or denying all storm water permits within one year of the permit application regulatory deadline consistent with Congress' intent.

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Section 402(p)(4) also specifies that permits shall provide for compliance as expeditiously as practicable, but in no event later than 3 years after the permit issuance date. A summary of permit application and issuance deadlines is provided in Table 11-3.

The Transportation Act of 1991 modified the application deadlines for industrial activities owned or operated by municipalities. Specifically, industrial activities owned or operated by municipalities with populations between 100,000 and 250,000 (medium-sized municipalities) and power plants, airports, and uncontrolled sanitary landfills owned or operated by municipalities with populations less than 100,000 (small municipalities) must have submitted Part 1 group applications by May 18, 1992, and Part 2 by May 17, 1993. Other industrial activities owned or operated by municipalities with a population of less than 100,000 have been placed into Phase II of the storm water program for future rulemaking.

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Figure 11-1.

Industrial Categories Associated With Industrial Activity

The eleven categories engaging in industrial activity are described below. Descriptions of Standard Industrial Classification [SIC] codes applicable to the storm water regulations are provided in Table 11-1.

(i) Facilities subject to storm water effluent limitations guidelines, new source performance standards, or toxic pollutant effluent standards under 40 *CFR* subchapter N (except facilities with toxic pollutant effluent standards which are exempted under category (xi) below;

(ii) Facilities classified as SIC 24 (except 2434), 26 (except 265 and 267), 28 (except 283), 29, 311, 32 (except 323), 33, 3441, and 373;

(iii) Facilities classified as SIC 10 through 14 (mineral industry) including active or inactive mining operations (except for areas of coal mining operations no longer meeting the definition of a reclamation area under 40 *CFR* §434.11(l) because the performance bond issued to the facility by the appropriate SMCRA authority has been released, or except for areas of non-coal mining operations which have been released from applicable State or Federal reclamation requirements after December 17, 1990) and oil and gas exploration, production, processing, or treatment operations, or transmission facilities that discharge storm water contaminated by contact with or that has come into contact with, any overburden, raw material, intermediate products, finished products, byproducts or waste products located on the site of such operations; (inactive mining operations are mining sites that are not being actively mined, but which have an identifiable owner/operator; inactive mining sites do not include sites where mining claims are being maintained prior to disturbances associated with the extraction, beneficiation, or processing of mined materials, nor sites where minimal activities are undertaken for the sole purpose of maintaining a mineral claim);

(iv) Hazardous waste treatment, storage, or disposal facilities, including those that are operating under interim status or a permit under subtitle C of RCRA;

(v) Landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA;

(vi) Facilities involved in the recycling of materials, including metal scrapyards, battery reclaimers, salvage yards, and automobile junkyards, including but not limited to those classified as SIC 5015 and 5093;

(vii) Steam electric power generating facilities, including coal handling sites;

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*** NOTES ***

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11. STORM WATER

B. Storm Water Permits

Typical Storm Water Discharge Permit Contents for Industrial Activities

It is likely that most storm water discharge permits will be modeled after EPA's baseline general permit. As such, the inspector will find that these permits address applicability, storm water Pollution Prevention Plans, effluent limitations, monitoring and reporting requirements, standard permit conditions, special conditions, reopener language, and Notice of Termination (NOT) provisions. The Pollution Prevention Plan is considered the most important requirement of the general permit; the same is probably true for individual permits.

Storm Water Pollution Prevention Plans

The discussion that follows refers to the general permits issued by EPA on September 9 and 25 of 1992. These permits are available to facilities located in States that have not been delegated NPDES permit authority. The inspector should review the facility's permit prior to the inspection, especially if the permit is different from the general permit. Each industrial and construction activity covered by the general permit must have a plan, tailored to site-specific conditions and designed to control the amount of pollutants in storm water discharges from the site. The inspector should verify that these plans have been updated as appropriate to reflect current conditions at the site. The permitting authority typically has the right to review and request changes in the Pollution Prevention Plan. Summaries of necessary components of these plans for industrial and construction activities are provided below for each of the two types of activities.

Pollution Prevention Plan for Industrial Activity

The Pollution Prevention Plan as required in the EPA storm water general permit for industrial activities must be prepared on or before April 1, 1993, and the facility must be in compliance with the Plan on or before October 1, 1993. New facilities must submit an NOI at least 48 hours prior to commencement of the industrial activity at the site. The Plan must be signed by a responsible corporate official such as a president, vice president, or general partner. This Plan is to be kept at the facility at all times and only has to be submitted for review when requested by EPA or by the operator of the municipal/separate storm sewer system when the facility discharges to a municipal/separate storm sewer. For large or complex facilities, the inspector should request a copy of the plan prior to inspection, to be more familiar with the facility during the inspection.

The Plan must contain a description of potential pollutant sources and a description of the measures and controls to prevent or minimize pollution of storm water. Specifically, the

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inspector should review the description of potential pollutant sources to verify that it reflects current conditions and includes:

- A map of the facility indicating the areas that drain to each storm water discharge point
- An indication of the industrial activities that occur in each drainage area
- A prediction of the pollutants that are likely to be present in the storm water
- A description of the likely sources of pollutants from the site
- An inventory of the materials that may be exposed to storm water
- The history of spills or leaks of toxic or hazardous materials for the past 3 years.

In addition, the inspector should verify that measures and controls described in the Plan, are current, and include the following:

- Good housekeeping or upkeep of industrial areas exposed to storm water
- Preventative maintenance of storm water controls and other facility equipment
- Spill prevention and response procedures to minimize the potential for and the impact of spills
- Testing of all outfalls to ensure there are no cross connections (i.e., only storm water is discharged)
- Training of employees on pollution prevention measures and controls, and record-keeping.

Checklists relating to specific elements of the storm water Pollution Prevention Plan analysis for industrial activities are provided in Appendix K.

Specific inspector questions, that may be appropriate at a given industrial site, to assess activity-specific source controls are presented in Appendix L. Site-specific Best Management Practices (BMPs) for industrial activities are summarized in Figure 11-2.

The EPA general permit also requires that facilities:

- Identify areas with a high potential for erosion and the stabilization measures or structural controls to be used to limit erosion in these areas
- Implement traditional storm water management measures (e.g., oil/water separators, vegetative swales, detention ponds) where they are appropriate for the site.

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The Plan must also have provisions for two tiers of inspections to be performed by the facility. The first tier consists of inspections of designated areas of equipment to be performed on a regular interval determined by the facility. These routine inspections are intended to determine the need for maintenance, good housekeeping, or other BMPs. The second tier of inspection is the comprehensive site evaluation, which requires qualified personnel to:

- Look for evidence of pollutants entering the drainage system
- Evaluate the performance of pollution prevention measures
- Identify areas where the Plan should be revised to reduce the discharge of pollutants
- Document both the routine inspections and the annual site evaluation in a report.

The compliance site evaluation can be done less frequently than the routine inspection (but not less than once per year). Documentation of both the routine inspections and the comprehensive site compliance evaluation must be included in the Plan.

Additional Requirements for EPCRA 313 Facilities

The EPA baseline general permit also includes special requirements for facilities subject to reporting requirements under Emergency Planning and Community Right-to-Know (EPCRA) (also known as Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986). Specifically, facilities that have discharges associated with industrial activity and that are subject to Section 313 of EPCRA for chemicals classified as Section 313 water priority chemicals" are subject to additional requirements. "Section 313 water priority chemicals" are defined in Part X Definitions of EPA's baseline general permit as "chemical or chemical categories which: 1) are listed at 40 *CFR* 372.65 pursuant to Section 313 of EPCRA; 2) are present at or above threshold levels at a facility subject to EPCRA Section 313 reporting requirements; and 3) that meet at least one of the following criteria; (i) Are listed in Appendix D of 40 *CFR* 122 on either Table II (organic priority pollutants), Table III (certain metals, cyanides, and phenols) or Table V (certain toxic pollutants and hazardous substances); (ii) are listed as a hazardous substance pursuant to section 311(b)(2)(A) of the CWA at 40 *CFR* 116.4; or (iii) are pollutants for which EPA has published acute or chronic water quality criteria."

Facilities that have discharges associated with industrial activity and that are subject to Section 313 of EPCRA for chemicals classified as Section 313 water priority chemicals are required to monitor storm water from the facility that comes into contact with any equipment, tank, container, or other vessel or area used for storage of a Section 313 water priority chemical, or located at a truck or rail car loading or unloading area where a Section 313 water priority chemical is handled. Pollutants that must be monitored semiannually include Oil and Grease (O&G), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Kjeldahl Nitrogen (TKN), phosphorus, pH, acute whole effluent toxicity, and any Section 313 water priority chemical for which the facility is subject to reporting requirements under Section 313 of EPCRA.

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Reports, summarizing the monitoring results obtained must be submitted annually, on the 28th day of the following January.

In addition to monitoring requirements, appropriate containment, drainage control, and/or diversionary structures must be provided in areas where Section 313 water priority chemicals are stored, processed, or otherwise handled. At a minimum, facilities must use either (1) curbing, culverting, gutters, sewers or other forms of drainage control to prevent or minimize the potential for storm water run-on or run-off to come into contact with significant sources of pollutants or (2) roofs, covers, or other forms of appropriate protection to prevent storage piles from exposure to storm water, and wind.

Additionally, storm water Pollution Prevention Plans must include a complete discussion of measures taken to conform with the following applicable guidelines, other effective storm water pollution prevention procedures, and applicable State rules, regulations, and guidelines:

- Liquid storage areas where storm water comes into contact with any equipment, tank, container, or other vessel used for Section 313 water priority chemicals
- Material storage areas for Section 313 water priority chemicals other than liquids
- Truck and rail car loading or unloading areas for liquid Section 313 water priority chemicals
- Areas where Section 313 water priority chemicals are transferred, processed, or otherwise handled
- Discharges from areas covered by (1), (2), (3), or (4)
- Facility site runoff other than from areas covered by (1), (2), (3), or (4)
- Preventative maintenance and housekeeping
- Facility security
- Training
- Engineering certification.

The Plan may incorporate other plans that the facility may have already prepared for other permits including Spill Prevention Control and Countermeasure (SPCC) Plans, or BMP Programs.

Pollution Prevention Plan for Construction Activity

The Pollution Prevention Plan as required in the EPA storm water general permit for construction activities must be prepared prior to submission of the NOI. An NOI for construction activities commencing before October 1, 1992, and continuing after that date, was due to be submitted by October 1, 1992. For construction activities commencing after October 1, 1992, an NOI must be submitted at least 48 hours prior to commencement of construction. The construction project must comply with the provisions of the Plan throughout the construction period and must be signed by a responsible official such as the president, vice president, or general partner. This Plan is to be kept at the construction facility during the entire construction period and only has to be submitted for review when requested by EPA.

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The Plan must contain a site description and a description of the measures and controls to prevent or minimize pollution of storm water. Specifically, the inspector should verify that the plan is current and that the description of the site includes the following:

- A description of the nature of the construction activity
- A sequence (schedule) of major construction activity
- An estimate of the total area of the site and of the area to be disturbed
- An estimate of the runoff coefficient of the site after construction is complete
- Any existing data on the quality of storm water discharge from the site
- The name of the receiving water
- Any information on the type of soils at the site
- A site map indicating drainage patterns and slopes after grading activities are complete, areas of soil disturbance, the outline of the area to be disturbed, the location of stabilization measures and controls, and surface waters at the discharge points.

Measures and controls must include three types of controls: erosion and sediment controls, storm water management controls, and other controls. The inspector should verify that appropriate measures and controls have been instituted as follows:

- Erosion and Sediment Controls — Disturbed areas where construction has permanently or temporarily ceased must be stabilized (i.e., seeding, mulching, etc.) within 14 days of the last disturbance or as soon as practicable in semi-arid and arid areas. (Areas that will be redisturbed within 21 days do not have to be stabilized.) Also, sites with common drainage locations that serve 10 or more disturbed acres must install a sediment basin where it is attainable (where a basin is not attainable, sediment traps, silt fence, or other equivalent measures must be installed). Sediment basins must provide 3,600 cubic feet of storage per acre drained. Drainage locations that serve less than 10 disturbed acres must install a sediment basin, a sediment trap, or a silt fence along the down slope and side slope perimeter.

- Storm Water Management Controls — The permittee must consider installing measures (storm water detention structures, infiltration measures, etc.) to control pollutants after construction is complete. Velocity dissipation devices must be installed in outfall channels to prevent erosion.

- Other Controls — The Plan must ensure that construction waste is not carried by storm water into the receiving waters. Measures must be taken to prevent construction vehicles from tracking soil off the construction site and to reduce the dust generation at the construction site. The operator must comply with State and/or local sanitary sewer or septic system regulations.

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Where State and local programs for sediment and erosion control, storm water management, or site permits exist, the operator must certify that the Plan reflects and is in compliance with the requirements of the applicable State or local program.

This Plan must also specify that operator personnel must inspect the construction site at least once every 7 days and within 24 hours of a rainfall of 0.5 inches or more. Areas with sites that have been finally stabilized or sites that are located in arid (i.e., less than 10 inches of rain per year) or semi-arid (10 to 20 inches of rain per year) areas must be inspected at least once a month. The inspector must prepare a report documenting his/her findings on the conditions of the controls and stabilized areas.

Checklists relating to specific elements of the storm water Pollution Prevention Plan analysis for construction activities are provided in Appendix M.

Specific inspector questions that may be appropriate at a given construction site to assess activity-specific source control are presented in Appendix N. Site-specific BMPs for construction activities are summarized in Figure 11-3.

Pollution Prevention Plan Implementation

Implementation of Pollution Prevention Plans require facilities to implement BMPs and train employees on how to carry out the goals of the Plan. The inspector should evaluate any implementation schedules developed by the facility for carrying out the Plan (e.g., deadlines for putting improved housekeeping measures into practice). The inspector should also determine whether appropriate individuals have been assigned to implement the specific aspects of the Plan and whether these individuals are aware of the requirements of that designation. If the Pollution Prevention Plan calls for the installation of structural controls, the inspector should verify that the controls are in place and in good working order or that the facility is on an appropriate schedule for construction of the structural control measures. The inspector should also ensure that management approves of the implementation schedule and strategy and is aware of the Pollution Prevention Plan process.

Additionally, employee training on the components and goals of the storm water Pollution Prevention Plan must be performed at all levels of responsibility. The inspector should verify that there are training programs and that the training focuses on spill prevention and response, good housekeeping practices, and materials management. Additionally, facilities that use or store EPCRA Section 313 water priority chemicals must conduct additional training on preventative measures, pollution control laws and regulations, the facility's storm water Pollution Prevention Plan, and features and operations of the facility that are designed to minimize discharges of Section 313 water priority chemicals, particularly due to spills.

Typical Storm Water Discharge Permit Contents for Municipal Separate Storm Sewer Systems

Permits must be obtained for all discharges from large and medium municipal separate storm sewer systems (and others as determined on a case-by-case basis). As mentioned above,

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the Director may either issue one system-wide permit covering all discharges from municipal separate storm sewers or issue distinct permits for appropriate categories of discharges within the system. EPA did not develop baseline general permits for storm water discharges from municipal separate storm sewer systems, because of the differing nature of discharges from municipal separate storm sewer systems in different parts of the country and the varying water quality impacts of municipal storm sewer discharges on receiving waters. Based on permit application requirements, these permits will likely address applicability, legal authority, source identification, discharge characterization, management programs, control and impact assessments, and financial commitments. The management program is considered to be the most important requirement of a municipal separate storm sewer system permit. Existing structural and non-structural prevention and control measures on discharges from municipal separate storm sewers must be described in Part 1 of the permit application.

Storm Water Management Programs

The discussion that follows provides a general discussion of management program requirements for municipal separate storm sewer systems. The inspector will have to review the facility's permit for specific considerations. Each municipal separate storm sewer system covered by a permit must develop a management program, tailored to system-specific conditions and designed to control the amount of pollutants in storm water discharges from the system. The inspector should verify that these programs are being implemented as appropriate to meet the current circumstances in the municipality. The permitting authority has the right to review and request changes in the storm water management program. Summaries of necessary components of these programs for municipal separate storm sewer systems are provided below for both large- and medium-size municipalities.

Management Programs for Municipal Separate Storm Sewer Systems

In Part 2 of the permit application, the permittee, to meet the Maximum Extent Practicable (MEP) standard, must identify additional prevention and control measures that will be implemented during the life of the permit. EPA recognizes that it may not be possible to identify all appropriate prevention and control permit conditions, but the process of identifying components of a comprehensive prevention and/or control program should begin early.

Management programs must address pollutants from four types of sources: runoff from commercial and residential areas, storm water runoff from industrial areas, runoff from construction sites, and non-storm water discharges. Permits should address MEP control measures for each of these components of the discharge. Discharges from some municipal separate storm sewer systems may also contain pollutants from other sources, such as runoff from land disposal activities. Where these other sources contribute significant amounts of pollutants to a municipal separate storm sewer system, appropriate control measures should be included. Also, permits should be written to reflect changing conditions that result from program development and implementation and corresponding improvements in water quality.

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Priorities for addressing storm water discharges should be based on consideration of controls that reduce pollutants to municipal separate storm sewer system discharges that are associated with storm water from commercial and residential areas, illicit discharges and illegal disposal, storm water from industrial areas, and runoff from construction sites. Permits for different municipalities should place different emphasis on controlling different components of discharges. For example, older municipalities will likely place more emphasis on cross-connections than newer municipalities, who may focus more on construction activities.

Management programs must describe priorities for implementing controls and should be based on the following four requirements:

1. Description of structural and source control measures that are to be implemented during the life of the permit to reduce pollutants from runoff from commercial and residential areas that is discharged from the municipal separate storm sewer system. The description must be accompanied by an estimate of the expected reduction of pollutant loads and a proposed schedule for implementing such controls. At a minimum, the description should include:

   - Maintenance activities and a maintenance schedule for structural controls.
   - Planning procedures to develop, implement, and enforce controls to reduce discharges from areas of new development and significant redevelopment after construction is complete.
   - Practices for operating and maintaining public streets, roads, etc., and procedures for reducing the impact as a result of deicing activities.
   - Procedures to ensure that flood management projects assess the impacts on the water quality of receiving water bodies and that existing structural flood control devices have been evaluated if retrofitting is possible for additional pollutant removal.
   - Program, including inspections and procedures to establish and implement controls, to monitor pollutants in runoff from operating or closed municipal landfills or other treatment, storage, or disposal facilities for municipal waste.
   - Program to reduce to the MEP pollutants in discharges from the application of pesticides, herbicides, and fertilizers. This may include educational activities, permits, certifications, and other measures for commercial applicators and distributors, and controls for application in public right-of-ways and at municipal facilities.

2. Description of a program, including a schedule, to detect and remove (or to require the discharger to the municipal separate storm sewer system to obtain a separate NPDES permit for) illicit discharges and improper disposal into the storm sewer. At a minimum, the proposed program should include:

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- Program, including inspections, to implement and enforce an ordinance, order, or similar means to prevent illicit discharges to the municipal separate storm sewer system
- Procedures to conduct on-going field screening activities during the life of the permit
- Procedures to be followed to investigate portions of the separate storm sewer system that indicate a reasonable potential of containing illicit discharges or other sources of non-storm water
- Procedures to prevent, contain, and respond to spills that may discharge into the municipal separate storm sewer
- Program to promote, publicize, and facilitate public reporting of the presence of illicit discharges or water quality impacts associated with discharges from municipal separate storm sewer systems
- Educational activities, public information activities, and other appropriate activities to facilitate the proper management and disposal of used oil and toxic materials
- Controls to limit infiltration of seepage from municipal sanitary sewers to municipal separate storm sewer systems.

3. Description of a program to monitor and control pollutants in storm water discharges to municipal systems from municipal landfills; hazardous waste treatment, disposal, and recovery facilities; industrial facilities that are subject to section 313 of SARA Title III; and industrial facilities that the municipal permit applicant determines are contributing a substantial loading to the municipal separate storm sewer system. The program should include:

   - Priorities and procedures for inspections and establishing and implementing control measures for such discharges
   - Monitoring program for storm water discharges associated with industrial facilities identified in 3., to be implemented during the term of the permit, including the submission of quantitative data.

4. Description of a program to implement and maintain structural and non-structural best management practices to reduce pollutants in storm water runoff from construction sites to the municipal separate storm sewer system. This program should include:

   - Procedures for site planning that incorporate consideration of potential water quality impacts
   - Requirements for non-structural and structural best management practices

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- Procedures for identifying priorities for inspecting sites and enforcing control measures that consider the nature of the construction activity, the topography, and the characteristics of soils and receiving water quality

- Appropriate educational and training measures for construction site operators.

Management Program Implementation

Implementation of management programs requires facilities to implement a variety of control measures, programs, procedures, and training of various individuals on how to carry out the goals of the program. The inspector should evaluate any implementation schedules developed by the municipality for carrying out the program and determine whether appropriate individuals have been assigned to implement the specific aspects of the program and if these individuals are aware of the requirements of that designation. If the program calls for the installation or maintenance of structural controls, the inspector should verify that the controls are in place and in good working order or that the facility is on an appropriate schedule for construction of the structural control measures.

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Figure 11-2.

Site-Specific Industrial Storm Water BMPs

Flow Diversion Practices

Flow diversion is practiced to channel storm water away from industrial activities to prevent storm water contact with industrial pollutants. Additionally, flow diversion may be used to channel polluted storm water directly to a treatment facility.

Flow diversion practices include storm water conveyances (e.g., channels, gutters, drains, and sewers), diversion dikes, and graded areas and pavement.

Exposure Minimization Practices

Exposure minimization is practiced to eliminate or minimize the contact of storm water with industrial activities and its pollutants. If contact of storm water with pollutants is minimized, the costs of collecting and treating and storm water and the environmental releases that occur will be reduced.

Exposure minimization practices include containment diking, curbing, drip pans, collection basins, sumps, covering, vehicle positioning, and loading and unloading by air pressure or vacuum.

Mitigative Practices

Mitigation is practiced to clean up or recover a substance (i.e., potential pollutant) before it comes in contact with storm water. Mitigation is a second step after pollution prevention,

Mitigative practices include sweeping, shoveling, excavation practices, vacuum and pump systems, sorbents, and gelling agents.

Other Preventative Practices

Other preventative practices can be taken to limit/prevent the exposure of storm water to industrial activities. These practices may be either structural or procedural measures taken to reduce/eliminate exposure.

Other preventative practices include preventative monitoring practices, dust control (land disturbances and demolition areas), dust control (industrial activities), signs and labels, security, area control procedures, and vehicle washing.

Sediment and Erosion Prevention Practices

Sediment and erosion prevention can be accomplished using seven general practices: vegetate the site, minimize soil exposure to storm water, keep runoff from disturbed areas, stabilize disturbed soils, slow down runoff, provide drainage ways for runoff, and remove sediment from the runoff before it leaves the site.

Sediment and erosion prevention practices include vegetative practices, structural erosion prevention, and sediment control practices.

Infiltration Practices

Infiltration practices are measures that increase the infiltration of storm water runoff into the ground through the use of very porous soils. Infiltration practices may also reduce the velocity of storm water, thereby minimizing erosion potential of the runoff.

Infiltration practices include vegetated filter strips, grassed swales, level spreaders, infiltration trenches, and porous pavements/concrete grids and modular pavements.

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Figure 11-3.

Site-Specific Construction Storm Water BMPs

Stabilization Practices

Stabilization is practiced to control erosion due to unvegetated areas. Stabilization reduces erosion potential in four ways: (1) by shielding the soil surface from direct erosive impact of raindrops, (2) by improving the soil's water storage porosity and capacity, (3) by slowing the runoff and allowing the sediment to drop out or deposit; and (4) by physically holding the soil in place with plant roots. Vegetative (e.g., grasses, trees, or shrubs) covers are the most common type of stabilization.

Stabilization practices include temporary seeding, mulching, geotextiles, chemical stabilization, permanent seeding and planting, buffer zones, preservation of natural vegetation, sod stabilization, stream bank stabilization, soil retaining measures, and dust control.

Structural Erosion and Sediment Control Practices

Structural erosion and sediment control diverts storm water flows away from exposed areas, conveys runoff, prevents sediments from moving offsite, and reduces the erosive forces of runoff waters.

Structural erosion and sediment control practices include earth dikes, drainage swales, interceptor dikes and swales, temporary stream crossing, temporary storm drain diversion, pipe slope drains, subsurface drains, silt fence, gravel or stone filter berm, storm drain inlet protection, sediment trap, temporary sediment basin, outlet protection, check dams, surface roughening, and gradient terraces.

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11. STORM WATER

C. Sampling and Inspection Considerations

Storm Water Pollutant Sources

Storm water contamination associated with industrial activities depends on a variety of factors, including the operations of the facility, the nature of precipitation, and the imperviousness of the soils. Storm water can pick up pollutants as it drains from the land, although other sources such as illicit connections, spills, and other improperly dumped materials may increase the pollutant loads discharged from storm sewers. The specific sources of pollutants in storm water vary depending on the nature of industry operations and specific facility features. Storm water discharges from industrial facilities may also contain excess toxics and conventional pollutant loadings where poor housekeeping and materials management activities are practiced.

One of the major efforts to evaluate storm water runoff was the National Urban Runoff Program (NURP), conducted between 1978 and 1983. This study evaluated storm water runoff from commercial and residential areas. The NURP study found that, on average, total suspended solids concentrations in storm water runoff are an order of magnitude greater than those in typical discharges from a sewage treatment plant providing secondary treatment. Additionally, COD was found to be comparable to that of a secondary treatment plant. Sampling conducted for the NURP study also detected 77 priority pollutants in storm water discharges from residential, commercial, and light industrial lands. While NURP did not evaluate oil and grease, other studies have shown hydrocarbon levels to be in the 2 to 10 mg/l range and have been shown to accumulate in bottom sediments and adversely affect benthic organisms.

Other studies have also shown that many storm sewers contain illicit non-storm water discharges, in which large amounts of waste are disposed of improperly. For example, one study found that 14 percent of the buildings in one area had improper storm drain connections with a much higher rate of 60 percent for automobile-related businesses and light industrial facilities. While some of these connections were illegal or improper plumbing, a majority of these connections were approved at the time they were built, but have since become unlawful discharges.

Six activities have been identified as major potential sources of pollutants in storm water discharges associated with industrial activity: (1) loading or unloading of dry bulk materials or liquids; (2) outdoor storage of raw materials or products; (3) outdoor process activities; (4) dust or particulate generating processes; (5) illicit connections or inappropriate management practices; and (6) waste disposal practices. More detailed discussion of these operations follows.

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Loading or unloading of dry bulk materials or liquids: These operations are typically performed along facility access roads and rail lines and at loading/unloading docks and terminals. Activities include pumping liquids or gases from truck or rail car to a storage facility or vice versa, pneumatic transfer of dry powder chemicals to or from the transportation vehicle, transfer by mechanical conveyor, and transfer of bags, boxes, drums, totes, or other containers from vehicles. Material spills and incidental material losses may discharge directly to the storm drain or may accumulate in soils or on surfaces and be washed away during a storm or facility washdown.

Outdoor storage of raw materials or products: This includes the storage of fuels, raw materials, by-products, intermediates, final products, and waste residuals. Storage practices include using containers such as drums or tanks, platforms, bins, silos, boxes, or piles. When these areas are exposed to rain and/or runoff, solid material and other pollutants may wash off or dissolve into solution and be carried away.

Outdoor process activities: This includes certain types of manufacturing and commercial operations or land-disturbing operations. Activities such as equipment maintenance, timber processing, rock crushing, and concrete mixing often occur outdoors. Processing operations can result in spills or product loss to the drainage system or creation of dusts or mists that can be deposited locally. Activities such as construction and mining cause large land disturbances. Disturbed land can result in soil loss and other pollutant loadings associated with increased runoff. Also, many facilities apply chemicals such as herbicides, pesticides, and fertilizer on the property regardless of whether process activities are conducted indoors or outdoors.

Dust or particulate generating processes: Industrial activities with stack emissions or process dusts can cause localized atmospheric deposition of pollutants that are washed away during storms. Heavy manufacturing operations such as smelting, mining, and cement manufacturing generate significant levels of dust. In addition, facilities, such as bakeries, can generate significant particulate emissions from baking oven exhausts.

Illicit connections or inappropriate management practices: Illicit connections tend to be found more often at older facilities as well as at facilities that use high volumes of process water or dispose of significant volumes of liquid waste. Pollutants from non-storm water discharges to the storm sewer are usually a result of improper connections, improper dumping, and the belief that absence of visible solids in a discharge is equivalent to the absence of pollution. Illicit connections are often associated with floor drains connected to storm sewers. Floor drains can be the source of non-storm water discharges such as heat exchanger condensate, facility washdown, and cooling waters. These discharges may be either intentional, with the discharger believing that the discharge does not contain pollutants, or inadvertent, if the operator is unaware that the floor drain is connected to the storm sewer.

Waste disposal practices: These activities include temporary storage of waste materials, operating landfills, waste piles, and land application sites. Outdoor waste treatment practices, such as waste pumping, wastewater treatment chemical addition, mixing, aeration, clarification, and solids dewatering, can contribute pollutant loadings to storm water.

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Storm Water Sampling Considerations

In addition to the applicable conditions described in Chapters Five through Eight on Sampling, Flow Measurement, Toxicity, and Laboratory Procedures and Quality Assurance, the inspector also must verify storm water specific sampling considerations. Sampling personnel must be especially flexible when attempting to collect storm water samples. Whether the inspector plans to sample a facility's storm water discharge or evaluate a facility's storm water discharge sampling program, he/she may need to adjust for any of the following:

- No rainfall
- Hazardous weather conditions
- Non-representative storm event (i.e., not within 50 percent of the volume and duration for the average storm event for that area)
- Duration between the previous measurable storm event and the storm event to be sampled of less than 72 hours
- Form of precipitation (i.e., snow melt or rainfall)
- Accessibility of sampling locations.

These conditions make sampling of storm water very difficult. When any of the situations described above arises, the inspector should determine the potential effects of these conditions on the sampling event and use his/her best judgment on proceeding. The decision may be to go on with the sampling, wait till a later date, or sample at a location that may not be the most appropriate sampling location. An inspector's review of a facility's storm water sampling data may require similar decisions to be made.

EPA's general permit established monitoring requirements for only certain classes of industrial sites. These requirements are identified in Appendix O. Permitting authorities are authorized to include more stringent monitoring conditions; therefore, the inspector should review the facility's permit to identify the site-specific requirements.

The storm water regulations specify the nature of the storm event to be sampled and the sample collection methodology:

- All samples must be collected from a storm event greater than 0.1 inches in magnitude.
- The storm event must be at least 72 hours after the previously measurable storm event (greater than 0.1 inches).
- Where feasible, the variance in the duration of the event and the total rainfall of the event should not exceed 50 percent from the average or median rainfall event in that area. A map of the United States with the rain zones and typical values of annual storm events is provided as Appendix P.

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- Data must be reported for both a grab and composite sample (except for discharges from holding ponds or impoundments with a retention time of greater than 24 hours; for those discharges, results for a grab sample must be reported).

- The grab sample must be taken within the first 30 minutes of the discharge (if impracticable, the grab can be collected in the first hour with a description of why a grab sample in the first 30 minutes was not possible).

- Composite samples may be either time- or flow-weighted.

- Composite samples may be collected with an automatic sampler or as a combination of a minimum of three aliquots taken in each hour of discharge for the entire discharge or for the first three hours of the discharge, with each aliquot being separated by a minimum of 15 minutes.

EPA's general permit requires retention of monitoring records for 6 years, since many facilities will not be required to submit the results of monitoring to the permitting authority. In addition, Pollution Prevention Plans must be kept for the life of the permit.

Sample types are consistent with those presented in 40 *CFR* Part 136, i.e., grab samples collected for pH, temperature, cyanide, phenols, total residual chlorine, oil and grease, fecal coliform, and fecal streptococcus and 24-hour composites collected for all other pollutants. An exception to this is if a facility is sampling storm water from an impoundment or holding pond with a retention time of more than 24 hours. In these cases, one grab sample can be collected and analyzed for all parameters.

One unique aspect of the storm water regulations is that a facility can demonstrate substantially identical outfalls or representative outfalls where it has two or more outfalls with similar effluents. In the case of group applications, the substantially identical outfall petition was to be submitted to EPA. Where the petition request was approved, the permittee only has to sample one of the substantially identical outfalls and report that the quantitative data also apply to the substantially identical outfalls. For facilities subject to EPA's general permit, the facility has to document why a given outfall is representative of more than one outfall and maintain this documentation on site. When assessing the applicability of substantially identical outfalls or representative outfalls, the inspector should verify that the outfalls receive storm water discharges from substantially identical or representative:

- Industrial activities and processes

- Significant materials that may be exposed to storm water

- Storm water management practices and material management practices

- Flows, as determined by the estimated runoff coefficient and approximate drainage area at each outfall.

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Flow Measurement Considerations

The storm water regulations allow for storm water flow to be measured or estimated. Flow measurement devices may either be permanent or portable devices. A discussion of flow measurement techniques and inspector procedures is provided in Chapter Six. In certain instances, a facility may estimate the storm water flow rate. EPA's *Storm Water Sampling Guidance Document* (July 1992) outlines the four most common methods for estimating storm water flow rate: the runoff coefficient method, the float method, the slope and depth method, and the bucket and stopwatch method.

The runoff coefficient method is the least accurate method for estimating flows and should only be used if all other measurement and estimation techniques are inappropriate. Runoff coefficients are documented estimates of the fraction of rainfall that will run off from the drainage area taking into account the part that infiltrates the ground. Commonly used runoff coefficients are presented in Appendix Q. For a site with multiple types of surface areas (e.g., flat lawns, brick streets, and light industrial areas) the average runoff coefficient should be determined by averaging the runoff coefficients over the entire site, taking into account the area of each of the different surface areas.

The float method is appropriate where the flow is easily accessible and open; the velocity is determined by measuring the time it takes a float to travel between two points, and the area is determined by measuring the depth and width of the flow.

The slope and depth method, based on Manning's Equation, is appropriate for flow from a pipe or ditch where the slope of the conveyance is known and the flow does not totally fill the ditch or pipe from which it is flowing. To use this method, the depth of the flow in the middle of the pipe or ditch is recorded, as is the inside diameter of the pipe or the width of the ditch.

The bucket and stopwatch method is appropriate where the flow is from a pipe or ditch, free flowing, and small enough to be captured in a bucket (or similar container). This method is rarely suitable for storm water flow measurement because of the impracticality of the procedure.

Inspecting for Illicit Connections

Illicit connections are point source discharges of pollutants to separate storm sewer systems that are not composed entirely of storm water and that are not authorized by an NPDES permit. There are two types of illicit connections: pronounced (direct hookups to the sewer system) and subtle (indirect, intermittent, usually without piping).

The first thing that an inspector should evaluate is the facility's non-storm water discharge certification. This certification, required as a component of the permit application, should include a description of the testing methods used, the date of any testing, and the onsite drainage points that were directly observed during the tests.

The storm water regulations do specify that certain "non-storm water discharges" may be authorized by a storm water permit, provided the measures and controls for non-storm water

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discharges are included in the facility's Pollution Prevention Plan. Authorized non-storm water discharges include:

- Discharges from firefighting activities
- Fire hydrant flushings
- Potable water sources including waterline flushings
- Irrigation drainage
- Lawn watering
- Routine external building washdown that does not use detergents or other compounds
- Pavement washwaters where spills or leaks of toxic or hazardous materials have not occurred (unless all spilled material has been removed) and where detergents are not used
- Air conditioning condensate
- Springs
- Uncontaminated ground water
- Foundation or footing drains where flows are not contaminated with process materials such as solvents.

Inspectors can evaluate facilities for illicit connections using a two-step process. First, inspectors should screen the facility for indications of possible illicit connections. If indications exist, the inspector needs to investigate for identification of actual illicit connections.

Prior to conducting an inspection, general facility and locational maps should be reviewed for potential areas of concern. Site maps required in the Pollution Prevention Plan, topographic maps (indicating drainage patterns), and sewer maps are three of the better sources, although, depending on the site, additional maps may be of assistance. Considerations during the mapping review include the density of industrial activity in the area, the type of industrial activity (and the likelihood of that industry having illicit connections), and the proximity of the industrial facility to the storm water outfall.

Upon arrival at the facility, the inspector should conduct a tour to detect indications of possible illicit connections. Indications may include the following:

- Dry weather flows
- Odors, residues, color, floatables, or other noticeable properties in the outfall
- Affected vegetation in the area of the outfall
- Structural damage (e.g., cracked cement, peeling paint, corroded metal).

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If any of these conditions exist, the inspector should consider performing field analytical testing on the discharge to ascertain the potential source of the discharge. Conductivity and pH are two tests that are inexpensive and easy to perform at the outfall location and can be key indicators of non-storm water discharges.

Upon identification of a potential illicit connection, the inspector should evaluate the flow pattern of the discharge. Continuous dry weather flows are a good indication of an illicit discharge, but may also be indicative of infiltration into the collection system. Also, the inspector should verify whether or not any NPDES-permitted flows are discharged to the outfall in question. Intermittent dry weather flows are probably not due to infiltration, especially where the flows vary considerably over a short period of time. The inspector should plan on possibly returning to the site to further investigate dry weather flows.

After evaluating the flow pattern of the discharge, the inspector should analyze all available chemical and physical data. All discernible properties of the discharge should be noted. Inspectors should be aware that discharges from illicit connections are not necessarily highly polluted. Sources such as non-contact cooling water or boiler blowdown may appear extremely clear and clean. The inspector should not consider these "clean" streams to be innocuous. For example, non-contact cooling water, which supposedly does not come in contact with any pollutants, other than heat, may be contaminated from leaking heat exchanger jackets or may be treated with anti-scaling chemicals, anti-oxidants, or biological inhibitors.

After characterizing the discharge, the inspector should try to correlate this water with industrial activities that may be contributing this discharge. Consideration should be given to chemical loading/unloading areas, cooling waters, process waters, pronounced illicit connections, and the age of the facility (i.e., older facilities are more likely to have illicit connections).

Inspectors prepared to investigate for possible illicit connections should have the following equipment available:

- Field test kit
- pH meter and buffer solution
- Conductivity meter and buffer solution
- Automatic sampler
- Instant camera and film
- Sample collection bottles
- Crowbar
- Flashlight/mirror
- Dye tracer (e.g., fluorescein)
- Topographic and sewer maps
- Cooler (with ice)
- Stakes
- Personal safety equipment.

To evaluate potential illicit connections, the inspector should investigate manholes, catch basins, storm water runoff direction, material storage areas, cleanliness of loading/unloading areas, spill control, nature and condition of waste management areas, floor drains, and

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storage areas. Processes or equipment for which the facility does not know the discharge destination should be considered to have a high potential as an illicit connection. Where the inspector believes that a process or piece of equipment may be the source of an illicit connection, dye tracer testing (using a fluorescent dye such as fluorescein) may be appropriate. If the dye is visible at the outfall, then an illicit connection has been identified. Failure to see the dye at the outfall is not necessarily indicative of the lack of an illicit connection. Decrepit sewer systems may prevent the dye from appearing at the outfall. In these instances, a sewer system investigation may be necessary.

Upon identification of an illicit connection, the permittee must do one of the following:

- Redirect the discharge into an approved outfall
- Submit a NPDES permit application (Forms 1 and 2C) for discharge
- Reconnect to the sanitary sewer system.
- Cease the discharge
- Recycle the water.

For additional information on identifying illicit connections, refer to EPA investigations of *Inappropriate Pollutant Entries Into Storm Drainage Systems, A User's Guide* (January 1993).

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12. COMBINED SEWER OVERFLOWS

A. Review of the CSO Policy

About 1,100 communities in the U.S. have sewer collection systems that are combined sanitary and storm sewer systems. In certain instances these sewers overflow, such as during rain events. The Combined Sewer Overflows (CSOs) consist of mixtures of domestic sewage, industrial and commercial wastewaters, inflow/infiltration, and storm water runoff. EPA estimates that there are as many as 15,000 CSO discharge points nationwide. CSOs are considered as point sources of pollution to surface waters. Thus, they are covered under the Clean Water Act (CWA) and are subject to the National Pollutant Discharge Elimination System (NPDES) permit program. However, until recently, CSOs received less than full attention in terms of national rulemaking or specific CSO permit conditions in individual NPDES permits. There are no national Best Available Technology/Best Control Technology (BAT/BCT) effluent guidelines and limitations for CSOs. Unlike Publicly Owned Treatment Works (POTWs), CSOs are not subject to secondary treatment requirements.

Two of the largest problems associated with CSO pollution control are (1) the complexity and variability of CSO discharges and (2) the potentially high costs of their abatement. The types, concentrations, and volumes of pollutants and their impacts on receiving waters vary widely from system to system, and within a system, they vary from one storm event to the next. Additionally, it can be difficult to determine the impact of CSOs on receiving water quality because, in most cases, such data have not been collected. Water Quality Standards (WQSs) are mostly based upon dry weather flows, and water quality and benthic data are collected during non-storm periods, which means impacts of CSOs on streams may not be completely understood. Impacts are often determined by environmental measurements such as beach closings, number of complaints regarding floatables, or poor aesthetics.

EPA's 1994 CSO Control Policy (59 *FR* 18688) has developed an approach to permitting CSOs that is designed to abate CSO pollution problems while still retaining the flexibility necessary to deal with each CSO situation on a site-specific basis. The Policy's strategy encourages permittees with CSOs to:

- Implement technology-based CSO controls as soon as possible but no later than January 1, 1997. The policy describes nine CSO control measures that may be considered minimum BAT/BCT, based on the permitting authority's best professional judgment.

- Develop a Long-Term CSO Control Plan (LTCP) generally within 2 years after the date of the NPDES permit provision, Section 308 information request, or enforcement action requiring the permittee to develop the plan. The policy describes the minimum elements which the LTCP should address.

- Implement the LTCP according to a schedule that allows the permittee to phase in implementation based on the relative importance of and adverse impacts upon WQS and the permittee's financial capability and its previous efforts to control CSOs.

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- Implement a post-construction compliance monitoring program.

The permitting and enforcement authorities are expected to take enforcement action against dry weather CSO discharges.

As outlined in the CSO Policy, the nine minimum CSO controls are listed in Table 12-1 and the elements of the LTCP are listed in Table 12-2. The major approach to CSO control, outlined in EPA's CSO Control Policy, is to:

- Eliminate CSOs to sensitive areas wherever possible (where not possible, provide treatment).
- Coordinate the review and revision of water quality standards with development of long-term CSO control plans.
- Evaluate a reasonable range of alternatives that could achieve the necessary level of control/treatment, and select the controls to be implemented based on cost/ performance evaluations.
- Develop an implementation schedule based on the relative impacts on WQS and designated uses, on the priority of projects identified in the LTCP, and on the permittee's financial capability.
- Maximize treatment of wet weather flows at the POTW.

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Table 12-1.

Nine Minimum CSO Controls

- Proper operation and regular maintenance programs for the sewer system and the CSOs
- Maximum use of the collection system for storage
- Review and modification of pretreatment requirements to ensure that CSO impacts are minimized
- Maximization of flow to the POTW for treatment
- Prohibition of CSOs during dry weather
- Control of solid and floatable materials in CSOs
- Establishment of pollution prevention programs
- Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls

Table 12-2.

Elements of the Long-Term CSO Control Plan

- Characterization, monitoring, and modeling of the combined sewer system
- Public participation
- Consideration of sensitive areas
- Evaluation of alternatives
- Cost/performance considerations
- Operational plan
- Maximizing treatment at the existing POTW treatment plant
- Implementation schedule
- Post-construction compliance monitoring program

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B. CSO Inspection Procedures

Each municipality's specific CSO requirements will be contained in an NPDES permit, an enforcement order, a consent decree, or other enforceable documents. The CSO conditions will be specific to that permittee. The compliance inspector will be faced with obtaining information to determine compliance in the following areas:

- Ensuring that CSOs do not occur during dry weather
- Implementation of the nine minimum CSO controls
- Adherence to schedule for development and submission of a Long-Term CSO Control Plan, including any interim deliverables
- Adherence to schedule for implementation of the CSO controls selected from the Long-Term CSO Control Plan
- Narrative, performance-based or numerical, water quality-based effluent limitations
- Monitoring program, including baseline information on frequency, duration, and impacts of CSOs
- Elimination or relocation of overflows from sensitive areas.

Preparation

Requirements for CSO control can be found in two separate documents: the permit and enforcement orders, such as Administrative Orders or Judicial Orders, or Consent Decrees. Inspectors should review the permit and other enforceable mechanisms issued to the permittee. The inspector may find CSO conditions that address:

- Requirements to implement and document implementation of technology-based controls (i.e., nine minimum controls) by the date specified in the permit or enforceable mechanism.
- Requirement to submit a report documenting the implementation of the nine minimum controls; the report will usually be required within 2 years of permit issuance.
- Requirements for the development, submission, and implementation of the Long-Term CSO Control Plan. Where the permittee is in the phase of developing a LTCP, there will usually be a schedule that provides 2 years or less for the development and submission of the plan, either in the permit or other appropriate enforceable

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mechanism. Where the permittee has completed a LTCP, there will be narrative requirements pertaining to the implementation, operation, and maintenance of the selected CSO controls described in the LTCP. There will also be a schedule for implementation of the CSO controls either in the permit or in an appropriate enforceable mechanism.

- Water quality-based effluent limits for CSOs. Numeric limits may not be found in the initial permits when the permittee is developing or implementing its LTCP. Instead, there will be a requirement to immediately comply with applicable WQSs expressed in the form of a narrative limitation. Permittees that have completed and are implementing their LTCPs may have one of the following permit conditions for CSOs:
  - A maximum number of overflow events per year for specified design conditions
  - Minimum percentage capture of combined sewage by volume for treatment under specified design conditions
  - Minimum percentage reduction of the mass of pollutants discharged for specified design conditions
  - Other performance-based standards and requirements.
- Requirements to implement a post-construction compliance monitoring program. This will be required for permittees that have completed and are implementing their LTCPs.
- Requirement to re-assess overflows to sensitive areas. This will only be imposed in those cases where elimination or relocation of CSOs from sensitive areas were proven not to be physically possible or economically achievable.
- Conditions establishing requirements for maximizing the treatment of wet weather flows at the treatment plant.

Other documents that the inspector should review are any CSO reports submitted by the permittee. The permittee may have submitted information in response to EPA 308 information requests on CSOs. The permittee may have submitted CSO monitoring plans or a report characterizing its CSOs, a report documenting implementation of the nine minimum CSO controls, or a Long-Term CSO Control Plan. Reviewing these permittee reports will help the inspector become knowledgeable about the permittee's specific CSO problems and existing CSO controls.

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Onsite Records Review

The types of CSO records that the inspector should find at the facility would be the following:

- Log books, reports, or internal memos describing maintenance and operation activities concerning the sewer system and CSO outfalls
- CSO outfall flow records
- Monitoring data on CSOs, collection system, or receiving stream
- Records pertaining to installation of CSO controls.

The specific records that a facility would maintain will depend on the specific CSO controls the facility has selected and is implementing. If the permittee has submitted a report documenting implementation of the CSO controls, the inspector should review appropriate records kept at the facility to verify the information in this report. Examples of possible records that might be kept to document the implementation of the nine minimum CSO controls are listed in Table 12-3. These examples are provided as illustrations and not requirements. The inspector should use the facility's permit or other enforceable document as a guide in determining what specific records the facility is required to keep and maintain. The facility's CSO Operations and Maintenance manual and CSO control plan can provide the inspector with insight into the specific types of records the facility would have.

Interviews

As with all of the NPDES compliance inspections, interviews with appropriate personnel with firsthand knowledge of CSO activities can be useful in obtaining factual information. The inspector should interview the person in the highest position of authority responsible for the day-to-day development or implementation of the LTCP. Other personnel, such as the collection crew or others involved in inspecting, operating, and maintaining CSOs or CSO controls should also be interviewed. It is particularly important that the inspector obtain written statements (see Chapter Two) where personnel are providing information that is not or cannot be substantiated by the facility's records or the inspector's own observations.

If the facility is developing or implementing a LTCP, the inspector may want to interview those personnel responsible for that plan. Generally, the facility will be under a schedule with distinct activities and milestones established. This schedule may be in the permit, but will more likely be in an enforcement order. Any schedules submitted by the permittee in a report or in its LTCP should not be referred to, as these are not enforceable schedules. The inspector should focus on verifying those LTCP development or implementation activities that (1) the permittee has reported have been developed/implemented and (2) the permittee was required to have developed/implemented according to a schedule in the permit or enforcement order.

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Facility Site Inspection

An inspection of the CSO outfalls is not normally part of an NPDES compliance inspection of the wastewater treatment plant. However, if the inspection's focus or one of its objectives is the investigation of compliance with CSO requirements, then the inspector may decide that an inspection of CSO structures, CSO treatment systems, or key areas of the collection system is necessary. If the intent of the inspection is to observe CSO treatment, it may be necessary to schedule this inspection during or immediately after a wet weather event. These outfalls would be located throughout the collection system and, therefore, may be several miles from the facility.

It is not necessary to inspect all of the CSO outfalls. The inspector can select a few either randomly or on the basis of location (closest to the plant) or other selection criteria. For example, the inspector may want to inspect those outfalls that have some type of treatment of solids and floatables to evaluate the operation and maintenance of the controls. The inspector might also select the largest (in discharge volume) outfalls, those that most frequently discharge (during wet weather), or those that are known to have an impact on water quality. Conversely, the inspector may want to select those outfalls that are subject to few inspections by the permittee.

If the inspector observes any dry weather CSO discharges, a photographic record should be made (see Chapter Two), and indepth interviews should be held and statements obtained from facility personnel.

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Table 12-3.

CSO Records

Nine Minimum CSO Controls	Examples of Records/Documentation
Proper operations and regular maintenance program	• Log of sewer system cleaning, flushing, or debris removal • Log of repair or maintenance of regulators • Log of lift station malfunctions and repairs made • Log of preventative maintenance of interceptor lift stations and pumps • Log of inspections of lift stations, sewer lines, and regulators
Maximum use of collection system for storage	• Hydraulic study of system and evaluation of alternatives to maximize wet weather flow storage capacity • Records of installation of in-line devices such as dams, regulators, and gates to retard flow • Installation of separate sanitary and storm water lines • Replacement of undersized pipes • Adjustment of regulator settings or upgrading/adjusting pumping rates at lift stations • Off-line temporary storage
Review and modification of the pretreatment program	• Inventory of nondomestic discharges • Assessment of significance of nondomestic discharges on CSO and receiving waters • Pretreatment controls to reduce/eliminate industrial contaminants during wet weather
Maximization of flows to the POTW for treatment	• Summary of analyses conducted • Maximum wet weather flow Wastewater Treatment Plant (WWTP) can receive without pass-through or interference • Description of modifications to be implemented

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Table 12-3.

CSO Records (Continued)

Nine Minimum CSO Controls	Examples of Records/Documentation
Prohibition of dry weather overflows (DWOs)	• Log of inspections of CSOs during dry weather and observations made during these inspections • Log of Dry Weather Overflow (DWO) reports submitted
Control of solids and floatable materials in CSOs	• Installation of screens or booms • Source control activities such as regular street cleaning, highly visible anti-litter programs
Pollution prevention	• Street sweeping, anti-litter campaigns
Public notification	• Date and proof of public notice, procedure (by newspaper, radio), public notice information
Monitoring of CSOs	• Identification of outfall locations • Number and location of overflow events including duration, volume, and pollutant loadings • Receiving stream data and impact (e.g., beach closings, fish kills) • Monitoring plan

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C. References and Checklist

References

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U.S. Environmental Protection Agency. April 1994. "Draft Combined Sewer Overflows Guidance for Long-Term Control Plan." EPA 832-R-94-001.

U.S. Environmental Protection Agency. April 1994. "Draft Combined Sewer Overflows Guidance for Nine Minimum Control Measures." EPA 832-R-94-002.

U.S. Environmental Protection Agency. April 1994. "Draft Combined Sewer Overflows Guidance for Permit Writers."

*** NOTES ***

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CSO EVALUATION CHECKLIST

A. IDENTIFICATION OF CSOs

Yes	No	N/A	1. Are all CSO points identified?
Yes	No	N/A	2. Does facility have maps/schematics of Combined Sewer System (CSS) depicting location of all CSO discharge points?
Yes	No	N/A	3. Is each CSO discharge point located by longitude, latitude, and street address on appropriate maps?

B. DRY WEATHER OVERFLOWS

Yes	No	N/A	1. Are the locations of all dry weather CSOs known by permittee?
Yes	No	N/A	2. Does permittee have records of quantitative loads and flows on all dry weather CSO events?
Yes	No	N/A	3. Has notification been given to EPA/State of all dry weather CSO discharges?
Yes	No	N/A	4. Are there any unreported dry weather CSOs?

C. RECORDS

			1. Are the following records kept for CSO events?
Yes	No	N/A	• Location
Yes	No	N/A	• Frequency of discharge
Yes	No	N/A	• Flow magnitude
Yes	No	N/A	• Discharge pattern
Yes	No	N/A	• Total volume of discharge
Yes	No	N/A	• Pollutant characterization
Yes	No	N/A	• Correlation with rainfall records
Yes	No	N/A	• Specific causes of overflows
Yes	No	N/A	• Flow collected/flow diverted?
Yes	No	N/A	2. Are records of CSO flows maintained?
Yes	No	N/A	3. Are records accurate?

D. OPERATION AND MAINTENANCE

Yes	No	N/A	1. Is there a CSS O&M manual and does it address O&M of CSO structures?
Yes	No	N/A	2. Does the facility conduct inspections of the CSS and CSO structures?
Yes	No	N/A	3. Are these inspections documented? Does documentation include results of various types of inspections, dates and times, corrective action taken if problems were found?
Yes	No	N/A	4. Is a log book of maintenance and repair on the CSS and CSO structures maintained? Does this note the type of problem (or indicate routine maintenance), repair made, or maintenance activity conducted, date?

G. COMPLIANCE SCHEDULES

			1. Is permittee meeting CSO compliance schedule for:
Yes	No	N/A	• Implementing nine minimum CSO controls?
Yes	No	N/A	• Developing LTCP?
Yes	No	N/A	• Implementing LTCP?
Yes	No	N/A	2. Has permittee requested an extension of time?

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13. POLLUTION PREVENTION

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13. POLLUTION PREVENTION

A. Overview of Pollution Prevention

Pollution prevention is a proactive environmental management approach for minimizing material and resource losses during production. Pollution prevention addresses all aspects of production processes from raw material usage and inventory procedures to waste management and utilities conservation. Management techniques that incorporate pollution prevention reduce or eliminate the generation of pollutants, wastes, and adverse ecological impacts through new approaches, material substitutions, and optimizing processes and operating procedures.

Pollution Prevention Goals

The goal of pollution prevention is to achieve the reduction of pollution by the elimination or reduction of waste. Pollution prevention is a multi-media approach that minimizes or eliminates pollutants released to land, air, and/or water without shifting pollutants from one medium to another. The Pollution Prevention Act of 1990 defines pollution prevention as:

> ...any practice which reduces the amount of a hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and any practice which reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants.

Pollution prevention, therefore, represents a fundamental shift in approach away from the conventional reliance on waste treatment/disposal or "end-of-pipe" treatment to the active investigation of prevention techniques. Facilities can implement pollution prevention through:

- Equipment or technology modifications
- Process or procedure modifications
- Substitution of raw materials
- Improvements in housekeeping, maintenance, training, and/or inventory control.

Waste Management Hierarchy

The goal of a facility's pollution prevention program is to eliminate or reduce the generation of pollutants and wastes at the source through careful consideration of materials usage, production processes, and waste management practices. The facility's pollution prevention program should identify opportunities for reducing the use of hazardous materials and the generation of wastes or releases, as well as opportunities for protecting natural resources through conservation and more efficient use of energy and water.

R0014780

The Pollution Prevention Act of 1990 includes a Waste Management Hierarchy that schematically depicts a comprehensive waste management program. The hierarchy assigns the highest priority to source reduction and places a decreasing level of preference on recycling, treatment, and disposal. To be most effective, a facility's pollution prevention program should focus on implementing source reduction. Where source reduction cannot be achieved, reuse and recycling projects should be implemented. If there is no feasible pollution prevention alternative, treatment and disposal should be used as a last resort. Figure 13-1 is a graphic representation of the waste management hierarchy. Each level of the hierarchy is described below.

Source Reduction

Source reduction refers to the use of materials, processes, or practices that reduce or eliminate the quantity and toxicity of wastes at the point of generation. Preventing wastes from being generated will decrease the need for costly treatment and disposal. Source reduction opportunities include raw material substitutions, improved operating practices, and process and equipment changes.

- **Raw material substitution**: Replacing hazardous materials with less hazardous (or less toxic) alternatives reduces releases to the environment of hazardous materials and wastes resulting from routine production processes and accidental spills. Examples of source reduction include (1) the substitution of soy-based or water-based ink to replace solvent-based ink for printing, (2) the use of recycled paper instead of virgin stock, (3) the replacement of styrofoam packing materials with re-usable hard-pack plastic materials for shipping products, (4) the elimination of trichloroethylene as a cleaning agent through replacement with a caustic cleaner such as potassium hydroxide or sodium hydroxide, and (5) the elimination of the use of freon.

- **Improved operating practices**: Improved operating practices can reduce waste generated as a result of poorly developed standard operating procedures, inadequate training, and inefficient production scheduling. In the past, facilities developed operating practices that maximized production without taking into account factors such as raw material usage, waste disposal costs, and environmental impacts. Examples of improved operating practices include, but are not limited to, waste segregation, better housekeeping, and establishment of preventive maintenance, training, and outreach programs.

- **Process and equipment modifications**: In the long run, one of the most effective source reduction techniques may involve process and equipment modifications. Changes to processes and equipment present significant opportunities for source reduction and pollution prevention. Such modifications include using newer or more efficient equipment or redesigning a process so that less raw material is required, yet product quality is maintained.

R0014781

Recycling

While source reduction prevents wastes from being generated, recycling turns by-products and wastes into reusable products. Recycling includes such practices as onsite or offsite recycling, materials exchange or reuse, and raw materials recovery.

- **Onsite/offsite recycling:** Both onsite and offsite recycling can help reduce dependence on expensive virgin materials by reusing spent materials.

- **Materials exchange or reuse:** A materials exchange system maximizes the use of a facility's excess raw materials and equipment. A system generally consists of a database for tracking the availability of excess materials by department (or whatever organizational unit is appropriate). In addition, a materials exchange system may include a communication link with the facility's supply system to alert stock clerks that excess items are on hand and should be used prior to purchasing new stock.

- **Materials recovery:** Some of the by-products and wastes generated during production can be recovered and sold as commodities. One example of materials recovery is the use of waste acids that no longer meet the requirements of a final, critical cleaning process in a secondary process that does not require the same level of cleanliness. Other examples of materials recovery as part of waste treatment are discussed below.

Waste Treatment

Unlike source reduction, waste treatment applies to wastes after generation. The goals of waste treatment technologies are to neutralize the waste, to recover energy or material resources, to render the waste nonhazardous, or to reduce the volume. Treatment technologies that enable material to be recovered include ion exchange, reverse osmosis, electrolytic metal recovery, and electrodialysis. Volume reduction through evaporation is an example of treatment. Although volume reduction decreases the amount of wastewater, the absolute quantity of hazardous or toxic waste released to the environment is not reduced. In addition, equipment for volume reduction requires a capital cost and energy costs.

Waste Disposal

Disposal should be considered only when all other options are exhausted. Disposal is considered the least favored waste management method because of the associated costs, liability, and environmental impacts. In addition, a limited number of permitted waste sites are available for disposing of hazardous material, and many of these sites are approaching capacity. Also, the transportation of wastes may pose hazards. Finally, the recordkeeping and reporting requirements associated with the disposal of hazardous wastes are an additional burden that can be avoided through preventive measures, such as source reduction.

R0014782

Pollution Prevention Benefits

Figure 13-2 summarizes the direct benefits to facilities through pollution prevention practices. A key benefit of source reduction is the improved potential for environmental compliance. In a time of increasingly stiff penalties for environmental violations, remaining in compliance is a top priority.

The implementation of source reduction measures can also reduce costs associated with waste management. The costs that may be reduced include expenditures for raw materials, waste disposal, transportation, handling and storage, training, management overhead, and emergency response. By decreasing the amount of hazardous waste shipped offsite for disposal, the facility may also reduce the costs associated with tracking and filing paper work required for hazardous waste manifests. Future costs, such as remediation activities, can also be avoided with source reduction activities.

In addition, source reduction will produce positive health and environmental benefits. Having less hazardous or toxic materials onsite will mean reduced occupational hazards, and, therefore, improved worker health and safety. Creating a safer workplace may reduce the need for expensive health and safety protection devices. Also, insurance cost may be lowered. A safer workplace will also improve employee job satisfaction. Another benefit is that reductions in the use of hazardous materials decrease the volume of toxic substances released to the environment from spills, leaks, and air emissions.

The indirect benefits of pollution prevention may be equally significant. One indirect benefit is reduced liability. The Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) "cradle to grave" provisions stipulate that a generator remains responsible for all environmental damage resulting from its waste including damage that occurs after disposal. A pollution prevention program can generate goodwill in the community and workplace, enhance the facility's public image, and foster environmental awareness among employees.

R0014783

Figure 13-1

Waste Management Hierarchy

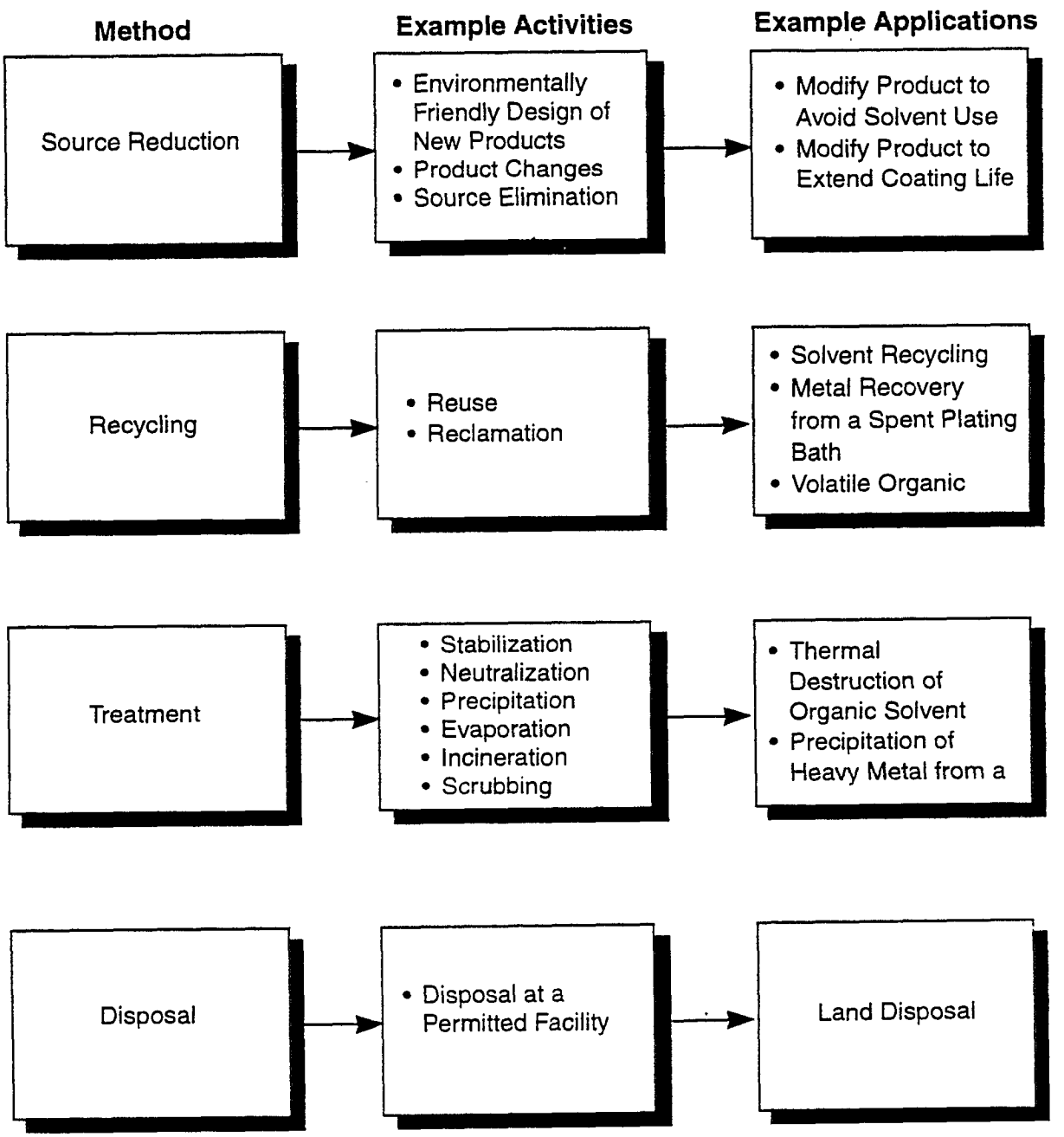

Figure 13-2

Benefits of Pollution Prevention

- Significantly reduces the amount of pollution released to the environment.
- Improves environmental and safety compliance.
- Improves worker health and safety.
- Provides the flexibility to choose cost-effective and environmentally sound solutions that will also result in improved efficiency and increased profit margins.
- Provides public recognition of a facility's efforts.
- Saves capital because of reductions in waste sent for costly treatment and disposal and because of decreased raw materials and energy usage.

R0014785

13. POLLUTION PREVENTION

B. Pollution Prevention Opportunity Assessment Procedures For Industrial Facilities

Because the primary objective of a routine National Pollutant Discharge Elimination System (NPDES) compliance inspection is an evaluation of the facility's compliance with its NPDES permit requirements, a pollution prevention assessment incorporated into a compliance assessment may, by necessity, be limited. Nevertheless, the inspector can use these routine NPDES compliance inspections to identify pollution prevention options, particularly those options that would improve compliance. Alternatively, a more comprehensive pollution prevention assessment can be conducted if the facility visit is being conducted for this purpose only. In this instance, the general procedure for a facility visit is the same as that for any inspection (e.g., preparation, entry, opening conference, facility tour), but the specific focus is on identifying pollution prevention opportunities for the facility to investigate. Two reference documents the inspector may find useful are the *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003) and the *Facility Pollution Prevention Guide* (EPA/600/R-92/088). These documents contain procedures for conducting a pollution prevention opportunity assessment. Pollution prevention opportunity assessments have four phases: (1) planning and organization, (2) assessment, (3) feasibility analysis, and (4) implementation. The four phases are summarized in Figure 13-3.

The inspector cannot perform all the steps in the type of pollution prevention assessment described in the *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003) and in the *Facility Pollution Prevention Guide* (EPA/600/R-92/088). These documents were developed as guides for waste generators who want to implement a pollution prevention program. The feasibility analysis and implementation phases require development of criteria to screen and rank the options, an indepth technical assessment on whether the options can be successfully applied at that facility, an economic evaluation, and the development of an implementation plan and schedule, which only the facility can determine. However, the inspector can evaluate whether the facility has conducted such an assessment and whether there are obvious pollution prevention opportunities.

It will be impossible, and unnecessary, for the inspector to have indepth knowledge and understanding of all production processes and facility activities. However, as part of the entire pollution prevention assessment, whether during the preparation, interview, or facility site visit, the inspector should strive to become familiar with the facility layout, equipment and processes, points of potential waste generation, types of waste generated, and how waste is handled and disposed of. If possible, the inspector should collect sufficient detailed information to develop a general flow diagram or material balance for each process step. The inspector should know the source, type, quantity, and concentration of each identified wastestream in order to identify data gaps, problem areas, and data conflicts.

R0014786

As the assessment is conducted, the inspector should keep the pollution prevention principles in mind:

- Multi-media focus looking at all environmental media as a unified whole to avoid transfers from one medium to another
- Comprehensive evaluation of the total environmental impacts over the lifecycle of the produce, from raw materials through manufacturing (including energy use) to use and ultimate disposal.

Preparation

The inspector should prepare for the assessment by examining information about the processes, operations, and waste management practices at the facility. Any background material should be reviewed in the facility's file. If the inspection is planned to focus on pollution prevention assessment, the inspector should contact the facility to inform plant officials of this objective. During this initial contact, the inspector should ask for information that will help identify potential pollution prevention options. Table 13-1 provides a list of useful information for this assessment.

As the inspector reviews facility information, he or she should develop a list of questions specific to the facility. The inspector should be seeking, through the facility-specific questions, information to answer the following general questions:

- What significant wastestreams are generated by the plant? How much waste is generated?
- Why are these considered "waste"?
- From which processes or operations do these waste streams originate?
- What is the production rate of each wastestream?
- Which wastes are hazardous and which are not? What makes them hazardous?
- How are the wastes managed at present?
- What are the input materials used that generate the wastestreams of a particular process or plant area?
- How efficient is the process? How much input material is:
  - Used in a process?
  - Released to water or air, or disposed of on land?
  - Destroyed or unaccounted for?
- What types of process controls are used to improve process efficiency?
- Are unnecessary wastes generated by mixing otherwise recyclable or recoverable hazardous wastes with other process wastes?

R0014787

- What types of housekeeping practices are used to limit the quantity of wastes generated?

- Has the plant developed a Pollution Prevention Plan or strategy?

There are numerous documents that identify pollution prevention techniques for specific types of industries, such as the metal finishing industry, the fabricated metal products industry, and the pharmaceutical industry. These documents and other pollution prevention information can be obtained from:

- Pollution Prevention Information Clearinghouse (PPIC)
  - Guidance and information on Pollution Prevention Opportunities, (202) 260-1023
- Pollution Information Exchange System (PIES)
  - Electronic Bulletin Board on Pollution Prevention Information, (703) 506-1025
- Center for Environmental Research Information (CERI)
  - Guidance and Information on Environmental Protection Programs, Publications Unit, U.S. EPA, 26 West Martin Luther King Drive, Cincinnati, OH 45268, (513) 569-7562, (513) 569-7566 (fax)

Interview

Just as with a routine NPDES compliance inspection, plant personnel should be interviewed when the inspector first arrives at the facility. The inspector should target personnel from the following areas:

- Management
- Environmental waste management
- Process engineering
- Facility maintenance
- Operation and production
- Safety and health
- Research and development
- Quality control
- Purchasing/inventory
- Shipping/receiving
- Storage.

From the interviews, the inspector should develop (or verify) a list of all waste minimization practices already in place. The inspector should also ask plant personnel for the plant's Pollution Prevention Plan or strategy and any suggested pollution prevention opportunities in the operations and processes and discuss with the plant personnel any pollution prevention opportunities that were identified during preparations for the site visit or during the onsite interviews.

R0014788

Again, as with a routine compliance inspection, the inspector should conduct a tour of the facility with plant personnel after the interview. The same areas of the manufacturing facility, materials and waste storage, loading and unloading, and treatment system should be reviewed. At each process area, the plant personnel most knowledgeable about the activity should describe the process or should answer any questions the inspector may have.

The inspector should make personal observations, seek confirmation of the interpretation of an activity that is occurring, and investigate any information plant personnel provide that appears to contradict what is being observed. The inspector should focus on:

- Loading and unloading operations
- In-plant transfers (raw materials handling)
- Process operations
- Housekeeping practices
- Maintenance activities
- Waste management operations.

The inspector should also check for signs of spills or leaks and assess overall cleanliness of the site. Throughout all the areas visited, the following wastestreams should be evaluated:

- Wastewater
- Air emissions, including stack and fugitive emissions (e.g., detectable odors and fumes)
- Hazardous wastes
- Nonhazardous solid wastes.

Each wastestream should be reviewed to:

- Determine whether the wastes are hazardous or nonhazardous
- Determine other physical and chemical characteristics of wastes and emissions
- Determine actual points of generation
- Determine quantities including variations
- Identify all handling, treatment, and storage procedures onsite.

By using the activities described above during a facility tour, the inspector should look for pollution prevention opportunities in the following general areas:

- Substituting less hazardous materials such as:
  - Using latex or water-based paints, rather than oil-based
  - Eliminating organic solvent cleaners and replacing with aqueous cleaners
- Limiting the amount of hazardous materials disposed of by:
  - Buying only the amount of material the facility needs
  - Using all materials before their expiration date
  - Using only the amount of material needed
  - Sharing materials or donating extra materials to community organizations.

R0014789

- Using and storing products carefully to prevent:

  - Accidents and spills
  - Mixtures of incompatible materials that can react, ignite, or explode.

- Recycling wastes, such as:

  - Used oil
  - Plastics, glass, paper, and metals
  - Spent solvents.

- Generating less pollution by:

  - Automating and improving process controls to optimize production operations
  - Allowing products to fully drain process chemicals before rinsing
  - Using less toxic materials (e.g., printing inks, dyes)
  - Adjusting production schedules to minimize cleanup operations
  - Sealing floor drains (permanently or temporarily) to prevent spills
  - Segregating wastes to support recycling (e.g., scrap metals, solvents).

- Turning waste products into new materials by:

  - Treating and recycling rinse waters
  - Recovering metals such as silver from waste materials
  - Recycling waste lubricants and coolants.

- Using fewer resources by:

  - Installing flow restrictors on rinse waters
  - Installing high efficiency boilers and furnaces
  - Using heat exchangers to heat process water supplies.

- Educating employees on the:

  - Goals of pollution prevention and waste management
  - Procedures to follow for waste disposal and pollution prevention
  - Accomplishments for the pollution prevention program being implemented.

Before leaving the facility, the inspector should meet with plant personnel. A list of pollution prevention options identified during the site visit should be prepared and discussed with plant personnel. Inspectors can discuss a pollution prevention technology or refer the facility representatives to EPA or State pollution prevention technical assistance offices. However, the inspector should not recommend specific measures to implement. Nor should the inspector suggest particular products or imply that a certain pollution prevention measure will enable the facility to achieve compliance.

Figure 13-3

Pollution Prevention Opportunity Assessment

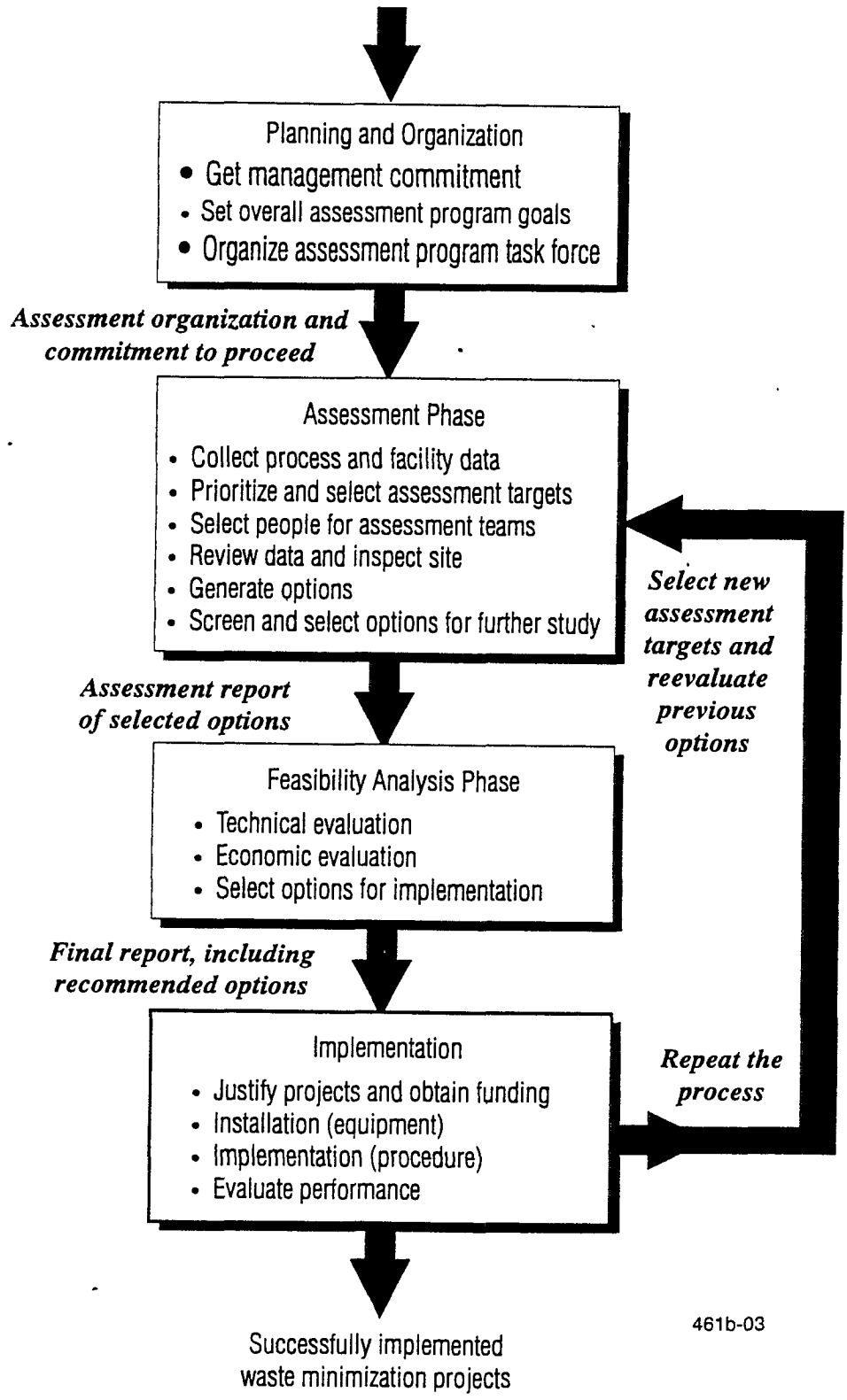

Table 13-1

Useful Facility Information to Conduct a Pollution Prevention Opportunity Assessment

Raw Materials Information

- Product composition
- Material Safety Data Sheets
- Product and raw material inventory and purchasing records
- Operator data logs
- Production schedules and records

Manufacturing Process Information

- Process flow diagrams
- Material and heat balances for production
- Manufacturing and pollution control processes
- Operating manuals and process descriptions
- Water usage rates
- Equipment and equipment specifications
- Piping and instrument diagrams
- Sewer layout diagrams
- Facility layout and elevation plans
- Equipment layouts and work flow diagrams

Waste Generation and Disposal Information

- Environmental permits—air emissions, solid waste, hazardous waste, NPDES, pretreatment
- RCRA information—manifests, annual reports
- Location of all wastewater, solid and hazardous waste collection, treatment, and storage points
- Diagram of air, wastewater, and/or hazardous waste treatment units
- Operating manuals for treatment units
- Emissions inventories [air, NPDES Discharge Monitoring Reports (DMRs), etc.]
- SARA Title III—Section 313 release reports
- Previous regulatory violations

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13. POLLUTION PREVENTION

C. Pollution Prevention Opportunity Assessment Procedures For Municipal Wastewater Treatment Plants

The Municipal Water Pollution Prevention (MWPP) program promotes the application of pollution prevention concepts of the Pollution Prevention Act to publicly owned treatment works. Pollution prevention can reduce the need for substantial capital investment in new infrastructure, enhance worker safety, improve the usability of sludge, and reduce operation and maintenance costs. Practices that stress a preventive approach to water pollution abatement include the following:

- A mechanism for routine assessments of the compliance status of Publicly Owned Treatment Works (POTWs). This mechanism should include an early warning system based on periodic self-audits and quantitative techniques for assessing the condition of municipal wastewater treatment systems.
- A reporting process on the capability of POTWs to sustain compliance.
- A process for identifying, implementing, and tracking corrective actions to prevent pollution and maintain compliance.
- A program that will encourage POTWs to develop pollution prevention projects.

Pollution prevention practices POTWs can adopt could focus in the areas of:

- Improved operation and maintenance
- Projects that reduce wastewater flows and pollutant loadings
- Energy and water conservation
- Timely planning and financing for future needs and economic growth prior to occurrence of wastewater permit violations
- Toxicity reductions at the source (industrial pretreatment, commercial and residential source reduction programs)
- Recycling
- Proper treatment of wastes
- Beneficial uses of sludge.

R0014794

Specific opportunities for optimizing each unit operation to maximize removal efficiency may include unit modifications to improve performance. For example:

- Clarifiers — Baffle installations and weir modifications to improve hydraulics and limit short circuiting
- Aeration basins — Baffles to limit short circuiting. Fine bubble diffusers to improve aeration. Use of automatic controls to optimize aeration and limit over-aeration.
- Aerobic digester — Recover energy from gas. Insulate digester.

At any time, but especially during upgrading and expansion, the following pollution prevention projects could be considered:

- Install high efficiency pumps, motors and drives.
- Use biological- rather than chemical-based treatment.
- Install equalization basins to improve efficient operation of downstream units and minimize the need for oversize units.
- Design plant layout to minimize the need for intermediate pumping.
- Consider ultraviolet or ozone disinfection instead of chlorine.
- Digest residuals rather than heat or chemical treat.
- Select dewatering equipment not only to maximize solids but to minimize the need for chemical feeds that increase the volume of residuals.
- Evaluate toxicity of all lubes, solvents, or cleaners, and replace them with less toxic alternatives such as citrus-based cleaners wherever possible.
- Reduce infiltration/inflow, which will result in several benefits:
  - — Reduces plant expansion needs
  - — Improves performance efficiency
  - — Reduces grit (which increases equipment wear and breakage and is a disposal problem).

The Industrial Pretreatment Program is one of the best opportunities to achieve pollution prevention. It represents source control. Pollution prevention programs or projects aimed at residential and commercial users can also reduce loadings. Such pollution prevention programs could:

- Encourage water conservation.
- Provide information on compatible or biodegradable cleaners to replace more toxic cleaners (for example, identify an alternative to chlorine-based "hang-in" type toilet bowl cleaners).

R0014795

- Encourage composting instead of garbage grinders.
- Enforce a commercial oil and grease ordinance requiring installation, operation, and maintenance of grease traps and recovery and recycle of oil and grease.
- Discourage oil and grease dumping.
- Prohibit disposable diaper flushing.

The POTW could also work with water utilities or agencies involved in establishing plumbing codes to reduce the metals (zinc, copper, and lead) found in drinking water supplies. These metals may be present because the water is corrosive to the pipes and leaches the metals from copper tubing, zinc-coated iron and steel pipes, and lead solder. The water utility may also be using water conditioning chemicals that contain metal salts.

The protocols for conducting a pollution prevention assessment at municipal wastewater treatment plants are similar to those for an industrial facility. The protocols of a Compliance Evaluation Inspection (CEI) are also appropriate, except that the focus during the interview, file review, and site visit is on identifying pollution prevention opportunities.

*** NOTES ***

13. POLLUTION PREVENTION

D. References

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*** NOTES ***

13. POLLUTION PREVENTION

D. References

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*** NOTES ***

R0014801

14. MULTI-MEDIA CONCERNS

A. Introduction

This chapter is intended as a guide for National Pollutant Discharge Elimination System (NPDES) inspectors who become involved in multi-media environmental compliance inspections. Multi-media compliance investigations are intended to determine a facility's status of compliance with applicable laws, regulations, and permits in more than one medium.

This chapter and the Media and Specific Inspection Components contained in Appendix S include a significant amount of material drawn directly from the National Enforcement Investigations Center's (NEIC's) "Multimedia Investigation Manual" revised March 1992. NPDES inspectors participating in multi-media inspections are referred to that document for further guidance.

*** NOTES ***

14. MULTI-MEDIA CONCERNS

B. Overview of the Multi-Media Approach to Inspections

All inspections can be grouped into four categories of increasing complexity, moving from Category A (program-specific compliance inspections) to Category D, (complex multi-media investigations), depending upon the complexity of the facility and the objectives of the investigation. The four categories of investigations are described below:

Category A: Program-specific compliance inspections (e.g., compliance with NPDES permit requirements), conducted by one or more inspectors. The objective is to determine facility compliance status for program-specific regulations.

Category B: Program-specific compliance inspections, which are conducted by one or more inspectors. The inspector(s) screen for and report on obvious key indicators of possible noncompliance in other environmental program areas.

Category C: Several concurrent and coordinated program-specific compliance investigations conducted by a team of investigators representing two or more program offices. The team, which is headed by team leader, conducts a detailed compliance evaluation for each of the target programs. The objective is to determine compliance for several targeted program-specific areas. Reports on obvious, key indicators of possible noncompliance in other environmental program areas are also made.

Category D: These comprehensive facility evaluations not only address compliance in targeted program-specific regulations, but also try to identify environmental problems that might otherwise be overlooked. The initial focus is normally on facility processes to identify activities (e.g., new chemical manufacturing) and by-products/wastestreams potentially subject to regulation. When regulated activities or wastestreams are identified, a compliance evaluation is made with respect to applicable requirements.

The investigation team, headed by a team leader, comprises staff thoroughly trained in different program areas. The on-site investigation is conducted during one or more site visits and involve intense concurrent program-specific compliance evaluations, often by the same cross-trained personnel.

Category D multi-media investigations are thorough and, consequently, resource intensive. They are appropriate for intermediate to large, complex facilities that are subject to a variety of environmental laws. Compliance determinations are made for several targeted program-specific areas, and reports on possible non-compliance are prepared.

Generally, all investigations will use essentially the same protocols, including pre-inspection planning, use of a project plan, sampling, inspection procedures, and a final report. The major difference will be in the number of different regulations addressed during Categories C and D investigations.

The multi-media approach to investigations has several advantages over program-specific inspections, including:

- A more comprehensive and reliable assessment of a facility's compliance with fewer missed violations.
- Improved enforcement support and better potential for enforcement.
- A higher probability to uncover/prevent problems before they occur or before they manifest an environmental or public health risk.
- Ability to respond more effectively to non-program-specific complaints, issues, or needs and to develop a better understanding of cross-media problems and issues, such as waste minimization
- Less resource intensive.

The success of a multi-media investigation program is contingent upon a good managerial system and the support of upper management. Since these investigations will often be conducted at larger facilities, adequate resources (time and personnel) must be provided. Good communications during the planning phase are essential to define the scope of the inspection, as well as each team member's role. Communications could also include State officials since State inspectors might also participate as team members. Because of the extent of the State's knowledge of the facility and its problems, State involvement is often critical to the success of the investigation. Similarly, coordination with other Federal or local agencies needs to be addressed, as necessary.

R0014805

14. MULTI-MEDIA CONCERNS

C. Multi-Media Concerns at NPDES Facilities and the Multi-Media Screening Program

RCRA

Many NPDES-regulated facilities are also subject to requirements of the Resource Conservation and Recovery Act (RCRA). RCRA regulates the generation, transportation, treatment, storage, and disposal of hazardous wastes. However, RCRA defers the control of hazardous wastes to the Clean Water Act (CWA) when those wastes are either directly discharged to surface waters (the direct discharge exclusion) or indirectly discharged to a wastewater treatment plant (the domestic sewage exclusion).

The costs of hazardous waste management using "traditional" storage, treatment, and disposal methods are rising significantly as facilities comply with the 1984 RCRA Amendments. Consequently, industrial facilities may use the two previously mentioned exclusions as preferred disposal methods. Since many of the 126 priority pollutants listed in the CWA would be considered hazardous waste constituents under RCRA, the discharge of these pollutants should concern the inspectors and operators of wastewater treatment plants. Hazardous wastes discharged to wastewater treatment plants pass through to surface waters unless incidentally removed in sludge, degraded, or "lost" through volatilization or exfiltration during the wastewater treatment process.

NPDES permit writers and inspectors may learn whether the facility conducts RCRA regulated activities, and the nature of those activities, from State and/or Environmental Protection Agency (EPA) RCRA authorities or databases such as Facility Index System (FINDS). Industrial facilities can use and/or generate hazardous waste. The hazardous wastes may be in the liquid, gas, or solid form. These wastes may be generated from raw materials, off-specification products, or residuals or emissions from the process operations. In addition, waste oils used by process equipment, solvents used in cleaning operations, or sludges from treatment of process wastewaters can be hazardous wastes.

Publicly Owned Treatment Works (POTWs) receiving hazardous wastes by truck, rail, or dedicated pipeline are subject to RCRA permit by rule requirements. Included among these requirements is the provision that corrective action must be taken to remedy any contamination that may have resulted from a release of hazardous waste or hazardous constituents from solid waste management units, such as surface impoundments, to the environment. For example, if a POTW that is subject to these RCRA requirements contaminates ground water through leaching or exfiltration, the permittee might be required to investigate the nature and extent of those releases and, where appropriate, implement

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corrective measures. Guidance on the nature of these requirements, and how they might affect POTWs, is now being developed.

RCRA/CERCLA

Another source of contaminated wastewaters is hazardous waste cleanup actions. Under RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), EPA, States, and private parties are initiating cleanups of contaminated sites. Much of the waste found at these sites is in liquid form, either as leachate or contaminated ground water. The treatment, and consequent discharge, of contaminated wastewaters from these sources is expected to increase in the future. These wastes will likely be complex mixtures, requiring careful examination of their composition to determine appropriate treatment techniques.

Nonhazardous Sludge

It has long been known that wastewater treatment results in the transfer of residuals from wastewater effluents to sludges. Several statutes and regulations, including the CWA, are charged with management of these nonhazardous sludges. Future NPDES permits will include disposal limitations for municipal sewage sludge as specified in 40 *CFR* Part 503. Many States already impose such requirements. NPDES inspectors will need to become more familiar with the relationship between State sewage sludge requirements and Federal sewage sludge management and disposal requirements under the CWA and those imposed by other statutes and regulations, particularly RCRA and the Clean Air Act (CAA). Municipal sewage sludge that is co-incinerated with other wastes is regulated by the CAA. Municipal sewage sludge that is co-disposed with other waste in a municipal solid waste landfill is regulated by 40 *CFR* Part 258. Industrial sludges are regulated by 40 *CFR* Part 257 if land applied and by 40 *CFR* Part 258 if disposed of in a nonhazardous landfill.

Air

Air emissions from wastewater treatment units are under increasing scrutiny. For organic chemical facilities, EPA is now considering developing wastewater treatment controls which explicitly recognize that treatment processes, such as air stripping, result in the transfer of volatile organics from wastewater effluents to the air. EPA is also considering air emissions from domestic wastewater treatment plants from two perspectives: ambient air quality concerns and a concern for worker health and safety. In another development, the 1984 RCRA amendments provide for the control of air emissions from authorized RCRA Treatment, Storage, and Disposal Facilities (TSDFs). As a result, wastewater treatment facilities at RCRA TSDFs are now being investigated by RCRA program personnel. Remedial actions may be required at some of these facilities and the regulatory issue of emissions from wastewater treatment facilities will be addressed.

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Multi-Media Screening

Regions and States are encouraged to incorporate multi-media screening into as many single medium inspections as possible (i.e., conduct Category B inspections in lieu of Category A inspections). Obtaining multi-media screening information earlier in the process will help target inspection resources and ensure that all non-compliance issues are included in any facility-specific enforcement strategy. The compliance inspector will use a multi-media screening checklist as a guide for making and recording observations and pertinent information.

The Environmental Services Division Field Branch Chiefs and NEIC have led the development and implementation of EPA's multi-media inspection program, including screening inspections. The National Multi-Media Screening Inspection Checklist, dated May 12, 1993, was developed as a general guideline by a Regional work group led by Region 3. A copy of this checklist is included in Appendix T.

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*** NOTES ***

14. MULTI-MEDIA CONCERNS

D. NPDES Inspectors and Multi-Media Inspections

Description of a Multi-Media Inspection

The strategy developed for multi-media inspections usually involves prioritizing the processes and waste management activities, followed by sysfematically moving from the beginning to the end of a process with emphasis on regulated waste stream generation and final disposition. The strategy should be somewhat flexible so that "mid-course corrections" can be made.

The compliance evaluations also need to be "sequenced" to progress, generally, from the most to least time consuming regulatory program. Personnel training and availability and other logistical factors may result in a combining of compliance evaluations. RCRA is often chosen as the initial focus because of the close relationship between process evaluations and generator requirements. Thus, the inspection of hazardous waste storage areas and Polychlorinated Biphenyl (PCB) transformers is often conducted early in the inspection, followed by the rest of the RCRA inspection. Compliance with regulatory programs that principally involve records reviews, such as TSCA, Emergency Planning and Community Right to Know Act (EPCRA), and CAA, are usually scheduled later in the inspection, as time permits.

The strategy for process and compliance evaluations should be developed by the inspection team coordinator and discussed with inspection team members. This will serve as the basis for explaining inspection activities and scheduling to the company during the opening conference.

The strategy should include checklists that address potential process wastestreams to be examined and media-specific compliance issues. Checklists can be a vital component of a compliance investigation to help ensure that an investigator does not overlook anything important. Checklists serve as a reminder of what needs to be asked or examined and to help an inspector remember the basic regulatory requirements.

In larger facilities, multiple site visits coordinated by the team leader may be necessary and desirable for completing the inspection. This approach can lead to a better inspection because of the opportunity to review information obtained in the office, then refine the inspection/strategy to "fill in the gaps" during a subsequent site visit.

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The NPDES Inspector's Role in a Multi-Media Inspection

Each multi-media investigation team member should bring special program expertise and experience and must be well trained in most facets of conducting a field investigation, including sampling. Most of the investigators on the team, including the team leader, should be current field investigators who already possess most of the necessary skills and qualifications. EPA Order 3500.1 sets forth specific training requirements for any EPA investigator who is leading a single medium investigation. These training requirements include both general inspection procedures and media-specific procedures. While an individual leading a multi-media investigation may not have had the media-specific training for each medium covered during that multi-media investigation, the team leader should have the media-specific training for at least two of the media.

The team leader has overall responsibility for the successful completion of the multi-media investigation. In addition, other investigators may be designated as leads for each of the specific media/programs that will be addressed. These individuals may work alone or have one or more inspectors/samplers as assistants, depending on workload and training objectives. However, all investigation team members should report directly to, and be accountable to, the team leader.

The following are some of the more important skills and qualifications that are necessary for team members:

- Knowledge of the Agency's policies and procedures regarding inspection authority, entry procedures/problems, enforcement actions, legal issues, and safety
- Thorough understanding of sampling equipment; quality assurance (QA) requirements for sample collection, identification, and preservation; and chain-of-custody procedures
- Knowledge of manufacturing/waste producing processes, pollution control technology, principles of waste management, flow measurement theory and procedures, and waste monitoring techniques/equipment
- Investigatory skills including the ability to gather evidence through good interviewing techniques and astute observations
- Ability to convey information gathered during the inspection into clear, understandable investigation reports.
- Up-to-date experience in conducting compliance inspections
- Good communication skills
- Basic understanding of the procedures of obtaining administrative warrants, including preparation of affidavits, technical content of the warrant application, and warrant and procedures for serving a warrant

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- At least one team member should have considerable knowledge of laboratory (analytical) methods and Quality Assurance (QA) requirements, if a laboratory evaluation is to be conducted

- For each of the areas addressed in the multi-media investigation, at least one team member should be trained.

Investigators should conduct themselves in a professional manner and maintain credibility. A cooperative spirit should be cultivated with facility representatives, when possible. All investigators should maintain a sensitivity to multi-media issues and implications and freely discuss, with other members of the team, observations/findings relating to one or more programs.

Investigators should restrict their onsite activities to the normal working hours of the facility, as much as possible. Investigators will need to keep abreast of specific program regulations and should also coordinate, as necessary, with other EPA and State inspectors and laboratory staff (if samples will be collected). The investigation team should implement appropriate field note taking methods and proper document control procedures, particularly when the company asserts a "confidential" claim. Investigators must ensure that important documents (e.g., project plan, safety plan, and logbooks) are not left unattended at the facility. Sensitive discussions do not take place in front of facility personnel or on company telephones.

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*** NOTES ***

E. References

NEIC. March 1992. *Multimedia Investigation Manual.*

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*** NOTES ***

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APPENDIX A

EPA ORDER 1440.2 HEALTH AND SAFETY REQUIREMENTS FOR EMPLOYEES ENGAGED IN FIELD ACTIVITIES

ENVIRONMENTAL PROTECTION AGENCY

ORDER

1440.2

July 12, 1981

PROTECTIVE SERVICES - SAFETY

HEALTH AND SAFETY REQUIREMENTS FOR EMPLOYEES ENGAGED IN FIELD ACTIVITIES

1. PURPOSE. This Order establishes policy, responsibilities, and mandatory requirements for occupational health and safety training and certification, and occupational medical monitoring of Agency employees engaged in field activities.

2. DEFINITIONS.

a. The term "field activities" as used in this Order means EPA program activities that are conducted by EPA employees outside of EPA administered facilities. These activities include environmental and pesticides sampling, inspection of water and wastewater treatment plants, and hazardous material spills and waste site investigations, inspections, and sampling.

b. The term "health and safety training" means scheduled, formal or informal training courses, approved and sponsored by EPA and conducted by EPA or its contracted agents which is designed to develop, improve and upgrade the health and safety knowledge of EPA employees involved in field activities.

c. The term "occupational medical monitoring" means surveillance over the health status of employees by means of periodic medical examinations or screening in accordance with the Agency's Occupational Medical Monitoring guidelines.

d. The term "certification" as used in this Order means that the employee has successfully completed the minimum classroom and field training requirements for the specified level of training and the Agency has issued a certificate attesting that the employee met these requirements.

3. REFERENCES.

a. 29 CFR 1910, Parts 16, 94, 96, 106, 109, 111, 134, 151, 1000, Occupational Health and Safety Standards.

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b. Executive Order 12196, Section 1-201, Sec. (k), Occupational Health and Safety Programs for Federal Employees.

c. 29 CFR 1960.59(a), Occupational Safety and Health for the Federal Employee.

d. EPA Occupational Health and Safety Manual, Chapter 7(1).

e. EPA Training and Development Manual, Chapter 3, Par 7(b).

f. Occupational Health and Safety Act of 1971, P.L. 91-596, Sec.6.

g. EPA Order on Respiratory Protection (Proposed).

h. 49 CFR, Parts 100-177, Transportation of Hazardous Materials.

i. EPA Order 1000.18, Transportation of Hazardous Materials.

j. EPA Order 3100.1, Change 1, Uniforms, Protective Clothing, and Protective Equipment.

4. BACKGROUND. Field activities are a critical part of most EPA programs. These activities range from routine environmental reconnaissance sampling, inspections, and monitoring, to entering and working in environments with known and unknown hazards. Since protection can not be engineered into the field working situation, the protection of personnel engaged in field activities involves training employees in safe operational procedures and the proper use of appropriate personal protective clothing and equipment.

5. APPLICABILITY. This Order applies to all EPA organizational units which have employees engaged in field activities.

6. POLICY. It is the policy of the Environmental Protection Agency to carry out its field activities in a manner that assures the protection of its employees.

7. RESPONSIBILITIES.

a. Assistant Administrators, Regional Administrators, Deputy Assistant Administrators, Laboratory Directors, and Division Directors. These officials are responsible within their jurisdictions for implementing the provisions of this Order and for budgeting the necessary funds for employee training and certification, personal protective clothing and equipment, and occupational medical monitoring programs.

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b. Supervisors. Supervisors are responsible for complying with the requirements of this Order for employee training and certification, and occupational medical monitoring programs. They will identify those employees who require training and certification, and occupational medical monitoring, and assure they receive it to comply with the provisions of this Order and will insure these requirements are properly contained in position descriptions and job postings.

c. Employees. Employees are responsible for making known upon request from their supervisors the extent of their individual occupational. health and safety training and the history of their occupational medical monitoring participation. Employees should notify their supervisor of any hazardous work situation and make suggestions for corrective measures. Employees are responsible for applying the knowledge, skills, and techniques acquired through training in a manner that will help assure their health and safety and that of fellow workers.

d. Occupational Health and Safety Designees. The Occupational Health and Safety Designees are responsible for identifying program areas that require training and certification, and occupational medical monitoring; recommending or providing training and certification resources to meet the requirements of this Order; and maintaining records of persons receiving training and certification.

e. Office of Occupational Health and Safety. The Director, Office of Occupational Health and Safety is responsible for establishing policy and requirements for adequate training and certification programs for field activities, developing and maintaining an occupational medical monitoring program, approving health and safety training and certification programs for employees involved in field activities, and for evaluating the results of these training and certification programs.

8. OBJECTIVES.

a. Training and Certification. The objective of the health and safety training and certification programs for employees involved in field activities are:

(1) To assure that EPA employees are aware of the potential hazards they may encounter during the performance of field activities;

(2) To provide the knowledge and skills necessary to perform the work with the least possible risk to personal health and safety;

(3) To assure that Agency program goals are accomplished in as safe and healthful manner as feasible; and

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(4) To assure that EPA employees can safely disengage themselves from an actual hazardous situation which may occur during a field activity.

b. Occupational Medical Monitoring. The objectives of the occupational Medical Monitoring program are:

(1) To detect any adverse effects of occupational exposure on the employees health and to initiate prompt corrective actions when indicated; and

(2) To assure that employees assigned arduous or physically taxing jobs or jobs requiring unique skills are able to perform those jobs without impairing their health and safety or the health and safety of others.

9. TRAINING AND CERTIFICATION REQUIREMENTS. Employees shall not be permitted to engage in routine field activities until they have been trained and certified to a level commensurate with the degree of anticipated hazards.

a. Basic Level. All employees shall be provided a minimum of 24 hours of health and safety training prior to their becoming involved in normal, routine field activities. The training shall include but not be limited to classroom instruction in all the following subject areas:

(1) Employee Rights and Responsibilities;
(2) Nature of Anticipated Hazards;
(3) Emergency Help and Self-Rescue;
(4) Vehicles - Mandatory Rules and Regulations;
(5) Safe Use of Field Equipment;
(6) Use, Handling, Storage, and Transportation of Hazardous Materials;
(7) Personal Protective Equipment and Clothing, Use and Care; and
(8) Safe Sampling Techniques.

In addition to classroom instruction, the employee shall accompany an employee experienced in field activities and perform actual field tasks for a minimum of three days within a period of three months after classroom instruction. Employees satisfactorily completing these requirements will receive certification at the Basic Level of training from the Occupational Health and Safety Designee at the Reporting Unit.

b. Intermediate Level. All inexperienced employees who are to work with experienced employees in uncontrolled hazardous waste and hazardous spills sites investigators or employees engaged in other activities which at a later data are determined by the Director, Office of Occupational Health and Safety, to present unique hazards requiring additional training, shall be provided a minimum of 8 hours of additional health and safety training. This

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training shall include (in addition to the Basic Level requirements) but not be limited to the following subject matter:

(1) Site surveillance, observation, and safety plan development;
(2) Use and decontamination of totally enclosed protective clothing and equipment;
(3) Use of field test equipment for radioactivity, explosivity, and other measurements; and
(4) Topics specific to other identified activities.

In addition to classroom instruction, the employee shall accompany another employee experienced in hazardous waste and spill site investigations and/or cleanup operations and perform actual field tasks for a minimum of three days within a three month after classroom instruction. The employee should also be able to provide on-the-job training and instructions to inexperienced employees during normal routine field activities (as required above). Employees satisfactorily completing these requirements will be certified at the Intermediate Level by the Occupational Health and Safety Designee at the Reporting Unit.

c. Advanced Level. All employees who manage uncontrolled hazardous waste site and spill site monitoring, sampling, investigations, and cleanup operations shall be provided a minimum of 8 hours additional health and safety training. The classroom training shall include but not be limited to (in addition to the Basic and Intermediate Level requirements), instruction in the following subject areas:

(1) Management of restricted and safe zones;
(2) Rules of Handling the Press and VIP's; and
(3) Safe Use of Specialized Sampling Equipment.

In addition to classroom instruction, the employee shall accompany another employee with experience in managing hazardous waste and spill site investigations or cleanup operations and perform actual field tasks for a minimum of three days within a period of three month period after classroom instruction. After satisfactorily completing these requirements, employees will receive Advanced Level certification from the Occupational Health and Safety Designee at the Reporting Unit.

d. General.

(1) An employee may receive certification at the next higher level by completing only the additional training requirements if certified at the next lower level within the previous one-year period.

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(2) The Director, Office of Occupational Health and Safety, may certify employees based on an evaluation of previous training, education, and experience. Recommendations for this type certification should be made to the Director by the Occupational Health and Safety Designee at the Reporting Unit.

10. FREQUENCY OF TRAINING. Employees at the Basic, Intermediate, and Advanced Levels shall complete a minimum of 8 hours of refresher classroom instruction annually consisting of a review of all subject areas to maintain their certification. In addition to the classroom instruction, employees shall have demonstrated by having performed actual field tasks that they have sufficient practical experience to perform their assigned duties in a safe and healthful manner.

11. RECORD OF TRAINING.

a. A record of the level of training and certification shall be maintained in the employee's official personnel file.

b. The Occupational Health and Safety Designee shall maintain a roster of employee training and certification so that a schedule of annual training can be established.

c. The Occupational Health and Safety Designee shall issue a certificate to the employee showing the level of training and certification.

12. OCCUPATIONAL MEDICAL MONITORING REQUIREMENTS. All employees routinely engaged in field activities which present the probability of exposure to hazardous or toxic substances, which are arduous or physically taxing, or which require the use of respiratory protective equipment shall be included in the Agency's Occupational Medical Monitoring Program. Employees should not be permitted to engage in field activities unless they have undergone a baseline medical examination (as defined in the Agency's Occupational Medical Monitoring Guidelines), which will show physical fitness and provide a base to measure any adverse effects their activities may have on these individuals.

13. SAVING PROVISIONS. Changes in the Act, Executive Order, or EPA and OSHA standards and guidelines which occur after the effective date of this Order will automatically come under the purview of this Order on the effective date of the change.

Full implementation of this Order shall be within one year of its effective date

ORDER	1440.2 July 12, 1981

Edward J. Hanley
Director, Office of Management
Information and Support Services

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APPENDIX B

SAMPLE SECTION 308 LETTER

Certified Mail—Return Receipt Requested

Date

Dear Sir:

Pursuant to the authority contained in Section 308 of the Clean Water Act (33 U.S.C. 1251 et seq.), representatives of the U.S. Environmental Protection Agency (EPA), or a contractor retained by EPA, shall conduct, within the next year, a compliance monitoring inspection of your operations, including associated waste treatment and/or discharge facilities located at (site of inspection). This inspection will ascertain the degree of compliance with the requirements of the National Pollutant Discharge Elimination System (NPDES) permit issued to your organization.

Our representatives may observe your process operations, inspect your monitoring and laboratory equipment and methods, collect samples, and examine appropriate records, and they will be concerned with related matters.

In order to facilitate easy access to the plant site, please provide the name of the responsible facility official who can be contacted upon arrival at the plant. Additionally, we would appreciate receiving a list of the safety equipment you would recommend that our representatives have in their possession in order to enter and conduct the inspection safely. Please provide the information requested within 14 days of receipt of this letter.

If you have any questions concerning this inspection, please call (appropriate designated official).

Sincerely,

Director
Water Management Division

Sample Section 308 Letter

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APPENDIX C

EPA'S MEMORANDUM ON ENTRY PROCEDURES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MEMORANDUM

OFFICE OF ENFORCEMENT

TO: Regional Administrators
Surveillance and Analysis Division Directors
Enforcement Division Directors

FROM: Assistant Administrator for Enforcement

SUBJECT: Conduct of Inspections After the Barlow's Decision

I. Summary

This document is intended to provide guidance to the Regions in the conduct of inspections in light of the recent Supreme Court decision in Marshall v. Barlow's, Inc., ___U.S.__, 98 S. Ct. 1816 (1978). The decision bears upon the need to obtain warrants or other process for inspections pursuant to EPA-administered Acts.

In Barlow's, the Supreme Court held that an OSHA inspector was not entitled to enter the non-public portions of a work site without either (1) the owner's consent, or (2) a warrant. The decision protects the owner against any penalty or other punishment for insisting upon a warrant.

In summary, Barlow's should only have a limited effect on EPA enforcement inspections:

- Inspections will generally continue as usual;
- Where an inspector is refused entry, EPA will seek a warrant through the U.S. Attorney;
- Sanctions will not be imposed upon owners of establishments who insist on a warrant before allowing inspections of the non-public portions of an establishment.

The scope of the Barlow's decision is broad. It affects all current inspection programs of EPA, including inspections conducted by State personnel and by contractors. The Agency's procedures for inspections, particularly where entry is denied, were largely in accord with the provisions of Barlow's before the Supreme Court issued its ruling. Nevertheless, a number of changes in Agency procedure are warranted. Thus, it is important that all personnel involved in the inspection process be familiar with the procedural guidelines contained in this document.

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This document focuses on the preparation for and conduct of inspections, including (1) how to proceed when entry is denied, (2) under what circumstances a warrant is necessary, and (3) what showing is necessary to obtain a warrant.

II. Conduct of Inspections

The following material examines the procedural aspects of conducting inspections under EPA-administered Acts. Inspections are considered in three stages: (1) preparation for inspection of premises, (2) entry onto premises, and (3) procedures to be followed where entry is refused.

A. Preparation

Adequate preparation should include consideration of the following factors concerning the general nature of warrants and the role of personnel conducting inspections.

(1) Seeking a Warrant Before Inspection

The Barlow's decision recognized that, on occasion, the Agency may wish to obtain a warrant to conduct an inspection even before there has been any refusal to allow entry. Such a warrant may be necessary when surprise is particularly crucial to the inspection, or when a company's prior bad conduct and prior refusals make it likely that warrantless entry will be refused. Pre-inspection warrants may also be obtained where the distance to a U.S. Attorney or a magistrate is considerable so that excessive travel time would not be wasted if entry were denied. At present, the seeking of such a warrant prior to an initial inspection should be an exceptional circumstance, and should be cleared through Headquarters. If refusals to allow entry without a warrant increase, such warrants may be sought more frequently. (For specific instructions on how to obtain a warrant, see Part D.)

(2) Administrative Inspections v. Criminal Investigations

It is particularly important for both inspectors and attorneys to be aware of the extent to which evidence sought in a civil inspection can be used in a criminal matter, and to know when it is necessary to secure a criminal rather than a civil search warrant. There are three basic rules to remember in this regard: (1) If the purpose of the inspection is to discover and correct, through civil procedures, noncompliance with regulatory requirements, and administrative inspection (civil) warrant may be used; (2) if the inspection is in fact intended , in whole or in part, to gather evidence for a possible criminal prosecution, a criminal search warrant must be obtained under Rule 41 of the Federal Rules of Criminal Procedure; and (3) evidence obtained during a valid civil inspection is generally admissible in criminal proceedings. These principles arise from the recent Supreme Court cases of Marshall v. Barlow's, Inc., supra; Michigan v. Tyler, ___U.S.___, 98 S.Ct. 1942 (1978); and U.S. v. LaSalle National Bank, ___U.S.___, 57 L. Ed: 2d 221 (1978). It is not completely clear whether a combined investigation for civil and criminal violations may be properly conducted under civil or "administrative" warrant, but we believe a civil warrant can properly be used unless the intention is clearly to conduct a criminal investigation.

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(3) The Use of Contractors to Conduct Inspections

Several programs utilize private contractors to aid in the conduct of inspections. Since, for the purpose of inspections, these contractors are agents of the Federal government, the restrictions of the Barlow's decision also apply to them. If contractors are to be conducting inspections without the presence of actual EPA inspectors, these contractors should be given training in how to conduct themselves when entry is refused. With respect to obtaining or executing a warrant, an EPA inspector should always participate in the process, even if he was not at the inspection where entry was refused.

(4) Inspections Conducted by State Personnel

The Barlow's holding applies to inspections conducted by State personnel and to joint Federal/State inspections. Because some ERA programs are largely implemented through the States, it is essential that the Regions assure that State-conducted inspections are conducted in compliance with the Barlow's decision, and encourage the State inspectors to consult with their legal advisors when there is a refusal to allow entry for inspection purposes. State personnel should be encouraged to contact the EPA Regional Enforcement Office when any questions concerning compliance with Barlow's arise.

With regard to specific procedures for States to follow, the important points to remember are: (1) The State should not seek forcible entry without a warrant or penalize an owner for insisting upon a warrant, and (2) the State legal system should provide a mechanism for issuance of civil administrative inspection warrants. If a State is enforcing an EPA program through a State statute, the warrant process should be conducted through the State judicial system. Where a State inspector is acting as a contractor to the Agency, any refusal to allow entry should be handled as would a refusal to an Agency inspector as described in section II.B.3. Where a State inspector is acting as a State employee with both Federal and State credentials, he would utilize State procedures unless the Federal warrant procedures are more advantageous, in which case, the warrant should be sought under the general procedures described below. The Regions should also assure that all States which enforce EPA programs report any denials of entry to the appropriate Headquarters Enforcement Attorney for the reasons discussed in section II.B.4.

B. Entry

(1) Consensual Entry

One of the assumptions underlying the Court's decision is that most inspections will be consensual and that the administrative inspection framework will thus not be severely disrupted. Consequently, inspections will normally continue as before the Barlow's decision was issued. This means that the inspector will not normally secure a warrant before undertaking an inspection but, in an attempt to gain admittance, will present his credentials and issue a notice of inspection where required. The establishment owner may complain about allowing an inspector to enter or otherwise express his displeasure with EPA or the Federal government. However, as long as he allows the inspector to enter, the entry is voluntary and consensual unless the inspector is expressly told to leave the premises. On the other hand, if the inspector has gained entry in a coercive manner (either in a verbal or physical sense), the entry would not be consensual.

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Consent must be given by the owner of the premises or the person in charge of the premises at the time of the inspection. In the absence of the owner, the inspector should make a good faith effort to determine who is in charge of the establishment and present his credentials to that person. Consent is generally needed only to inspect the non-public portions of an establishment - i.e., any evidence that an inspector obtains while in an area open to the public is admissible in an enforcement proceeding.

(2) Withdrawal of Consent

The owner may withdraw his consent to the inspector at any time. The inspection is valid to the extent to which it has progressed before consent was withdrawn. Thus, observations by the inspector, including samples and photographs, obtained before consent was withdrawn, would be admissible in any subsequent enforcement action. Withdrawal of consent is tantamount to a refusal to allow entry and should be treated as discussed in section II.B.3. below, unless the inspection had progressed far enough to accomplish its purposes.

(3) When Entry is Refused

Barlow's clearly establishes that the owner does have the right to ask for a warrant under normal circumstances.[1] Therefore, refusal to allow entry for inspection purposes will not lead to civil or criminal penalties if the refusal is based on the inspector's lack of warrant and one of the exemptions discussed in Part C does not apply. If the owner were to allow the inspector to enter his establishment only in response to a threat of enforcement liability, it is quite possible that any evidence obtained in such an inspection would be inadmissible. An inspector may, however, inform the owner who refused entry that he intends to seek a warrant to compel the inspection. In any event, when entry is refused, the inspector should leave the premises immediately and telephone the designated Regional Enforcement Attorney as soon as possible for further instructions. The Regional Enforcement Attorney should contact the U.S. Attorney's Office for the district in which the establishment desired to be inspected is located and explain to the appropriate Assistant United States Attorney the need for a warrant to conduct the particular inspection. The Regional Attorney should arrange for the United States Attorney to meet with the inspector as soon as possible. The inspector should bring a copy of the appropriate draft warrant and affidavits. Samples are provided in the appendix to this document.

(4) Headquarters Notification

It is essential that the Regions keep Headquarters informed of all refusals to allow entry. The Regional Attorney should inform the appropriate Headquarters Enforcement Attorney of any refusals to enter and should send a copy of all papers filed to Headquarters. It is necessary for Headquarters to monitor refusals and Regional success in obtaining warrants to evaluate the need for improved procedures and to assess the impact of Barlow's on our compliance monitoring progress.

[1] FIFRA inspections are arguably not subject to this aspect of Barlow's. See discussion, p. 5 and 6.

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C. Areas Where a Right of Warrantless Entry Still Exists

(1) Emergency Situations

In an emergency, where there is no time to get a warrant, a warrantless inspection is permissible. In Camara v. Municipal Court, 387 U.S. 523 (1967), the Supreme Court states that "nothing we say today is intended to foreclose prompt inspections, even without a warrant, that the law has traditionally upheld in emergency situations." Nothing stated in Barlow's indicates any intention by the court to retreat from this position. The Regions will always have to exercise considerable judgement concerning whether to secure a warrant when dealing with an emergency situation. However, if entry is refused during and emergency, the Agency would need the assistance of the U.S. Marshal to gain entry, and a warrant could probably be obtained during the time necessary to secure that Marshal's assistance.

An emergency situation would include potential imminent hazard situations, as well as situations where there is potential for destruction of evidence or where evidence of a suspected violation may disappear during the time that a warrant is being obtained.

(2) FIFRA Inspection

There are some grounds for interpreting Barlow's as not being applicable to FIFRA inspections. The Barlow's restrictions do not apply to areas that have been subject to a long standing and pervasive history of government regulation. An Agency administrative law judge held recently that even after the Barlow's decision, refusal to allow a warrantless inspection of a FIFRA regulated establishment properly subjected the owner to civil penalty. N. Jones & Co., Inc., I.F. & R Docket No. III-121C (July 27, 1978). For the present, however, FIFRA inspections should be conducted under the same requirements applicable to other enforcement programs.

(3) "Open Fields" and "In Plain View" Situations

Observation by inspectors of things that are in plain view, (i.e., of things that a member of the public could be in a position to observe) does not required a warrant. Thus, an inspector's observations from the public area of a plant or even from certain private property not closed to the public are admissible. Observations made even before presentation of credentials while on private property which is not normally closed to the public are admissible.

D. Securing a Warrant

There are several general rules for securing warrants. Three documents have to be drafted: (a) an application for a warrant, (b) an accompanying affidavit, and (c) the warrant itself. Each document should be captioned with the District Court of jurisdiction, the title of the action, and the title of the particular document.

The application for a warrant should generally identify the statutes and regulations under which the Agency is seeking the warrant, and should clearly identify the site or establishment desired to be inspected (including, if possible, the owner and/or operator of the site). The application can be a one or two page document if all of the factual background for

seeking the warrant is stated in the affidavit, and the application so states. The application should be signed by the U.S. Attorney or by his Assistant U.S. Attorney.

The affidavits in support of the warrant application are crucial documents. Each affidavit should consist of consecutively numbered paragraphs, which describe all of the facts that support warrant issuance. If the warrant is sought in the absence of probable cause, it should recite or incorporate the neutral administrative scheme which is the basis for inspecting the particular establishment. Each affidavit should be signed by someone with personal knowledge of all the facts stated. In cases where entry has been denied, this person would most likely be the inspector who was denied entry. Note that an affidavit is a sworn statement that must either be notarized or personally sworn to before the magistrate.

The warrant is a direction to an appropriate official (an EPA inspector, U.S. Marshal or other Federal officer) to enter a specifically described location and perform specifically described inspection functions. Since the inspection is limited by the terms of the warrant, it is important to specify to the broadest extent possible the areas that are intended to be inspected, any records to be inspected, any samples to be taken, and any articles to be seized, etc. While a broad warrant may be permissible in civil administrative inspections, a vague or overly broad warrant will probably not be signed by the magistrate and may prove susceptible to constitutional challenge. The draft warrant should be ready for the magistrate's signature at the time of submission via a motion to quash and suppress evidence in Federal District court. Once the magistrate signs the draft warrant, it is an enforceable document. Either following the magistrate's signature or on a separate page, the draft warrant should contain a "return of service" or "certificate of service". This portion of the warrant should indicate upon whom the warrant was personally served and should be signed and dated by the inspector. As they are developed, more specific warrant issuance documents will be drafted and submitted to the Regions.

E. Standards or Bases for the Issuance of Administrative Warrants

The Barlow's decision establishes three standards or bases for the issuance of administrative warrants. Accordingly, warrants may be obtained upon a showing: 1) of traditional criminal probable cause, 2) of civil probable cause, or 3) that the establishment was selected for inspection pursuant to a neutral administrative inspection scheme.

(1) Civil Specific Probable Cause Warrant

Where there is some specific probable cause for issuance of a warrant such as an employee complaint or competitor's tip, the inspector should be prepared to describe to the U.S. Attorney in detail the basis for this probable cause.

The basis for probable cause will be stated in the affidavit in support of the warrant. This warrant should be used when the suspected violation is one that would result in a civil penalty or other civil action.

(2) Civil Probable Cause Based on a Neutral Administrative Inspection Scheme

Where there is no specific reason to think that a violation has been committed, a warrant may still be issued if they Agency can show that the establishment is being inspected pursuant to a neutral administrative scheme. As the Supreme Court stated in Barlow's:

> "Probable cause in the criminal law sense is not required. For purposes of an administrative search, such as this, probable cause justifying the issuance of a warrant may be based not only on specific evidence of an existing violation, but also on a showing that "reasonable legislative or administrative standards for conducting an . . . inspection are satisfied with respect to a particular (establishment)." A warrant showing that a specific business has been chosen for an OSHA search on the basis of a general administrative plan for the enforcement of the act derived from neutral sources such as, for example, dispersion of employees in various type of industries across a given area, and the desired frequency of searches in any of the lesser divisions of the area, would protect an employers Fourth Amendment rights.

Every program enforced by the Agency has such a scheme by which it prioritizes and schedules its inspections. For example, a scheme under which every permit holder in a given program is inspected on an annual basis is a satisfactory neutral administrative scheme. Also, a scheme in which one out of ever three known PCB transformer repair shops is inspected on an annual basis is satisfactory, as long as neutral criteria such as random selection are used to select the individual establishment to be inspected. Headquarters will prepare and transmit to the Regions the particular neutral administrative scheme under which each program's inspections are to be conducted. Inspections not based on specific probable cause must be based on neutral administrative schemes for a warrant to be issued. Examples of two neutral administrative schemes are provided in the appendix. (Attachments II and III)

The Assistant U.S. Attorney will request the inspector to prepare and sign an affidavit that states the facts as he knows them. The statement should include the sequence of events culminating in the refusal to allow entry and a recitation of either the specific probable cause or the neutral administrative scheme which led to the particular establishment's selection for inspection. The Assistant U.S. Attorney will then present a request for an inspection warrant, a suggested warrant, and the inspector's affidavit to a magistrate or Federal district court judge.[2]

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[2] The Barlow's decision states that imposing the warrant requirement on OSHA would not invalidate warrantless search provisions in other regulatory statutes since many such statutes already "envision resort to Federal court enforcement when entry is refused". There is thus some question as to whether the existence of a non-warrant Federal court enforcement mechanism in a statute requires the use of that mechanism rather than warrant issuance. We believe that the Barlow's decision gives the Agency the choice of whether to proceed through warrant issuance or through an application for an injunction, since the decision is largely based on the fact that a warrant procedure imposes virtually no burden on the inspecting Agency. In addition, any Agency could attempt to secure a warrant prior to inspection on an ex parte basis, something not available under normal injunction proceedings. Several of the acts enforced by the EPA have provisions allowing the Administrator to seek injunctive relief to assure compliance with the various parts of a particular statute. There may be instances where it would be more appropriate to seek injunctive relief to gain entry to a facility than to attempt to secure a warrant for inspection, although at this point we cannot think of any. However, since the warrant process will be far more expeditious than the seeking of an injunction, any decision to seek such an injunction for inspection purposes should be cleared through appropriate Headquarters staff.

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(3) Criminal Warrants

Where the purpose of the inspection is to gather evidence for a criminal prosecution, the inspector and the Regional Attorney should request that the U.S. Attorney seek a criminal warrant under Rule 41 of the Federal Rules of Criminal Procedure. This requires a specific showing of probable cause to believe that evidence of a crime will be discovered. Agency policy on the seeking of criminal warrants has not been affected by Barlow's. The distinction between administrative inspections and criminal warrant situations is discussed in Section II.A.2.

F. Inspecting with a Warrant

Once the warrant has been issued by the magistrate or judge, the inspector may proceed to the establishment to commence or continue the inspection. Where there is a high probability that entry will be refused even with a warrant or where there are threats of violence, the inspector should be accompanied by a U.S. Marshal when he goes to serve the warrant on the recalcitrant owner. The inspector should never himself attempt to make any forceful entry of the establishment. If the owner refuses entry to an inspector holding a warrant but not accompanied by a U.S. Marshal, the inspector should leave the establishment and inform the Assistant to the U.S. Attorney and the designated Regional Attorney. They will take appropriate action such as seeking a citation for contempt. Where the inspector is accompanied by a U.S. Marshal, the Marshal is principally charged with executing the warrant. Thus, if refusal or threat to refuse occurs, the inspector should abide by the U.S. Marshal's decision whether it is to leave, to seek forcible entry, or otherwise.

The inspector should conduct the inspection strictly in accordance with the warrant. If sampling is authorized, the inspector must be sure to carefully follow all procedures, including the presentation of receipts for all samples taken. If records or other property are authorized to be taken, the inspector must receipt thge property taken and maintain an inventory of anything taken from the premises. This inventory will be examined by the magistrate to assure that the warrant's authority has not been exceeded.

G. Returning the Warrant

After the inspection has been completed, the warrant must be returned to the magistrate. Whoever executes the warrant, (i.e., whoever performs the inspection), must sign the return of service form indicating to whom the warrant was served and the date of service. He should then return the executed warrant to the U.S. Attorney who will formally return it to the magistrate or judge. If anything has been physically taken from the premises, such as records or samples, an inventory of such items must be submitted to the court, and the inspector must be present to certify that the inventory is accurate and complete.

III. Conclusion

Except for requiring the Agency to formalize its neutral inspection schemes, and for generally ending the Agency's authority for initiating civil and/or criminal actions for refusal to allow warrantless inspections, Barlow's should not interfere with EPA enforcement inspections.

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Where there is doubt as to how to proceed in any entry case, do not hesitate to call the respective Headquarters program contact for assistance.

Marvin B. Durning

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APPENDIX D

EPA'S MEMORANDUM AND DEFICIENCY NOTICE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MEMORANDUM

OFFICE OF ENFORCEMENT

SUBJECT: "Deficiency Notice" Implementation to Improve Quality Assurance in NPDES Permittee Self-Monitoring Activities

FROM: Director, Enforcement Division (EN-338)

TO: Enforcement Division Directors, Regions I - X
Surveillance and Analysis Division Directors, Regions I - X
Director, National Enforcement Investigations Center, Denver

The Enforcement Divisions and the Surveillance and Analysis Divisions in several Regions have developed a form, called a Deficiency Notice, which their inspectors issue at the end of compliance inspections. This Deficiency Notice alerts NPDES permittees to problems in their routine self-monitoring activities. On June 11, 1979, the Office of Water Enforcement proposed that all the Regional offices adopt this form along with the Guidance for its use, and asked for your comments on this proposal. The Deficiency Notice and Guidance, which are attached, reflect your comments.

We have ordered the Deficiency Notice Forms, which will be printed on no-carbon-required paper and will be color coded in pads to correlate with the NPDES Compliance Inspection Form (EPA 3560-3). You may reproduce the attached form for use until you receive these forms.

The Deficiency Notice was designed so that State NPDES programs might easily use it. However, EPA cannot now sanction its use by the States since the Office of Management and Budget (OMB) has not authorized the form for non-Federal use. We will attempt to get OMB approval.

Since the Deficiency Notice provides a swift and simple mechanism for responding to deficiencies in self-monitoring data, I believe that its use will substantially improve the performance of wastewater treatment facilities without creating additional resource burdens or enforcement problems. If you have any questions about the Deficiency Notice or its use, please do not hesitate to call Gary Polvi of my staff at 755-0994.

J. Brian Molloy

Attachments

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DEFICIENCY NOTICE GUIDANCE

Purpose

The purpose for using the Deficiency Notice is to provide a swift and simple method for improving the quality of data from NPDES self-monitoring activities. Since an inspector may issue a Deficiency Notice during any NPDES compliance inspection to alert the permittee to either existing or potential problems in self-monitoring, its receipt prompts the permittee to quickly take corrective action, as close as possible to the time the inspector perceives the problem.

Scope

The Deficiency Notice is a tool for use in conjunction with any type of EPA NPDES compliance inspection (i.e., compliance evaluation, sampling, performance audit, biomonitoring, etc.), during which the inspector identifies problems with self-monitoring that warrant response.

The Deficiency Notice and Guidance were designed so that State NPDES compliance monitoring programs could also easily use them. (Note the use of the term "regulatory authority" throughout this guidance.) However, EPA cannot yet sanction the States' use of this form because the Office of Management and Budget (OMB) has not yet approved the form for non-Federal use.

Use of the Deficiency Notice does not apply to a wide range of possible permit violations. It is to be used by the inspector to alert permittees to deficiencies in their self-monitoring activities only. The enforcement office of the regulatory authority (i.e., the EPA Regional Enforcement Division or its State counterpart), not the inspector, will continue to handle violations relative to compliance schedules or effluent limitations.

Form Description

The Deficiency Notice (see attachment) is one page long and is for use in conjunction with the standard EPA Compliance Inspection Form (EPA 3560-3 September, 1977). The reverse side of the Notice contains general instructions to inspectors for completing the form. The regulatory authority using the form may add other specific instructions that do not conflict with this guidance.

The form has four sections: (1) basic facility data, (2) deficiencies, (3) comments, and (4) inspector identification. These sections contain individual spaces where the inspector during an inspection can log deficiencies in the following self-monitoring activities: (1) monitoring location, (2) flow measurement, (3) sample collection/holding time, (4) sample preservation, (5) test procedures, (6) record keeping, (7) other self-monitoring deficiencies (i.e., sampling frequency, instrument calibration, etc.). Since the existing Compliance Inspection Form (which inspectors now complete) includes questions and answers relating to the above seven activities, inspectors should not need much additional time to complete this Deficiency Notice.

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Administrative Procedures

With few exceptions (see March 7, 1977 EMS Guide), the handling and tracking of Deficiency Notices will follow the normal EPA Enforcement Management System (EMS) procedures. Inspectors can issue the Deficiency Notice to a permittee immediately following a compliance inspection if they discover any permit deficiencies which the Notice includes. Under unusual circumstances inspectors may delay issuing a Deficiency Notice until after conferring with other officials of the regulatory authority.

EMS requires the offices responsible for inspections and for NPDES enforcement to jointly establish a policy delineating the procedure for the permittee to appropriately respond to the Deficiency Notice. In the EPA Regions, the Directors of the Enforcement Division and the Surveillance and Analysis (S&A) Division will develop this policy. If the offices agree to allow the permittee to submit a separate written response rather than to include the response as part of a regular Discharge Monitoring Report (DMR) submission, they will require the inspector to record the necessary mailing instructions and deadline for response under the additional comment section of the Deficiency Notice. The inspector indicates the appropriate method for the permittee's response in the "requested action" section of the Deficiency Notice. Due to the nature of most self-monitoring problems it is reasonable for the regulatory authority to ask that the permittee submit a written description of any corrective actions within 15 work days after receiving the Notice. Where the permittee is asked to respond as part of a regular DMR submission, a similar reporting time allowance should be allotted. In either response option, the inspector should always indicate in the Deficiency Notice the requested date for permittee response.

Having the permittee document Deficiency Notice corrective actions as part of a regular DMR submission establishes accountability for the compliance inspection in the official NPDES permit compliance file even before a compliance review is undertaken. This is a resource efficient method of documenting the minimum benefit from performing inspections.

The issuance of a Deficiency Notice is not a formal enforcement action. It is not intended and must not be construed as an administrative or legal order to the permittee. Therefore, the action by the permittee to respond is voluntary, but incentive for such response comes from the positive consideration it may have on further formal enforcement follow-up of the inspection.

When the regulatory authority receives the permittee's response to the Deficiency Notice, they will review the inspection data and the permittee's response according to EMS procedures. If during routine reviews of inspection data, the authorities note deficiencies in self-monitoring data and note that the inspector did not issue a Deficiency Notice, they may issue one at any time.

The responsibility for all enforcement activity shall always remain in the enforcement/compliance review office of the regulatory authority. After agreement between the Directors of the Regional Enforcement Division and the S&A Division, these offices should incorporate details for insuring which office retains which responsibility into the Regional EMS.

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Whether or not a Deficiency Notice has been issued, the enforcement office of the regulatory authority can take administrative or legal action at any time. Also, a Deficiency Notice may not be appropriate in those cases where additional enforcement action is expected or litigation against the permittee is already underway.

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DEFICIENCY NOTICE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) *(Read instructions on back of last part before completing)*	PERMITTEE *(Facility)* NAME AND ADDRESS
PERMITTEE REPRESENTATIVE *(Receiving this Notice)*/Title	NPDES PERMIT NO.

During the compliance inspection carried out on *(Date)* _____ the deficiencies noted below were found. Additional areas of deficiency may be brought to your attention following a complete review of the Inspection Report and other information on file with the REGULATORY AUTHORITY administering your NPDES PERMIT.

D E F I C E N C I E S

MONITORING LOCATION *(Describe)*

FLOW MEASUREMENT *(Describe)*

SAMPLE COLLECTION / HOLDING TIME *(Describe)*

SAMPLE PRESERVATION *(Describe)*

TEST PROCEDURES SECTION 304(h). **40 CFR 136** *(Describe)*

RECORD KEEPING *(Describe)*

OTHER SELF-MONITORING DEFICIENCIES *(Describe)*

ADDITIONAL COMMENTS

REQUESTED ACTION—Your attention to the correction of the deficiencies noted above is requested. Receipt of a description of the corrective actions taken will be considered in the determination of the need for further Administrative or Legal Action. Your response is to be **(Inspector line out inappropriate response method)**: (1) Include with your next *NPDES Discharge Monitoring Report (DMR) or (2) submitted as directed by the inspector.* Questions regarding possible follow-up action can be answered by the REGULATORY AUTHORITY to which your DMRs are submitted and which administers your NPDES Permit.

INSPECTOR'S SIGNATURE	INSPECTOR'S ADDRESS/PHONE NO.	REGULATORY AUTHORITY/ADDRESS	DATE
INSPECTOR'S PRINTED NAME			

EPA Form 3560-4 (2-80)

EPA Deficiency Notice Form

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APPENDIX E

NPDES COMPLIANCE INSPECTION REPORT FORM 3560-3

EPA

United States Environmental Protection Agency
Washington, D.C. 20460

Water Compliance Inspection Report

Form Approved.
OMB No. 2040-0057
Approval expires 10-31-95

Section A: National Data System Coding (i.e., PCS)

Transaction Code	NPDES	yr/mo/day	Inspection Type	Inspector	Fac Type
1 | 2 | 5 |	3 | 11	12 | 17	18 |	19 |	20 |

Remarks

21 \| 66

Inspection Work Days	Facility Self-Monitoring Evaluation Rating	B1	QA	Reserved
67 | 69	70 |	71 |	72 |	73 | 74 | 75 | 80

Section B: Facility Data

Name and Location of Facility Inspected *(For industrial users discharging to POTW, also include POTW name and NPDES permit number)*	Entry Time/Date	Permit Effective Date
	Exit Time/Date	Permit Expiration Date

Name(s) of On-Site Representative(s)/Title(s)/Phone and Fax Number(s)	Other Facility Data
Name, Address of Responsible Official/Title/Phone and Fax Number Contacted ☐ Yes ☐ No	

Section C: Areas Evaluated During Inspection *(Check only those areas evaluated)*

☐ Permit	☐ Flow Measurement	☐ Operations & Maintenance	☐ CSO/SSO (Sewer Overflow)
☐ Records/Reports	☐ Self-Monitoring Program	☐ Sludge Handling/Disposal	☐ Pollution Prevention
☐ Facility Site Review	☐ Compliance Schedules	☐ Pretreatment	☐ Multimedia
☐ Effluent/Receiving Waters	☐ Laboratory	☐ Storm Water	☐ Other:

Section D: Summary of Findings/Comments *(Attach additional sheets of narrative and checklists as necessary)*

Name(s) and Signature(s) of Inspector(s)	Agency/Office/Phone and Fax Numbers	Date
Signature of Management Q A Reviewer	Agency/Office/Phone and Fax Numbers	Date

EPA Form 3560-3 (Rev 9-94) Previous editions are obsolete.

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APPENDIX F

SAMPLE CHAIN-OF-CUSTODY FORM

U.S. ENVIRONMENTAL PROTECTION AGENCY
Environmental Services Division

CHAIN OF CUSTODY RECORD

REGION VIII, ONE DENVER PLACE
999 18TH STREET
DENVER, CO 80202-2413

PROJ. NO.	PROJECT NAME							NO OF CON-TAINERS							REMARKS
SAMPLERS: *(Signature)*															
STAT. NO	DATE	TIME	COMP	GRAB	STATION LOCATION										

Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date/Time	Received by: *(Signature)*
Relinquished by: *(Signature)*	Date/Time	Received for Laboratory by: *(Signature)*	Date/Time	Remarks	

Split Samples
[ ] Accepted [ ] Declined Signature

Distribution Original Accompanies Shipment First Copy to Coordinator Field File Second Copy to Representative of Inspected Facility

R8 EPA-014B (4-21-86)

8-15076

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APPENDIX G

SUPPLEMENTAL FLOW MEASUREMENT INFORMATION

Appendix G

SUPPLEMENTAL FLOW MEASUREMENT INFORMATION

Basic Hydraulic Calculations

The relationship between the flow rate (Q), the average velocity (V), and the cross-sectional area of the flow (A) is given by the following equation:

$$Q = VA$$

where Q = flow in cubic feet per second
V = velocity in feet per second
A = area in square feet.

To convert flow in cubic feet of water per second to flow in gallons of water per minute, the following proportionality is used:

$$\frac{\text{cubic feet}}{\text{second}} \times \frac{7.48 \text{ gallons water}}{\text{cubic foot of water}} \times \frac{60 \text{ seconds}}{\text{minute}} = \frac{\text{gallons}}{\text{minute}}$$

To convert from cubic feet per second to million gallons per day, multiply the number of cubic feet per second by 0.6463.

The cross-sectional area (A) of a pipe is described by:

$$A = \tfrac{1}{4}\pi d^2$$

where d = diameter of the pipe in feet.

Flow Measurement Devices

Flow data may be collected instantaneously or continuously. Instantaneous flows must be measured when samples are taken so that the pollutant concentrations can be correlated to flow data. In a continuous flow measurement system, flow measurements are summed to obtain a value for the total flow to verify NPDES permit compliance.

A typical continuous flow measurement system consists of a flow device, a flow sensor, transmitting equipment, a recorder, and a totalizer.

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Instantaneous flow data can be obtained without using such a system. The primary flow device is constructed to yield predictable hydraulic responses related to the rate of wastewater or water flowing through the device. As previously mentioned, examples of such devices include weirs and flumes, which relate water depth (head) to flow; Venturi meters, which relate differential pressure to flow; and electromagnetic flowmeters, which relate induced electric voltage to flow. In most cases, a standard primary flow device has undergone detailed testing and experimentation and its accuracy has been verified.

Flow is measured by many methods; some are designed to measure open channel flows, and others are designed to measure flows in pipelines. A complete discussion of all available flow measurement methods, their supporting theories, and the devices used are beyond the scope of this manual. The most commonly used flow measurement devices and procedures for inspecting them will be described briefly in the following paragraphs. For more detail, inspectors should consult the publications listed in "References" at the end of this chapter.

Primary Devices

Weirs. A weir consists of a thin vertical plate with a sharp crest that is placed in a stream, channel, or partly filled pipe. Figure G-1 shows a profile of a sharp-crested weir and indicates the appropriate nomenclature. Four common types of sharp-crested weirs are shown in Figure G-2. This figure illustrates the difference between suppressed and contracted rectangular weirs and illustrates Cipolletti (trapezoidal) and V-notch (triangular) weirs.

To determine the flow rate, it is necessary to measure the hydraulic head (height) of water above the crest of the weir. For accurate flow measurements, the crest must be clean, sharp, and level. The edge of the crest must not be thicker than 1/8 inch.

The rate of flow over a weir is directly related to the height of the water (head) above the crest at a point upstream of the weir where the water surface is level. To calculate the discharge over a weir, the head must first be measured by placing a measuring device upstream of the weir, at a distance of at least 4 times an approximate measurement of the head. A measurement can be taken at the weir plate to approximate the head. However, if this measurement is used to calculate the discharge, this value will provide only a rough estimate of the discharge.

The head-discharge relationship formulas for nonsubmerged contracted and suppressed rectangular weirs, Cipolletti weirs, and V-notch weirs are provided in Table G-1. Discharge rates for the 90-degree V-notch weir (when the head is measured at the weir plate) are included in Table G-2. Flow rates for 60- and 90-degree V-notch weirs can be determined from the graph in Figure G-3. Minimum and maximum recommended flow rates for Cipolletti weirs are provided in Table G-3. Figure G-4 is a nomograph for flow rates for rectangular weirs using the Francis formulas.

Parshall Flume. The Parshall flume is composed of three sections: a converging upstream section, a throat or contracted section, and a diverging or dropping downstream section. When there is free fall out of the throat of a Parshall flume, no diverging downstream section is required. It operates on the principle that when open channel water flows through a constriction in the channel, it produces a hydraulic head at a certain point upstream of the

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constriction that is proportional to the flow. The hydraulic head is used to calculate the flow. Flow curves are shown in Figure G-5 to determine free flow through 3 inches to 50 feet Parshall flumes.

The Parshall flume is good for measuring open channel waste flow because it is self cleaning; therefore, sand or suspended solids are unlikely to affect the operation of the device. The flume is both simple and accurate.

The flume size is given by the width of the throat section. Parshall flumes have been developed with throat widths from 1 inch to 50 feet. The configuration and standard nomenclature for Parshall flumes are provided in Figure G-6. Strict adherence to all dimensions is necessary to achieve accurate flow measurements. Figure G-6 provides Parshall flume dimensions for various throat widths, and Table G-4 provides the minimum and maximum flow rates for free flow through Parshall flumes.

For free nonsubmerged flow in a Parshall flume of throat and upstream head (Ha in feet), the discharge relationship for flumes of 8 feet or less is given by the general equation Q = CWHan, where Q = flow.

Table G-5 provides the values of C, n, and Q for different sizes (widths) of the Parshall flumes. Nomographs, curves, or tables are readily available to determine the discharge from head observations.

Flow through a Parshall flume may also be submerged. The degree of submergence is indicated by the ratio of the downstream head to the upstream head (Hb/Ha), which is the submergence ratio. Hb is the height of water measured above the crest. The flow is submerged if the submerged ratio is:

- Greater than 0.5 for flumes under 3 inches
- Greater than 0.6 for flumes 6 to 9 inches
- Greater than 0.7 for flumes 1 to 8 feet
- Greater than 0.8 for flumes larger than 8 feet.

If submerged conditions exist, the inspector should apply a correction factor to the free flow determined using the relationship Q= CWHn. These correction factors are shown in Figure G-7 for different sizes of the Parshall flume.

Palmer-Bowlus Flume. The Palmer-Bowlus flume is also composed of three sections: a converging upstream section, a contracted section or throat, and a diverging downstream section (Figure G-8). The upstream depth of the water (head) above the raised step in the throat is related to the discharge rate. The head should be measured at a distance d/2 upstream of the throat where d is the size (width) of the flume. The height of the step is usually unknown until the manufacturer's data are consulted, it is difficult to manually measure the height of water above the step at an upstream point. The dimensions for Palmer-Bowlus flumes are not standardized as they are for Parshall flumes. Therefore, no standard flow equation exists. Instead, rating curves are provided by manufacturers of Palmer-Bowlus flumes to relate the head to the discharge rate.

The flume must be installed with a minimum channel slope downstream to maintain critical

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flow through the flume and prevent the flume from becoming submerged. A small jump or rise in the water surface below the throat indicates that critical flow through the flume has probably occurred and submerged conditions do not exist. Accurate flow measurements can usually be obtained with upstream depths that are up to 95 percent of the pipe diameter. Table G-6 provides a table of the maximum slopes recommended for installation of Palmer-Bowlus flumes. Advantages of this type of flow measurement device are the following:

- It is easily installed in existing systems.
- Head loss is insignificant.
- Unit is self cleaning.

Venturi Meter. The Venturi (differential pressure) meter is one of the most accurate primary devices for measuring flow rates in pipes. The Venturi meter is basically a pipe segment consisting of an inlet section, a converging section, and a throat, along with a diverging outlet section as illustrated in Figure G-9. The water velocity is increased in the constricted portion of the inlet section resulting in a decrease in the static pressure. The pressure difference between the inlet pipe and the throat is proportional to the square of the flow. The pressure difference can easily be measured very accurately, resulting in an accurate flow measurement. An advantage of the Venturi meter is that it causes little pressure (head) loss. The formula for calculating the flow in a Venturi meter is as follows:

$$Q = cKd_2^2\sqrt{h_1 - h_2} \qquad \text{(King1963)}$$

where Q = volume of water, in cubic feet per second
c = discharge coefficient, obtain from Table G-7. C varies with Reynold's number, meter surfaces, and installation

h1 = pressure head at center of pipe at inlet section, in feet of water h2 = pressure head at throat, in feet of water
K = constant which relates d2 to d1 for Venturi meters. Obtain values of K from Table G-8 or calculate according to the formula

$$K = \sqrt[4]{\frac{2g}{1 - \left[\frac{d_2}{d_1}\right]^4}}$$

where d_2 = throat diameter, in feet
d_1 = diameter of inlet pipe, in feet

Electromagnetic Flowmeter. The electromagnetic flowmeter operates according to Faraday's Law of Induction: the voltage induced by a conductor moving at right angles through a magnetic field will be proportional to the velocity of the conductor through the field. In the electromagnetic flowmeter, the conductor is the liquid stream to be measured and the field is produced by a set of electromagnetic coils. A typical electromagnetic flowmeter is shown in Figure G-10. The induced voltage is transmitted to a converter for signal conditioning. The

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meter may be provided with recorder and totalizer using electric or pneumatic transmission systems. This type of flowmeter is useful at sewage lift stations and for measuring total raw wastewater flow or raw or recirculated sludge flow.

Electromagnetic flowmeters are used in full pipes and have many advantages, including: accuracies of +1 percent, a wide flow measurement range, a negligible pressure loss, no moving parts, and rapid response time. However, they are expensive and buildup of grease deposits or pitting by abrasive wastewaters can cause error. Regular checking and cleaning of the electrodes is necessary. The meter electronics can be checked for proper operation with devices specially made for this purpose. The meter should be checked at least annually. The calibration of an electromagnetic flowmeter cannot be verified except by returning it to the factory or by the dye dilution method.

Propeller Meter. The propeller meter (Figure G-11) operates on the principle that liquid hitting the propeller will cause the propeller to rotate at a speed proportional to the flow rate. The meter is self-contained and requires no energy or equipment other than a mechanical totalizer to obtain a cumulative flow reading. Equipment may be added to the meter to produce a flow reading, to pace chemical feed equipment, and to control telemetering equipment for remote readout. The calibration of a propeller meter can be checked by returning it to the factory, by comparing its readings to another meter measuring the same flow, or by using the dye dilution method.

Secondary Devices

Secondary devices are the devices in the flow measurement system that translate the interaction of primary devices in contact with the fluid into the desired records or readout. They can be organized into two broad classes:

- Nonrecording type with direct readout (e.g., a staff gauge) or indirect readout from fixed points (e.g., a chain, wire weight, float)
- Recording type with either digital or graphic recorders (e.g., float in well, float in flow, bubbler, electrical, acoustic).

The advantages and disadvantages of various secondary devices are provided in Table G-9.

Pumps

Some wastewater facilities may need to measure flow by means of pumps in which discharge-versus-power relationships have been determined from measurements of the average output or input during a period in which discharge measurements were made. Suitable curves may be developed from these test data. When readily available from the manufacturer, pump curves may be used by the inspector to estimate flow.

Because of wear on pumps and uncertainty regarding actual discharge heads, pump curves at best only provide an estimate of the flow. Pump curves are not normally accurate enough to be used for NPDES permit discharge flow measurements. Pump curves have been used for

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determining large flows, such as the cooling water discharge from large steam electric power plants, where a high degree of accuracy was not necessary.

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Table G-1

Head-Discharge Relationship Formulas for Nonsubmerged Weirs*

Weir Type	Contracted	Suppressed	Remarks	Reference
Rectangular				
Francis formulas	$Q = 3.33 (L - 0.1 nH)H^{1.5}$	$Q = 3.33 L H^{1.5}$	Approach velocity neglected	King 1963
	$Q = 3.33 [(H + h)^{1.5}-h^{1.5}](L - 0.1nH)$	$Q = 3.33 L[(H + h)^{1.5} - h^{1.5}]$	Approach velocity considered	King 1963
Cipolletti	$Q = 3.367 L H^{1.5}$	NA	Approach velocity neglected	King 1963
	$Q = 3.367 L (H + h)^{1.5} - h^{1.5}$	NA	Approach velocity considered	EPA 1973
V-notch				
Formula for 90° V-notch only	$Q = 2.50 H^{2.5}$	NA	Not appreciably affected by approach velocity	King 1963
	$Q = 3.01 H_w 2.48$	NA	Head measured at weir plate	Eli and Peterson 1979 (EPA-61809A-2B)

Q = discharge in cubic feet
H = head in feet
NA = not applicable
H_w = head in feet at weir plate
n = number of end contractions
L = crest length in feet
h = head in feet due to the approach velocity = $v^2/2g$
V = approach velocity
g = gravity (32.2 ft/sec^2)

*Selection of a formula depends on its suitability and parameters under consideration.

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Table G-2

Discharge of 90° V-Notch Weir—Head Measured at Weir Plate

Head@ Weir in Feet	Flow Rate in CFS	Head@ Weir in Feet	Flow Rate in CFS	Head@ Weir in Feet	Flow Rate in CFS
0.06	0.003	0.46	0.439	0.86	2.071
0.07	0.004	0.47	0.463	0.87	2.140
0.08	0.006	0.48	0.488	0.88	2.192
0.09	0.008	0.49	0.513	0.89	2.255
0.10	0.010	0.50	0.540	0.90	2.318
0.11	0.013	0.51	0.567	0.91	2.382
0.12	0.016	0.52	0.595	0.92	2.448
0.13	0.019	0.53	0.623	0.93	2.514
0.14	0.023	0.54	0.653	0.94	2.582
0.15	0.027	0.55	0.683	0.95	2.650
0.16	0.032	0.56	0.715	0.96	2.720
0.17	0.037	0.57	0.747	0.97	2.791
0.18	0.043	0.58	0.780	0.98	2.863
0.19	0.049	0.59	0.813	0.99	2.936
0.20	0.056	0.60	0.848	1.00	3.010
0.21	0.063	0.61	0.883	1.01	3.085
0.22	0.070	0.62	0.920	1.02	3.162
0.23	0.079	0.63	0.957	1.03	3.239
0.24	0.087	0.64	0.995	1.04	3.317
0.25	0.097	0.65	1.034	1.05	3.397
0.26	0.107	0.66	1.074	1.06	3.478
0.27	0.117	0.67	1.115	1.07	3.556
0.28	0.128	0.68	1.157	1.08	3.643
0.29	0.140	0.69	1.199	1.09	3.727
0.30	0.152	0.70	1.243	1.10	3.813
0.31	0.165	0.71	1.287	1.11	3.889
0.32	0.178	0.72	1.333	1.12	3.987
0.33	0.193	0.73	1.379	1.13	4.076
0.34	0.207	0.74	1.426	1.14	4.166
0.35	0.223	0.75	1.475	1.15	4.257
0.36	0.239	0.76	1.524	1.16	4.349
0.37	0.256	0.77	1.574	1.17	4.443
0.38	0.273	0.78	1.625	1.18	4.538
0.39	0.291	0.79	1.678	1.19	4.634
0.40	0.310	0.80	1.730	1.20	4.731
0.41	0.330	0.81	1.785	1.21	4.829
0.42	0.350	0.82	1.840	1.22	4.929
0.43	0.371	0.83	1.896	1.23	5.030
0.44	0.393	0.84	1.953	1.24	5.132
0.45	0.415	0.85	2.012	1.25	5.235

Equation $Q = 3.01\ Hw^{2.48}$, where Hw, head, is in feet at the weir and Q is in cubic feet per second.

Table G-3

Minimum and Maximum Recommended Flow Rates for Cipolletti Weirs

Crest Length, ft.	Minimum Head, ft.	Minimum Flow Rate		Maximum Head, ft.	Maximum Flow Rate	
		MGD	CFS		MGD	CFS
1	0.2	0.195	0.301	0.5	0.769	1.19
1.5	0.2	0.292	0.452	0.75	2.12	3.28
2	0.2	0.389	0.602	1.0	4.35	6.73
2.5	0.2	0.487	0.753	1.25	7.60	11.8
3	0.2	0.584	0.903	1.5	12.0	18.6
4	0.2	0.778	1.20	2.0	24.6	38.1
5	0.2	0.973	1.51	2.5	43.0	66.5
6	0.2	0.17	1.81	3.0	67.8	105.0
8	0.2	0.56	2.41	4.0	139.0	214.0
10	0.2	1.95	3.01	5.0	243.0	375.0

Table G-4

Minimum and Maximum Recommended Flow Rates for Free Flow Through Parshall Flumes

Throat Width, W	Minimum Head, ft.	Minimum Flow Rate		Maximum Head, ft.	Maximum Flow Rate	
		MGD	CFS		MGD	CFS
1 in.	0.07	0.003	0.005	0.60	0.099	0.153
2 in.	0.07	0.007	0.011	0.60	0.198	0.306
3 in.	0.10	0.018	0.028	1.5	1.20	1.86
6 in.	0.10	0.035	0.054	1.5	2.53	3.91
9 in.	0.10	0.05	0.091	2.0	5.73	8.87
1 ft.	0.10	0.078	0.120	2.5	10.4	16.1
1.5 ft.	0.10	0.112	0.174	2.5	15.9	24.6
2 ft.	0.15	0.273	0.423	2.5	21.4	33.1
3 ft.	0.15	0.397	0.615	2.5	32.6	50.4
4 ft.	0.20	0.816	1.26	2.5	43.9	67.9
5 ft.	0.20	1.00	1.55	2.5	55.3	85.6
6 ft.	0.25	1.70	2.63	2.5	66.9	103
8 ft.	0.25	2.23	3.45	2.5	90.1	139
10 ft.	0.30	3.71	5.74	3.5	189	292
12 ft.	0.33	5.13	7.93	4.5	335	519

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Table G-5

Free-Flow Values of C and N for Parshall Flumes

Based on the Relationship $Q = CWH^n$
(American Petroleum Institute 1969)

Flume Throat, W		C	n	Max. Q CFS
1	in.	0.338	1.55	0.15
2	in.	0.676	1.55	0.30
3	in.	0.992	1.55	1.8
6	in.	2.06	1.58	3.9
9	in.	3.07	1.53	8.9
1	ft.	4W*	$1.522W^{0.026}$	16.1
1.5	ft.	4W*	$1.522W^{0.026}$	24.6
2	ft.	4W*	$1.522W^{0.026}$	33.1
3	ft.	4W*	$1.522W^{0.026}$	50.4
4	ft.	4W*	$1.522W^{0.026}$	67.9
5	ft.	4W*	$1.522W^{0.026}$	85.6
6	ft.	4W*	$1.522W^{0.026}$	103.5
7	ft.	4W*	$1.522W^{0.026}$	121.4
8	ft.	4W*	$1.522W^{0.026}$	139.5

Where W = Flume throat width

Q = Flow (CFS)

C = Constant

H = Head upstream of the flume throat (feet)

n = Constant

* = W should be represented in feet to calculate C

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Table G-6

Minimum and Maximum Recommended Flow Rates for Free Flow Through Plasti-Fab Palmer-Bowlus Flumes

D Flume Size (in.)	Maximum Slope for Upstream (%)	Minimum Head (ft.)	Minimum Flow Rate		Maximum Head (ft.)	Maximum Flow Rate	
			MGD	CFS		MGD	CFS
6	2.2	0.11	0.023	0.035	0.36	0.203	0.315
8	2.0	0.15	0.048	0.074	0.49	0.433	0.670
10	1.8	0.18	0.079	0.122	0.61	0.752	1.16
12	1.6	0.22	0.128	0.198	0.73	1.18	1.83
15	1.5	0.27	0.216	0.334	0.91	2.06	3.18
18	1.4	0.33	0.355	0.549	1.09	3.24	5.01
21	1.4	0.38	0.504	0.780	1.28	4.81	7.44
24	1.3	0.44	0.721	1.12	1.46	6.70	10.4
27	1.3	0.49	0.945	1.46	1.64	8.95	13.8
30	1.3	0.55	1.26	1.95	1.82	11.6	18.0

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Table G-7

Coefficients of Discharge c for Venturi Meters (King 1963)

Diameter of Throat, in.	Throat Velocity, ft. per sec.								
	3	4	5	10	15	20	30	40	50
1	0.935	0.945	0.949	0.958	0.963	0.966	0.969	0.970	0.972
2	0.939	0.948	0.953	0.965	0.970	0.973	0.974	0.975	0.977
4	0.943	0.952	0.957	0.970	0.975	0.977	0.978	0.979	0.980
8	0.948	0.957	0.962	0.974	0.978	0.980	0.981	0.982	0.983
12	0.955	0.962	0.967	0.978	0.981	0.982	0.983	0.984	0.985
18	0.963	0.969	0.973	0.981	0.983	0.984	0.985	0.986	0.986
48	0.970	0.977	0.980	0.984	0.985	0.986	0.987	0.988	0.988

Table G-8

Values of K in Formula for Venturi Meters (King 1963)

$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K	$\frac{d^2}{d^1}$	K
0.20	6.31	0.33	6.34	0.46	6.45	0.59	6.72	0.72	7.37
0.21	6.31	0.34	6.34	0.47	6.46	0.60	6.75	0.73	7.45
0.22	6.31	0.35	6.35	0.48	6.47	0.61	6.79	0.74	7.53
0.23	6.31	0.36	6.35	0.49	6.49	0.62	6.82	0.75	7.62
0.24	6.31	0.37	6.36	0.50	6.51	0.63	6.86	0.76	7.72
0.25	6.31	0.38	6.37	0.51	6.52	0.64	6.91	0.77	7.82
0.26	6.31	0.39	6.37	0.52	6.54	0.65	6.95	0.78	7.94
0.27	6.32	0.40	6.38	0.53	6.54	0.66	7.00	0.79	8.06
0.28	6.32	0.41	6.39	0.54	6.59	0.67	7.05	0.80	8.20
0.29	6.32	0.42	6.40	0.55	6.61	0.68	7.11	0.81	8.35
0.30	6.33	0.43	6.41	0.56	6.64	0.69	7.17	0.82	8.51
0.31	6.33	0.44	6.42	0.57	6.66	0.70	7.23	0.83	8.69
0.32	6.33	0.45	6.43	0.58	6.69	0.71	7.30	0.84	8.89

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Table G-9

Advantages and Disadvantages of Secondary Devices

Device	Advantages	Disadvantages
Hook Gauge	Common	Requires training to use, easily damaged
Stage Board	Common	Needs regular cleaning, difficult to read top of meniscus
Pressure Measurement		
a. Pressure Bulb	Since no compressed air is used, source can be linked directly to sampler	Openings can clog, expensive
b. Bubbler Tube	Self-cleaning, less expensive, reliable	Needs compressed air or other air source
Float	Inexpensive, reliable	Catches debris, requires frequent cleaning to prevent sticking and changing buoyancy, and corroding hinges
Dipper	Quite reliable, easy to operate	Oil and grease foul probe, causing possible sensor loss
Ultrasonic	No electrical or mechanical contact	Errors from heavy turbulence and foam, calibration procedure is more involved than for other devices

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Figure G-1

Profile and Nomenclature of Sharp-Crested Weirs
(Associated Water and Air Resource Engineers, Inc., 1973)

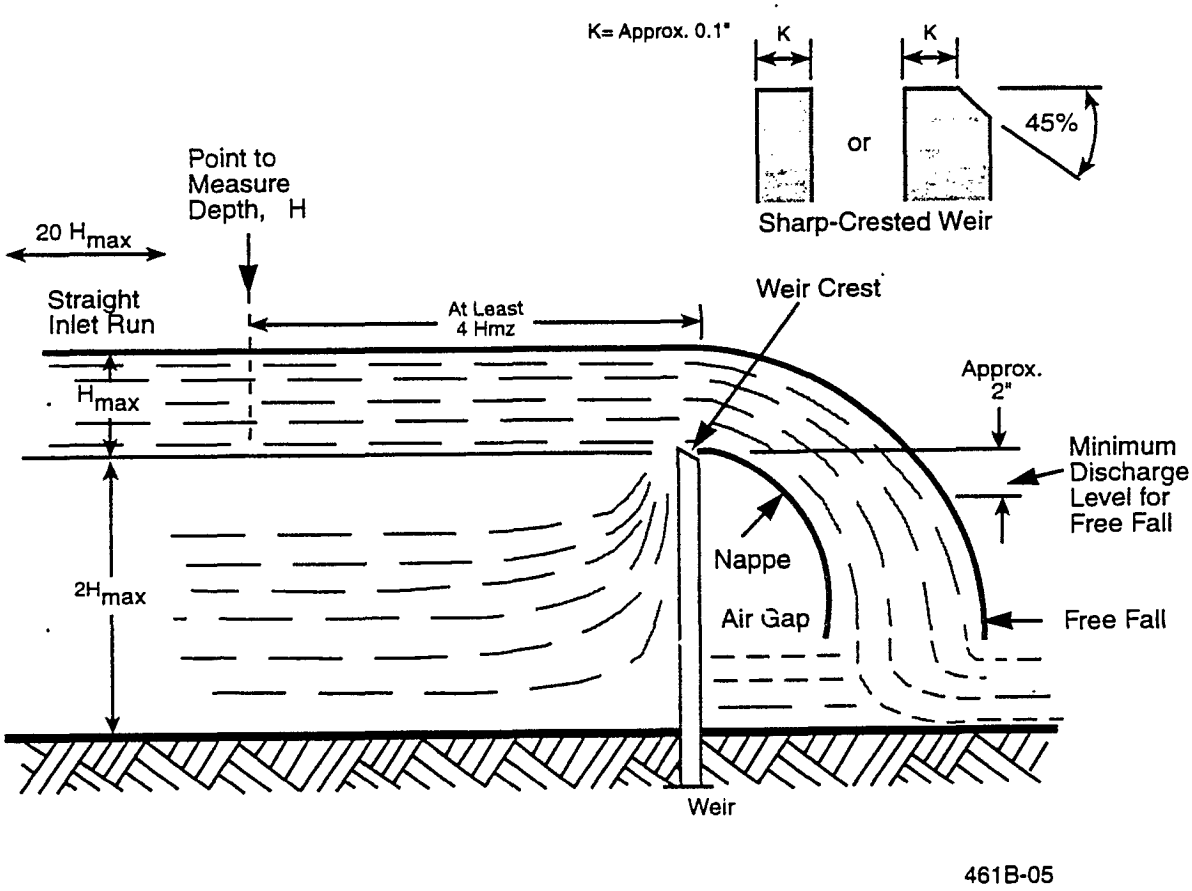
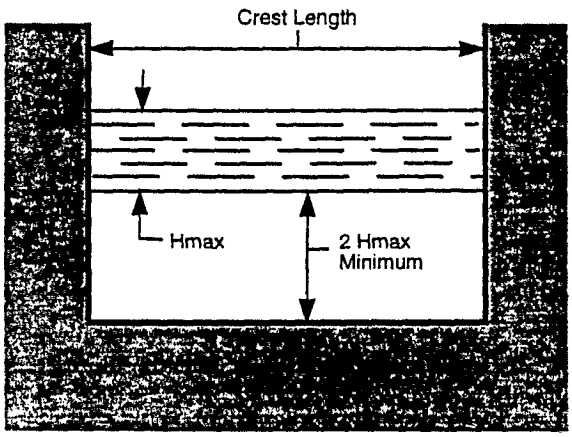
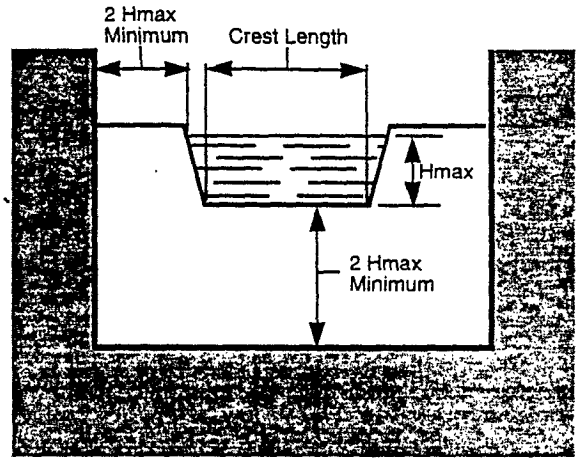


Figure G-2

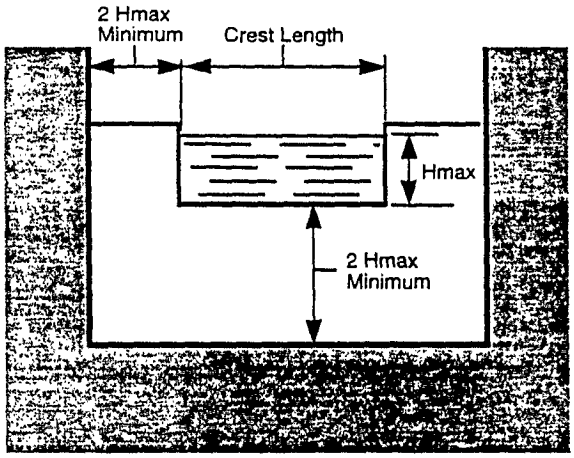
Three Common Types of Sharp-Crested Weirs (Associated Water and Air Resource Engineers, Inc., 1973)



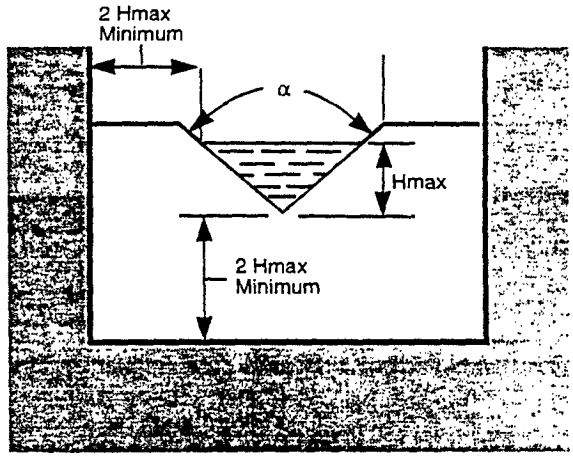
Suppressed (Without End Contractions) Rectangular Weir



Trapezoidal (Cipolletti) Sharp-Crested Weir



Contracted (With End Contractions) Rectangular Weir



V-Notch (Triangular) Sharp-Crested Weir

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Figure G-3

Flow Rates for 60° and 90° V-Notch Weirs
(Associated Water and Resource Engineers, Inc., 1973)

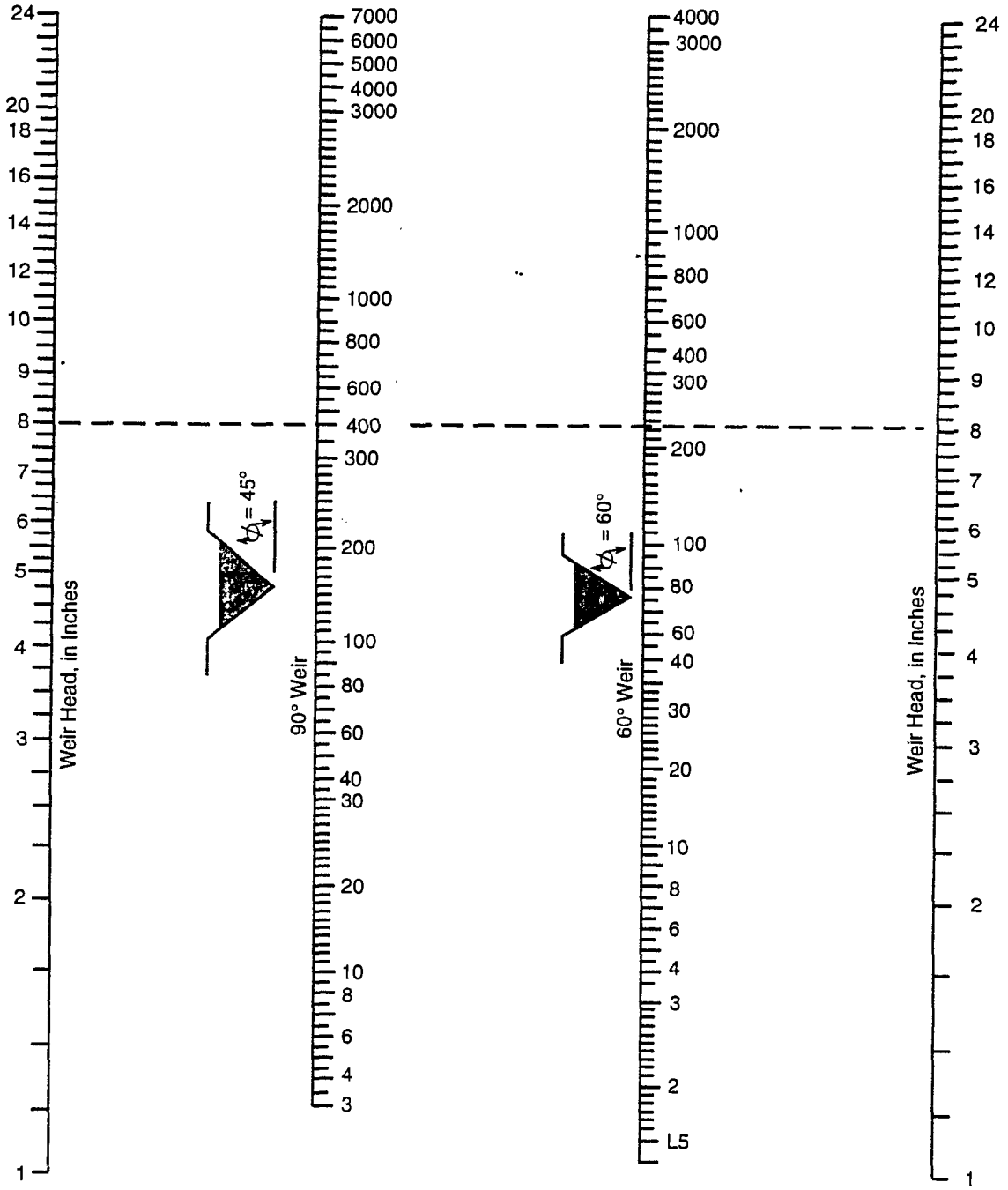

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Figure G-4

Nomograph for Capacity of Rectangular Weirs
(Associated Water and Air Resource Engineers, Inc., 1973)

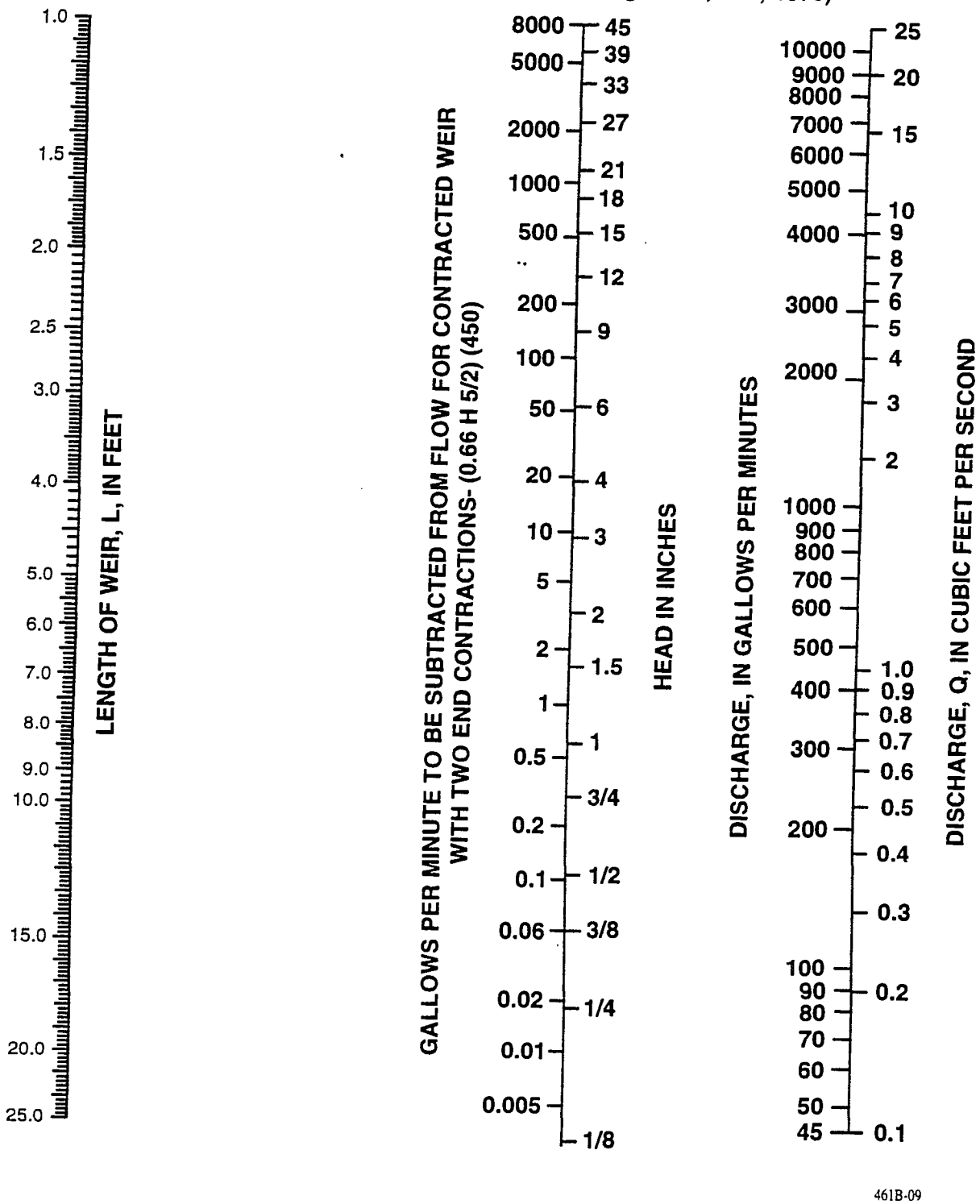

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Figure G-5

Flow Curves for Parshall Flumes
(Associated Water and Air Resource Engineers, Inc., 1973)

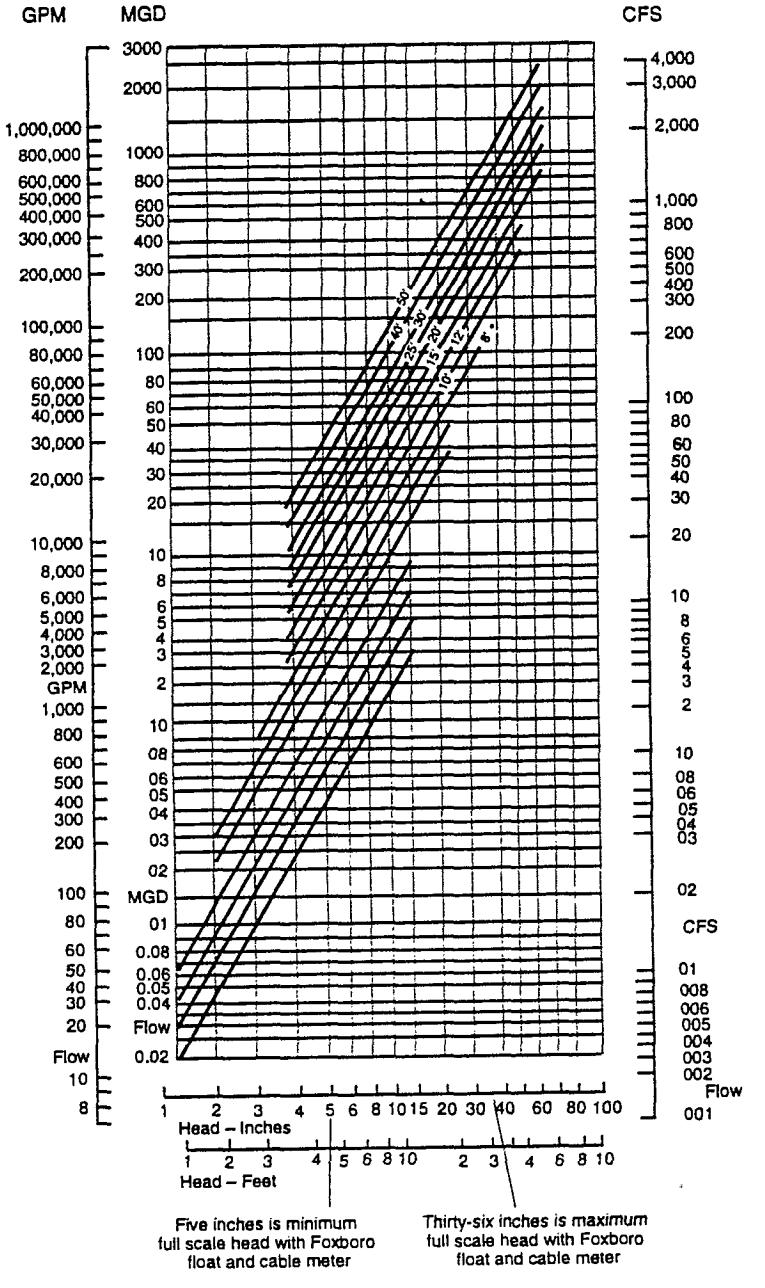

Figure G-6

Dimensions and Capacities of Parshall Measuring Flumes for Various Throat Widths (Associated Water and Air Resource Engineers, Inc., 1973)

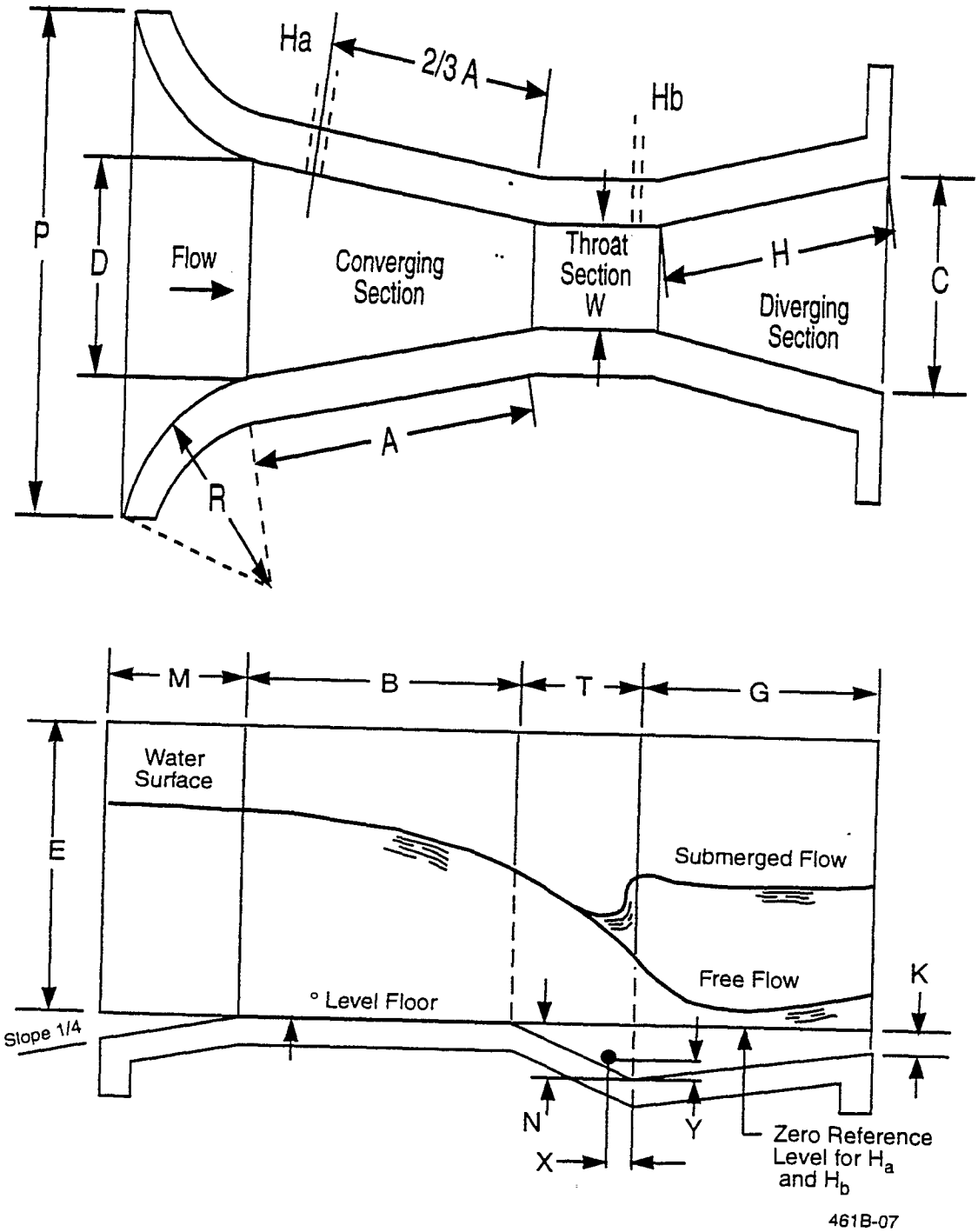

Figure G-6

Dimensions and Capacities of Parshall Measuring Flumes for Various Throat Widths (Continued)

W		A		⅔A		B		C		D		E		T		G		H		K	M		N		P		R		X	Y	Free-Flow Capacity (Second-Foot*)	
Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	In.	In.	Ft.	In.	Ft.	In.	Ft.	In.	In.	In.	Mini-mum	Maxi-mum
0	3	1	6⅜	1	¼	1	6	0	7	0	10 3/16	1-1½	0	0	6	1	0	1	5/32	1	0	0	2¼	0	0	0	0	1	1½	0.03	1.9
0	6	2	7/16	1	4 5/16	2	0	1	3½	1	3⅝	2	0	1	0	2	0	0	0	3	1	0	4½	2	11½	1	4	2	3	0.05	3.9
0	9	2	10⅝	1	11⅛	2	10	1	3	1	10⅝	2	6	1	0	1	6	0	0	3	1	0	4½	3	6½	1	4	2	3	0.09	8.9
1	0	4	6	3	0	4	4⅞	2	0	2	9¼	3	0	2	0	3	0	0	0	3	1	3	9	4	10¾	1	8	2	3	0.11	16.1
1	6	4	9	3	2	4	7⅞	2	6	3	4⅜	3	0	2	0	3	0	0	0	3	1	3	9	5	6	1	8	2	3	0.15	24.6
2	0	5	0	3	4	4	10⅞	3	0	3	11½	3	0	2	0	3	0	0	0	3	1	3	9	6	1	1	8	2	3	0.42	33.1
3	0	5	6	3	8	5	4¾	4	0	5	1⅞	3	0	2	0	3	0	0	0	3	1	3	9	7	3½	1	8	2	3	0.61	50.4
4	0	6	0	4	0	5	10⅝	5	0	6	4¼	3	0	2	0	3	0	0	0	3	1	6	9	8	10¾	2	0	2	3	1.30	67.9
5	0	6	6	4	4	6	4½	6	0	7	6⅝	3	0	2	0	3	0	0	0	3	1	6	9	10	1¼	2	0	2	3	1.60	85.6
6	0	7	0	4	8	6	10⅜	7	0	8	9	3	0	2	0	3	0	0	0	3	1	6	9	11	3½	2	0	2	3	2.60	103.5
7	0	7	6	5	0	7	4¼	8	0	9	11⅜	3	0	2	0	3	0	0	0	3	1	6	9	12	6	2	0	2	3	3.00	121.4
8	0	8	0	5	4	7	10⅛	9	0	11	1¾	3	0	2	0	3	0	0	0	3	1	6	9	13	8¼[1]	2	0	2	3	3.50	139.5

*Equals 1 cu. ft. per sec.

LEGEND:

- W Width of flume throat.
- A Length of side wall of converging section.
- ⅔A Distance back from end of crest to gauge point.
- B Axial length of converging section.
- C Width of downstream end of flume.
- D Width of upstream end of flume.
- E Depth of flume.
- T Length of flume throat.
- G Axial length of diverging section.
- H Length of side wall of the diverging section.
- K Difference in elevation between lower end of flume and crest.
- M Length of approach floor.
- N Depth of depression in throat below crest.
- P Width between ends of curved wing walls.
- R Radius of curved wing wall.
- X Horizontal distance to H_b gauge point from low point in throat.
- Y Vertical distance to H_b gauge point from low point in throat.

Figure G-7

Effect of Submergence on Parshall Flume Free Discharge (Civil Engineering, ASCE)

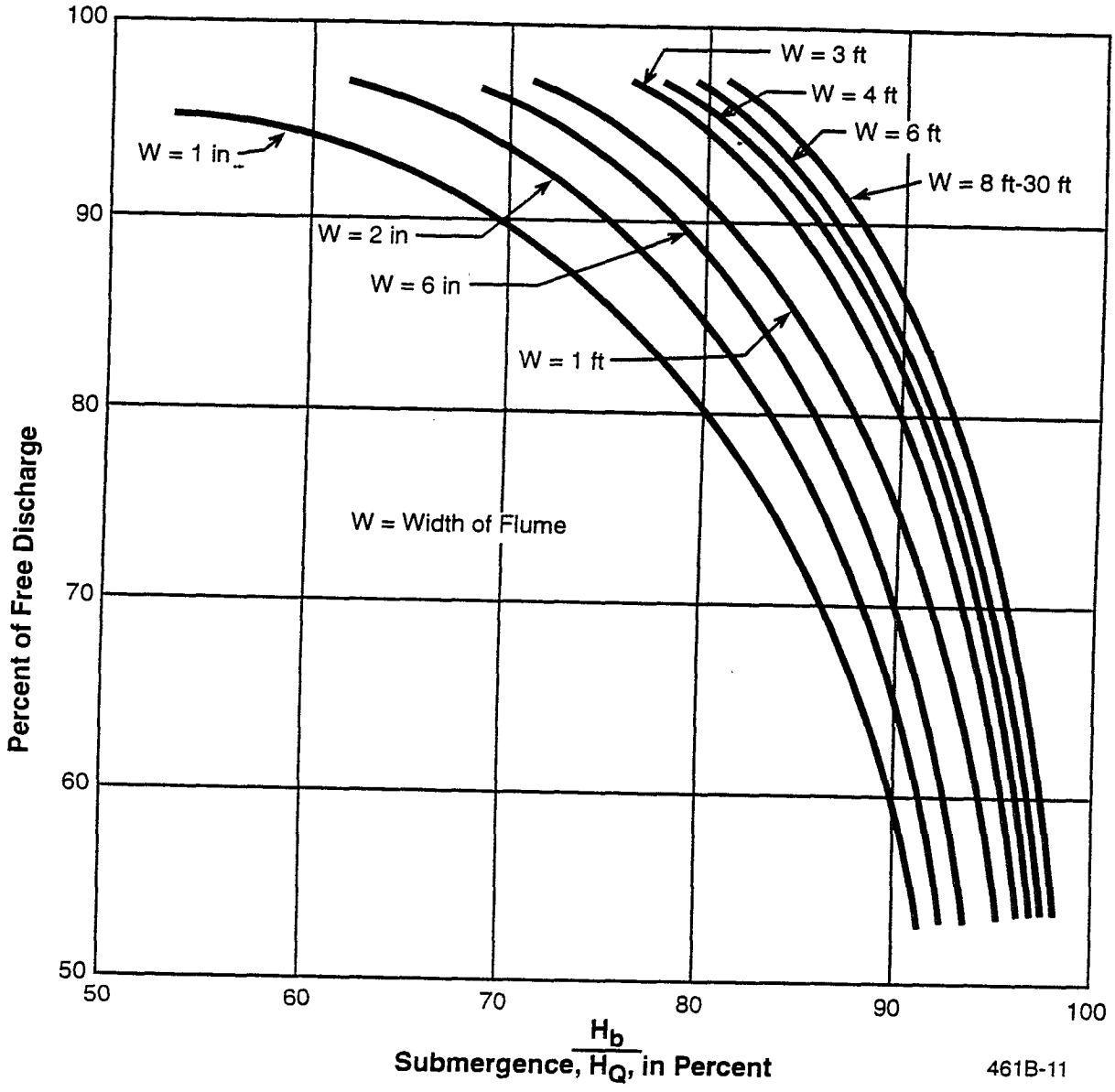

Figure G-8

Free-Flowing Palmer-Bowlus Flume

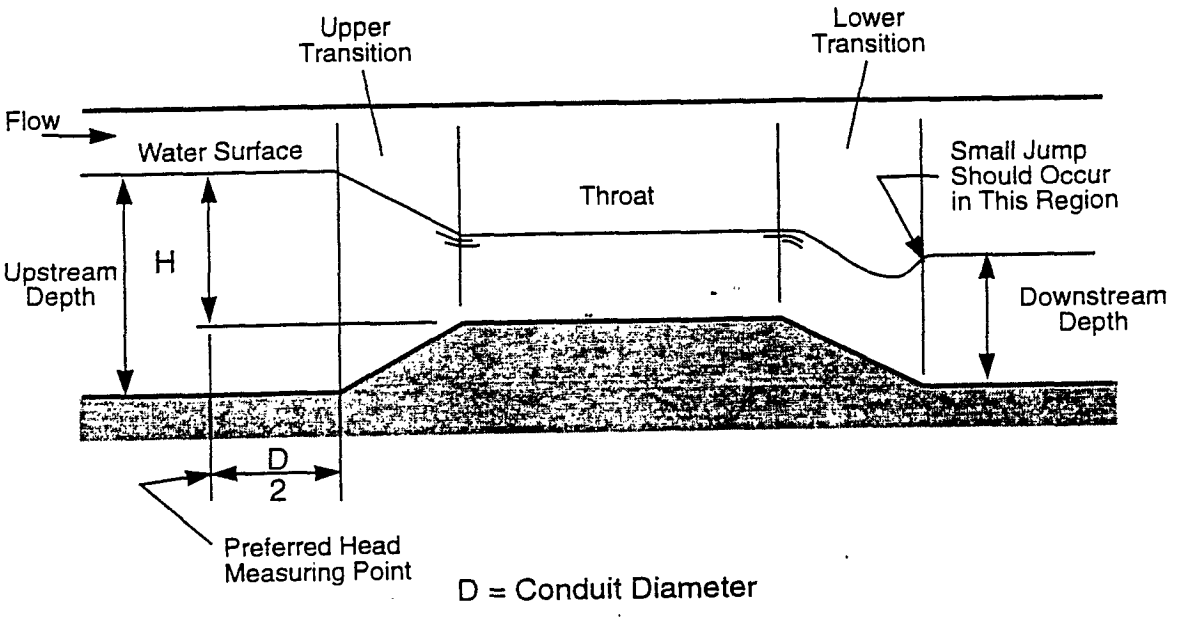

Figure G-9

Configuration and Nomenclature of Venturi Meter

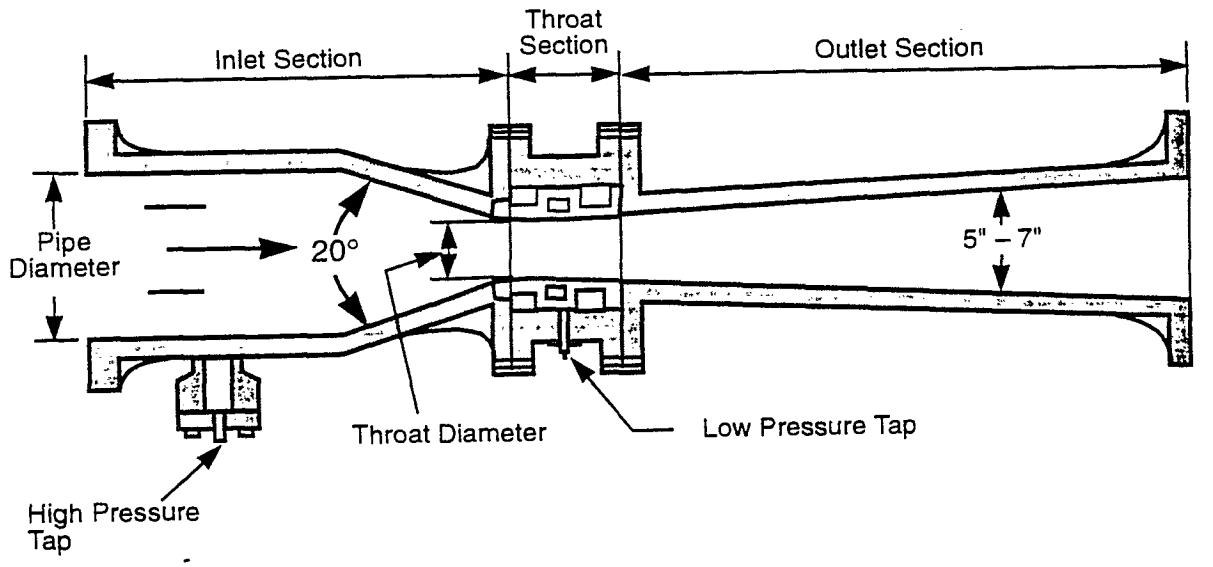

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Figure G-10

Electromagnetic Flowmeter

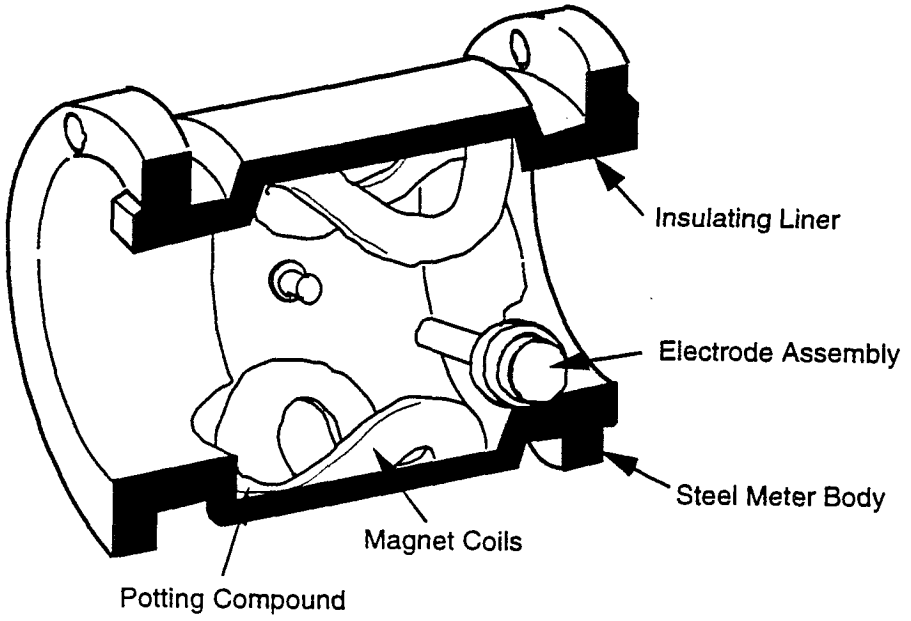
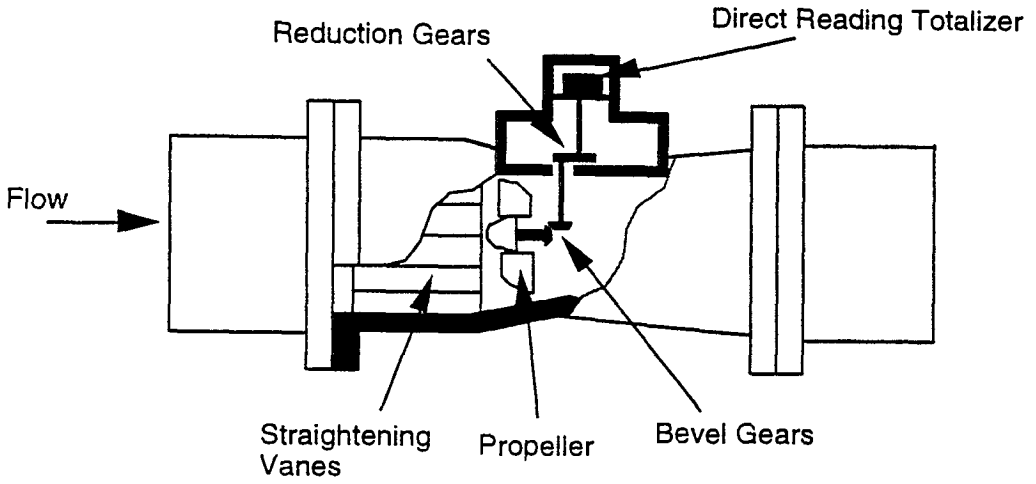


Figure G-11

Propeller Flowmeter



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APPENDIX H

RECOMMENDED EFFLUENT TOXICITY TEST CONDITIONS

Table H-1

Summary of Recommended Test Conditions for Sheepshead Minnow (*Cyprinodon variegatus*) Larval Survival and Growth Test

1.	Test type:	Static renewal
2.	Salinity:	20 °/oo to 32 °/oo ± 2 °/oo
3.	Temperature:	25 ± 2°C
4.	Light quality:	Ambient laboratory illumination
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient lab levels)
6.	Photoperiod:	14 h light, 10 h darkness
7.	Test chamber size:	300 mL - 1 L beakers or equivalent
8.	Test solution volume:	250 - 750 mL/replicate (loading and DO restrictions must be met)
9.	Renewal of test concentrations:	Daily
10.	Age of test organisms:	Newly hatched larvae (less than 24 h old)
11.	Larvae/test chamber:	15 larvae/chamber (minimum of 10)
12.	Replicate chambers/concentration:	4 (minimum of 3)
13.	Source of food:	Newly hatched Artemia) nauplii (less than 24 h old)
14.	Feeding regime:	Feed once a day 0.10 g wet weight Artemia nauplii per replicate on Days 0-2; feed 0.15 g wet weight Artemia nauplii per replicate on Days 3-6
15.	Cleaning:	Siphon daily, immediately before test solution renewal
16.	Aeration:	None, unless DO falls below 60% of saturation, then aerate all chambers. Rate should be less than 100 bubbles/min.
17.	Dilution water:	Uncontaminated source of natural seawater, or hypersaline brine or artificial seawater mixed with deionized water

R0014873

Table H-1

Summary of Recommended Test Conditions for Sheepshead Minnow (*Cyprinodon variegatus*) Larval Survival and Growth Test (Continued)

18. Effluent concentrations:	5 and a control
19. Dilution factor:	Approximately 0.3 or 0.5
20. Test duration:	7 days
21. Effects measured:	Survival and growth (weight)

R0014874

Table H-2

Summary of Recommended Test Conditions for Sheepshead Minnow (*Cyprinodon variegatus*) Embryo Larval Survival and Teratogenicity Test

1.	Test type:	Static renewal
2.	Salinity:	5 °/oo to 32 °/oo ± 2 °/oo
3.	Temperature:	25 ± 2°C
4.	Light quality:	Ambient laboratory light
5.	Light intensity:	10-20 uE/m²/s, or 50-100 ft-c (ambient laboratory levels)
6.	Photoperiod:	14 h light, 10 h darkness
7.	Test chamber size:	500 mL
8.	Test solution volume:	400 mL (minimum of 250 mL)
9.	Renewal of test concentration:	Daily
10.	Age of test organisms:	less than 24 h old
11.	No. of embryos/chamber:	15 (minimum of 10)
12.	Replicate test chambers/ concentration:	4 (minimum of 3)
13.	Embryos per concentration:	60 (minimum of 30)
14.	Feeding regime:	Feeding not required
15.	Aeration:	None unless DO falls below 60% saturation
16.	Dilution water:	Uncontaminated source of sea water; deionized water mixed with artificial sea salts, or hypersaline brine
17.	Effluent test concentrations:	5 and a control
18.	Dilution factor:	Approximately 0.3 or 0.5
19.	Test duration:	9 days
20.	Effects measured:	Percent hatch; percent larvae dead or with debilitating morphological and/or behavior abnormalities such as: gross deformities; curved spine; disoriented, abnormal swimming behavior; surviving normal larvae from original embryos

R0014875

Table H-3

Summary of Recommended Test Conditions for the Inland Silverside (*Menidia beryllina*) Larval Survival and Growth Test

1.	Test type:	Static renewal
2.	Salinity:	5 °/oo to 32 °/oo (± 2 °/oo of the selected test salinity)
3.	Temperature:	25 ± 2°C
4.	Light quality:	Ambient laboratory illumination
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient lab levels)
6.	Photoperiod:	14 h light, 10 h darkness
7.	Test chamber size:	300 mL - 1 L containers
8.	Test solution volume:	250 - 750 mL/replicate (loading and DO restrictions must be met)
9.	Renewal of test concentrations:	Daily
10.	Age of test organisms:	7 - 11 days post hatch
11.	Larvae/test chamber and control:	15 (minimum of 10)
12.	Replicate chambers/concentration:	4 (minimum of 3)
13.	Source of food:	Newly hatched Artemia nauplii
14.	Feeding regime:	Feed 0.10 g wet weight Artemia nauplii per replicate on days 0-2; feed 0.15 g wet weight Artemia nauplii per replicate on days 3-6
15.	Cleaning:	Siphon daily, immediately before test solution renewal and feeding
16.	Aeration:	None, unless DO concentration falls below 60% of saturation, then aerate all chambers. Rate should be less than 100 bubbles/min.
17.	Dilution water:	Uncontaminated source of sea water or deionized water mixed with hypersaline brine.

Table H-3

Summary of Recommended Test Conditions for the Inland Silverside (*Menidia beryllina*) Larval Survival and Growth Test (Continued)

18. Effluent concentrations:	At least 5 and a control
19. Dilution factor:	Approximately 0.3 or 0.5
20. Test duration:	7 days
21. Effects measured:	Survival and growth (weight)

Table H-4

Summary of Recommended Test Conditions for *Mysidopsis bahia* 7-Day Survival, Growth, and Fecundity Test

1.	Test type:	Static renewal
2.	Salinity:	20 °/oo to 32 °/oo ± 2 °/oo
3.	Temperature:	26 ± 27°C
4.	Photoperiod	16 h light, 8 h dark, with phase in/out period
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft.-c.)
6.	Test chamber:	8 oz plastic disposable cups, or 400 mL glass beakers
7.	Test solution volume:	150 mL per replicate cup
8.	Renewal of test solutions:	Daily
9.	Age of test organisms:	7 days
10.	Number of treatments per study:	Minimum of 5 treatments and a control
11.	Number of organisms per test chamber:	5
12.	Number of replicate chambers per treatment:	8
13.	Source of food:	Artemia nauplii
14.	Feeding regime:	Feed 150 24-h old nauplii per mysid daily, half after test solution renewal and half after 8 - 12 h.
15.	Aeration:	None unless DO falls below 60% saturation, then gently in all cups
16.	Dilution water:	Natural sea water or hypersaline brine
17.	Test duration:	7 days
18.	Dilution factor:	Survival, growth, and egg development
19.	Effects measured:	Approximately 0.3 or 0.5
20.	Cleaning:	Pipette excess food from cups daily

Table H-5

Summary of Recommended Effluent Toxicity Test Conditions for the Fathead Minnow *Pimephales promelas* Larval Survival and Growth Test

1. Test type:	Static renewal
3. Temperature(°C):	25 ± 1°C
3. Light quality:	Ambient laboratory illumination
4. Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient laboratory levels)
5. Photoperiod:	16 h light, 8 h darkness
6. Test chamber size:	500 mL
7. Test solution volume:	250 mL/replicate
8. Renewal of test concentrations:	Daily
9. Age of test organisms:	Newly hatched larvae less than 24 h old
10. No. larvae per test chamber:	15 (minimum of 10)
11. No. replicate chambers per concentration:	4 (minimum of 3)
12. No. larvae per concentration:	60 (minimum of 30)
13. Feeding regime:	Feed 0.1 mL newly hatched (less than 24-h old) brine shrimp nauplii three times daily at 4-h intervals or, as a minimum, 0.15 mL twice daily, 6 h between feedings (at the beginning of the work day prior to renewal, and at the end of the work day following renewal). Sufficient larvae are added to provide an excess. Larvae are not fed during the final 12 h of the test
14. Cleaning:	Siphon daily, immediately before test solution renewal
15. Aeration:	None, unless DO concentration falls below 40% saturation. Rate should not exceed 100 bubbles/min
16. Dilution water:	Moderately hard synthetic water is prepared using MILLIPORE MILLI-Q^R or equivalent deionized water and reagent grade chemicals or 20% DMW (see Section 7)

Table H-5

Summary of Recommended Effluent Toxicity Test Conditions for the Fathead Minnow *Pimephales promelas* Larval Survival and Growth Test (Continued)

17. Effluent concentrations:	Minimum of 5 and a control
18. Dilution factor:[1]	Approximately 0.3 or 0.5
19. Test duration:	7 days
20. Endpoints:	Survival and growth (weight)
21. Test acceptability:	80% or greater survival in controls; Average dry weight of surviving controls equals or exceeds 0.25 mg
22. Sampling requirement:	For on-site tests, samples are collected daily, and used with 24 h of the time they are removed from the sampling device. For off-site tests, a minimum of three samples are collected, and used as described in Paragraph 11.7.1
23. Sample volume required:	2.5 L/day

[1] Surface water test samples are used as collected (undiluted).

Table H-6

Summary of Recommended Effluent Toxicity Test Conditions for the Fathead Minnow *Pimephales promelas* Embryo-Larval Survival and Teratogenicity Test

1.	Test type:	Static renewal
2.	Temperature:	25 ± 1°C
3.	Light quality:	Ambient laboratory illumination
4.	Light intensity:	10-20 uE/m^2/s 50-100 ft-c (ambient laboratory levels)
5.	Photoperiod:	16 h light, 8 h darkness
6.	Test chamber size:	150-500 mL
7.	Test solution volume:	70-200 mL
8.	Renewal of test concentration:	Daily
9.	Age of test organisms:	Less than 36-h old embryos
10.	No. embryos per test chamber:	15 (minimum of 10)
11.	No. replicate test chambers per concentration:	4 (minimum of 3)
12.	No. embryos per concentration:	60 (minimum of 30)
13.	Feeding regime:	Feeding not required
14.	Aeration:	None unless DO falls below 40% saturation
15.	Dilution water:	Moderately hard synthetic water is prepared using MILLIPORE MILLI-Q^R or equivalent deionized water and reagent grade chemicals or 20% DMW (see Section 7). The hardness of the test solutions must equal or exceed 25 mg/L ($CaCO_3$) to ensure hatching.
16.	Effluent test concentrations:	5 and a control
17.	Dilution factor[1]	Approximately 0.3 or 0.5
18.	Test duration:	7 days

[1] Surface water test samples are used as collected (undiluted).

R0014881

Table H-6

Summary of Recommended Effluent Toxicity Test Conditions for the Fathead Minnow *Pimephales promelas* Embryo-Larval Survival and Teratogenicity Test (Continued)

19. Endpoint:	Combined mortality (dead and deformed organisms)
20. Test acceptability:	80% or greater survival in controls
21. Sampling requirement:	For on-site tests, samples are collected daily and used within 24 h of the time they are removed from the sampling device. For off-site tests a minimum of three samples are collected and used as described in Paragraph 11.7.1.
22. Sample volume required:	2.5 L/day

R0014882

Table H-7

Summary of Recommended Effluent Toxicity Test Conditions for the *Ceriodaphia* Survival and Reproduction Test

1.	Test type:	Static renewal
2.	Temperature(°C):	25 ± 1°C
3.	Light quality:	Ambient laboratory illumination
4.	Light intensity:	10-20 uE/m^2/s 50-100 ft-c (ambient lab levels)
5.	Photoperiod:	16 h light, 8 h darkness
6.	Test chamber size:	30 mL
7.	Test solution volume:	15 mL
8.	Renewal of test solutions:	Daily
9.	Age of test organisms:	Less than 24 h; and all released within a 8-h period
10.	No. neonates per test chamber:	1
11.	No. replicate test chambers per concentration:	10
12.	No. neonates per test concentration:	10
13.	Feeding regime:	Feed 0.1 mL each of YCT and algal suspension per test chamber daily.
14.	Aeration:	None
15.	Dilution water:	Moderately hard synthetic water is prepared using MILLIPORE MILLI-Q^R or equivalent deionized water and reagent grade chemicals or 20% DMW (see Section 7).
16.	Effluent concentrations:	Minimum of 5 effluent concentrations and a control.
17.	Dilution factor[1]	Approximately 0.3 or 0.5
18.	Test duration:	Until 60% of control females have three broods (may require more or less than 7 days).

[1] Surface water test samples are used undiluted.

R0014883

Table H-7

Summary of Recommended Effluent Toxicity Test Conditions for the *Ceriodaphia* Survival and Reproduction Test (Continued)

19. Endpoints:	Survival and reproduction
20. Test acceptability:	80% or greater survival and an average of 15 or more young/surviving female in the control solutions. At least 60% of surviving females in controls should have produced their third brood.
21. Sampling requirements:	For on-site tests, samples are collected daily, and used within 24 h of the time they are removed from the sampling device. For off-site tests, a minimum of three samples are collected, and used as described in Paragraph 12.6.1.
22. Sample volume required:	1 L

R0014884

Table H-8

Summary of Recommended Effluent Toxicity Test Conditions for the Algal (*Selenastrum capricornutum*) Growth Test

1.	Test type:	Static
2.	Temperature:	25 ± 1°C
3.	Light quality:	"Cool white" fluorescent lighting
4.	Light intensity:	86 ± 8.6 uE/M2/s (400 ± 40 ft-c)
5.	Photoperiod:	Continuous illumination
6.	Test chamber size:	125 mL or 250 mL
7.	Test solution volume:	50 mL or 100 mL
8.	Renewal of test solutions:	None
9.	Age of test organisms:	4 to 7 days
10.	Initial cell density in test chambers:	10,000 cells/mL
11.	No. replicate chambers/concentration:	3
12.	Shaking rate:	100 cpm continuous, or twice daily by hand
13.	Dilution water:	Algal stock culture medium without EDTA or enriched surface water
14.	Effluent concentrations:	Minimum of 5 and a control
15.	Dilution factor[1]:	Approximately 0.3 or 0.5
16.	Test duration:	96 h
17.	Endpoint:	Growth (cell counts, chlorophyll fluorescence, absorbance, biomass)
18.	Test acceptability:	2 X 10^5 cells/mL in the controls; Variability of controls should not exceed 20%
19.	Sample volume required:	1 L (one sample for test initiation)

[1] Surface water samples for toxicity tests are used undiluted.

R0014885

Table H-9

Summary of Test Conditions and Test Acceptability Criteria for *Ceriodaphnia dubia* Acute Toxicity Tests With Effluents and Receiving Waters

1.	Test type:	Static non-renewal, static-renewal, or flow-through
2.	Test duration:	24, 48, or 96 h
3.	Temperature:[1]	20°C ± 1°C or 25°C ± 1°C
4.	Light quality:	Ambient laboratory illumination
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient laboratory levels)
6.	Photoperiod:	16 h light, 8 h darkness
7.	Test chamber size:	30 mL (minimum)
8.	Test solution volume:	15 mL (minimum)
9.	Renewal of test solutions:	Minimum, after 48 h
10.	Age of test organisms:	Less than 24-h old
11.	No. organisms per test chamber:	Minimum, 5 for effluent and receiving water tests
12.	No. replicate chambers per concentration:	Minimum, 4 for effluent and receiving water tests
13.	No. organisms per concentration:	Minimum, 20 for effluent and receiving water tests
14.	Feeding regime:	Feed YCT and *Selenastrum* while holding prior to the test; newly-released young should have food available a minimum of 2 h prior to use in a test; add 0.1 mL each of YCT and *Selenastrum* 2 h prior to test solution renewal at 48 h
15.	Test chamber cleaning:	Cleaning not required
16.	Test solution aeration:	None

[1] Acute and chronic toxicity tests performed simultaneously to obtain acute/chronic ratios must use the same temperature and water hardness.

R0014886

Table H-9

Summary of Test Conditions and Test Acceptability Criteria for *Ceriodaphnia dubia* Acute Toxicity Tests With Effluents and Receiving Waters (Continued)

17. Dilution water:	Moderately hard synthetic water prepared using MILLIPORE MILLI-Q^{R} or equivalent deionized water and reagent grade chemicals or 20% DMW (see Section 7), receiving water, or synthetic water modified to reflect receiving water hardness.
18. Test concentrations:	Effluents: Minimum of five effluent concentrations and a control Receiving Waters: 100% receiving water and a control
19. Dilution series:	Effluents: ≥ 0.5 dilution series Receiving Waters: None, or ≥ 0.5 dilution series
20. Endpoint:	Effluents: Mortality (LC50 or NOAEC) Receiving Waters: Mortality (Significant difference from control)
21. Sampling and sample holding requirements:	Effluents and Receiving Waters: Grab or composite samples are used within 36 h of completion of the sampling period.
22. Sample volume required:	1 L
23. Test acceptability criterion:	90% or greater survival in controls

R0014887

Table H-10

Summary of Test Conditions and Test Acceptability Criteria for *Daphia pulex* and *D. magna* Acute Toxicity Tests With Effluents and Receiving Waters

1.	Test type:	Static non-renewal, static-renewal, or flow-through
2.	Test duration:	24, 48, or 96 h
3.	Temperature:[1]	20°C ± 1°C or 25°C ± 1°C
4.	Light quality:	Ambient laboratory illumination
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient laboratory levels)
6.	Photoperiod:	16 h light, 8 h darkness
7.	Test chamber size:	30 mL (minimum)
8.	Test solution volume:	25 mL (minimum)
9.	Renewal of test solutions:	Minimum, after 48 h
10.	Age of test organisms:	Less than 24-h old
11.	No. organisms per test chamber:	Minimum, 5 for effluent and receiving water tests
12.	No. replicate chambers per concentration:	Minimum, 4 for effluent and receiving water tests
13.	No. organisms per concentration:	Minimum, 20 for effluent and receiving water tests
14.	Feeding regime:	Feed YCT and *Selenastrum* while holding prior to the test; newly-released young should have food available a minimum of 2 h prior to use in a test; add 0.2 mL each of YCT and *Selenastrum* 2 h prior to test solution renewal at 48 h
15.	Test chamber cleaning:	Cleaning not required
16.	Test solution aeration:	None

[1] Acute and chronic toxicity tests performed simultaneously to obtain acute/chronic ratios must use the same temperature and water hardness.

R0014888

Table H-10

Summary of Test Conditions and Test Acceptability Criteria for *Daphia pulex* and *D. magna* Acute Toxicity Tests With Effluents and Receiving Waters (Continued)

17. Dilution water:	Moderately hard synthetic water prepared using MILLIPORE MILLI-Q^{R} or equivalent deionized water and reagent grade chemicals or 20% DMW (see Section 7), receiving water, or synthetic water modified to reflect receiving water hardness.
18. Test concentrations:	Effluents: Minimum of five effluent concentrations and a control Receiving Waters: 100% receiving water and a control
19. Dilution series:	Effluents: ≥ 0.5 dilution series Receiving Waters: None, or ≥ 0.5 dilution series
20. Endpoint:	Effluents: Mortality (LC50 or NOAEC) Receiving Waters: Mortality (Significant difference from control)
21. Sampling and sample holding requirements:	Effluents and Receiving Waters: Grab or composite samples are used within 36 h of completion of the sampling period.
22. Sample volume required:	1 L
23. Test acceptability criterion:	90% or greater survival in controls

R0014889

Table H-11

Summary of Test Conditions and Test Acceptability Criteria for Fathead Minnow (*Pinephales promelas*) Acute Toxicity Tests With Effluents and Receiving Waters

1.	Test type:	Static non-renewal, static-renewal, or flow-through
2.	Test duration:	24, 48, or 96 h
3.	Temperature:[1]	20°C ± 1°C or 25°C ± 1°C
4.	Light quality:	Ambient laboratory illumination
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient laboratory levels)
6.	Photoperiod:	16 h light, 8 h darkness
7.	Test chamber size:	250 mL (minimum)
8.	Test solution volume:	200 mL (minimum)
9.	Renewal of test solutions:	Minimum, after 48 h
10.	Age of test organisms:	1 - 14 days; 24-h range in age
11.	No. organisms per test chamber:	Minimum, 10 for effluent and receiving water tests
12.	No. replicate chambers per concentration:	Minimum, 2 for effluent tests Minimum, 4 for receiving water tests
13.	No. organisms per concentration:	Minimum, 20 for effluent tests Minimum, 40 for receiving water tests
14.	Feeding regime:	*Artemia* nauplii are made available while holding prior to the test; add 0.2 mL *Artemia* nauplii concentrate 2 h prior to test solution renewal at 48 h
15.	Test chamber cleaning:	Cleaning not required
16.	Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min

[1] Acute and chronic toxicity tests performed simultaneously to obtain acute/chronic ratios must use the same temperature and water hardness.

R0014890

Table H-11

Summary of Test Conditions and Test Acceptability Criteria for Fathead Minnow (*Pinephales promelas*) Acute Toxicity Tests With Effluents and Receiving Waters (Continued)

17. Dilution water:	Moderately hard synthetic water prepared using MILLIPORE MILLI-Q^{R} or equivalent deionized water and reagent grade chemicals or 20% DMW (see Section 7), receiving water, or synthetic water modified to reflect receiving water hardness.
18. Test concentrations:	Effluents: Minimum of five effluent concentrations and a control Receiving Waters: 100% receiving water and a control
19. Dilution series:	Effluents: ≥ 0.5 dilution series Receiving Waters: None, or ≥ 0.5 dilution series
20. Endpoint:	Effluents: Mortality (LC50 or NOAEC) Receiving Waters: Mortality (Significant difference from control)
21. Sampling and sample holding requirements:	Effluents and Receiving Waters: Grab or composite samples are used within 36 h of completion of the sampling period.
22. Sample volume required:	2 L for effluents and receiving waters
23. Test acceptability criterion:	90% or greater survival in controls

R0014891

Table H-12

Summary of Test Conditions and Test Acceptability Criteria for Mysid Shrimp (*Mysidopsis bahia*) Acute Toxicity Tests With Effluents and Receiving Waters

1.	Test type:	Static non-renewal, static-renewal, or flow-through
2.	Test duration:	24, 48, or 96 h
3.	Temperature:[1]	20°C ± 1°C or 25°C ± 1°C
4.	Light quality:	Ambient laboratory illumination
5.	Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient laboratory levels)
6.	Photoperiod:	16 h light, 8 h darkness
7.	Test chamber size:	250 mL (minimum)
8.	Test solution volume:	200 mL (minimum)
9.	Renewal of test solutions:	Minimum, after 48 h
10.	Age of test organisms:	1 - 5 days; 24-h range in age
11.	No. organisms per test chamber:	Minimum, 10 for effluent and receiving water tests
12.	No. replicate chambers per concentration:	Minimum, 2 for effluent tests Minimum, 4 for receiving water tests
13.	No. organisms per concentration:	Minimum, 20 for effluent tests Minimum, 40 for receiving water tests
14.	Feeding regime:	*Artemia* nauplii are made available while holding prior to the test; add 0.2 mL of concentrated suspension of *Artemia* nauplii ≤ 24 h old, daily (approximately 100 nauplii per mysid)
15.	Test chamber cleaning:	Cleaning not required
16.	Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min

[1] Acute and chronic toxicity tests performed simultaneously to obtain acute/chronic ratios must use the same temperature and water hardness.

R0014892

Table H-12

Summary of Test Conditions and Test Acceptability Criteria for Mysid Shrimp (*Mysidopsis bahia*) Acute Toxicity Tests With Effluents and Receiving Waters (Continued)

17. Dilution water:	5-30 °/oo ± 10%; modified GP2, Forty Fathoms®, or equivalent, artificial seawater prepared with MILLI-Q®, or equivalent, deionized water (see Section 7); or receiving water
18. Test concentrations:	Effluents: Minimum of five effluent concentrations and a control Receiving Waters: 100% receiving water and a control
19. Dilution series:	Effluents: ≥ 0.5 dilution series Receiving Waters: None, or ≥ 0.5 dilution series
20. Endpoint:	Effluents: Mortality (LC50 or NOAEC) Receiving Waters: Mortality (Significant difference from control)
21. Sampling and sample holding requirements:	Effluents and Receiving Waters: Grab or composite samples are used within 36 h of completion of the sampling period.
22. Sample volume required:	1 L for effluents 2 L for receiving water
23. Test acceptability criterion:	90% or greater survival in controls

R0014893

Table H-13

Summary of Test Conditions and Test Acceptability Criteria for Silverside (*Menidia beryllina*, *M. menidia*, and *M. peninsulae*) Acute Toxicity Tests With Effluents and Receiving Waters

1. Test type:	Static non-renewal, static-renewal, or flow-through
2. Test duration:	24, 48, or 96 h
3. Temperature:[1]	20°C ± 1°C or 25°C ± 1°C
4. Light quality:	Ambient laboratory illumination
5. Light intensity:	10-20 uE/m^2/s (50-100 ft-c) (ambient laboratory levels)
6. Photoperiod:	16 h light, 8 h darkness
7. Test chamber size:	250 mL (minimum)
8. Test solution volume:	200 mL (minimum)
9. Renewal of test solutions:	Minimum, after 48 h
10. Age of test organisms:	9 - 14 days; 24-h range in age
11. No. organisms per test chamber:	Minimum, 10 for effluent and receiving water tests
12. No. replicate chambers per concentration:	Minimum, 2 for effluent tests Minimum, 4 for receiving water tests
13. No. organisms per concentration:	Minimum, 20 for effluent tests Minimum, 40 for receiving water tests
14. Feeding regime:	*Artemia* nauplii are made available while holding prior to the test; add 0.2 mL *Artemia* nauplii concentrate 2 h prior to test solution renewal at 48 h
15. Test chamber cleaning:	Cleaning not required
16. Test solution aeration:	None, unless DO concentration falls below 4.0 mg/L; rate should not exceed 100 bubbles/min

[1] Acute and chronic toxicity tests performed simultaneously to obtain acute/chronic ratios must use the same temperature and water hardness.

R0014894

Table H-13

Summary of Test Conditions and Test Acceptability Criteria for Silverside (*Menidia beryllina, M. menidia,* and *M. peninsulae*) Acute Toxicity Tests With Effluents and Receiving Waters (Continued)

17. Dilution water:	Modified GP2, Forty Fathoms[R], or equivalent, artificial seawater prepared with MILLI-Q[R], or equivalent, deionized water (see Section 7); or receiving water: 1-32 °/oo ± 10% for *M. beryllina*; 15-32 °/oo ± 10% for *M. menidia* and *M. peninsulae*
18. Test concentrations:	Effluents: Minimum of five effluent concentrations and a control Receiving Waters: 100% receiving water and a control
19. Dilution series:	Effluents: ≥ 0.5 dilution series Receiving Waters: None, or ≥ 0.5 dilution series
20. Endpoint:	Effluents: Mortality (LC50 or NOAEC) Receiving Waters: Mortality (Significant difference from control)
21. Sampling and sample holding requirements:	Effluents and Receiving Waters: Grab or composite samples are used within 36 h of completion of the sampling period.
22. Sample volume required:	1 L for effluents 2 L for receiving water
23. Test acceptability criterion:	90% or greater survival in controls

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APPENDIX I

SLUDGE INSPECTION CHECKLISTS

PERMIT VERIFICATION

Yes No N/A 1. Are 40 *CFR* Part 503 sludge use and disposal requirements contained in a current NPDES permit, in a separate "sludge only" NPDES permit, in a RCRA Subtitle C permit, or in a CAA permit? [503.3 (a) (1) or (2)] (1)

2. Sludge use and disposal practice(s):

a. Land Application _____ [503.10]

Bulk Sewage Sludge _____ [503.11(e)]
Bulk Material Derived From Sewage Sludge _____ [503.11(e)]

or

Sold or Given Away in a Bag or Other Container _____ [503.11(j)]

b. Surface Disposal _____ [503.20]

c. Sewage Sludge Incineration [503.40]

d. On or Off Site Storage _____ [503.9(y)]

Date storage began _____ ended _____

(Maximum time allowed: 2 years from February 19, 1993)

e. Other (list) _____

Yes No N/A 3. Each sludge use or disposal practice is permitted? [503.3(a) (1)] (1)

Yes No N/A 4. Notification is given to EPA/State of new or different sludge disposal method? [Permit]

Yes No N/A 5. Number and location of disposal sites/activities are as described in the permit or fact sheet or land application plan (40 *CFR* Part 501)? [Permit]

Comments:

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RECORDKEEPING AND REPORTING EVALUATION

Yes	No	N/A	1.	Self-monitoring data are available for all regulated pollutants? [503.17], [503.27], [503.43]
Yes	No	N/A	2.	Pathogen and vector attraction reduction method description and certification statement available? [503.17], [503.27]
Yes	No	N/A	3.	Records are available for all use or disposal practices? [503.17], [503.27], [503.47]
Yes	No	N/A	4.	Accurate records of sludge volume or mass are maintained, when appropriate? [503.25], [503.47]
Yes	No	N/A	5.	Monitoring and analyses are performed more often than required by permit? If so, results are reported in the permittee's self-monitoring report? [Permit]
Yes	No	N/A	6.	Unit operations records verify compliance with pathogen and vector attraction reduction requirements, when appropriate? [503.15], [503.25]
Yes	No	N/A	7.	Self-monitoring is conducted at the frequency specified in the permit, in 503.16 Table 1 (land application), or in 503.26 Table 1 (surface disposal)? [503.16], [503.26] or [503.46 Table 1 (incineration)] (Production dependent 0-289 mtpy: 1/yr., 290-1499 mtpy: 1/qtr., 1500-14999 mtpy: 1/2 mo., 15000 mtpy and greater, 1/mo.) mtpy-metric ton per year
Yes	No	N/A	8.	Facility reports sludge monitoring data at the frequency specified in the permit? (Only for Class I facilities, total design flow >1 mgd, or serving >10,000 people) [503.18], [503.28], [503.48]
Yes	No	N/A	9.	Sludge records are maintained for at least 5 years? [503.17], [503.27], [503.47]
Yes	No	N/A	10.	Sludge data are reported on Discharge Monitoring Report (DMR) or approved form? [Permit]
Yes	No	N/A	11.	Sludge records are adequate to assess compliance with annual and/or cumulative pollutant loading rates or other established permit limits? [503.13(a) (2) (i)], [503.13(a) (4) (ii)]

Comments:

R0014898

SLUDGE SAMPLING AND ANALYSIS EVALUATION

Yes No N/A 1. Sludge samples are taken at locations specified in the permit? [Permit]

Yes No N/A 2. Sludge sample locations are appropriate for obtaining representative samples? [503.8(a)]

Yes No N/A 3. Sampling and analysis are conducted for parameters specified in the permit or in 40 *CFR* Part 503? [Permit], [503.13], [503.23], [503.46]

4. Sample collection procedures

Yes No N/A a. Adequate sample volumes are obtained?
Yes No N/A b. Proper preservation techniques are used?
Yes No N/A c. Containers conform to appropriate analytical method specified in 40 *CFR* Part 503.8?
Yes No N/A d. Samples analyzed in the appropriate timeframes in accordance with 40 *CFR* Part 503.8?

Yes No N/A 5. Are results reported on a dry weight basis? [503.13], [503.23], [503.43]

(Dry weight concentration = Wet weight concentration/Decimal fraction of solids)

e.g. A sludge containing 20 mg/l Cu and having 5% solids.

$$\text{Dry weight Cu (mg/kg)} = \frac{20 \text{ mg/l}}{0.05} = 400 \text{ mg/kg}$$

Yes No N/A 6. Sample is refrigerated subsequent to compositing?

Yes No N/A 7. Chain-of-custody procedures are employed?

Yes No N/A 8. Analytical methods used are approved methods of 40 *CFR* Part 503.8?

Comments:

R0014899

UNIT PROCESSES

General Sludge Processes

Yes	No	N/A	1.	Sludge process control parameters maintained as appropriate?
Yes	No	N/A	2.	Adequate equipment redundancy (e.g., back-up units)?
Yes	No	N/A	3.	Adequate sludge storage capacity?
Yes	No	N/A	4.	Contingency plan for sludge disposal practice?
Yes	No	N/A	5.	Solids handling operation adequate to manage volume of sludge?

Comments:

Drying Beds, Gravity Thickener, Centrifuge, and Dissolved Air Flotation

Yes	No	N/A	1.	Is primary unstabilized sludge fed to the thickener, centrifuge or drying bed?
				If yes, list percentage of unstabilized sludge _____.
			2.	What is the average % solids of the sludge before thickening, drying or centrifuging? _____ % after? _____ %
Yes	No	N/A	3.	Is sludge mixed with other materials before or after thickening?
Yes	No	N/A	4.	For sludge containing unstabilized solids, is the percent solids greater than 90% prior to mixing with other materials?
Yes	No	N/A	5.	For sludge containing no unstabilized solids, is the percent solids greater than 75% prior to mixing with other materials?

Comments:

UNIT PROCESSES (Continued)

Anaerobic Digestion

1. Sludge fed to digester(s) includes:
   ___Primary ___Secondary ___Combined

2. Digester(s) operating mode:
   ___high rate ___ low rate

Yes No N/A 3. Digester(s) are operated at proper temperature [mesophilic: 95°F (35°C) and thermophilic: 131°F (55°C)?

List operating mode ___ mesophilic
___ thermophilic

Yes No N/A 4. Temperature monitoring location and frequency sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP?

Average Temperature: ____°C or °F

Yes No N/A 5. Solids Retention Time (SRT) or Mean Cell Residence time (MCRT) calculated properly?*

Yes No N/A 6. SRT or MCRT sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP?

Average SRT or MCRT: ____days

*For batch operated digesters with no recycle:

$$\text{SRT or MCRT} = \frac{\text{Mass of solids in digester, kg}}{\text{Solids removed, kg/day}}$$

This formula can be used to estimate SRT or MCRT for all digester systems. For calculating SRT or MCRT for other system configurations, use the WEF Manual of Practice or other references. Always write down the calculation used by the facility no matter what the configuration is.

Comments:

UNIT PROCESSES (Continued)

Aerobic Digestion

1. Sludge fed to digester(s) includes:
___Primary ___Secondary ___Combined

2. Digester(s) operating mode:
___high rate ___ low rate

Yes No N/A 3. Digester(s) are operated at proper temperature [cryophilic: <50°F (<10°C), mesophilic: 50-108°F (10-42°C), and thermophilic: >108°F (42°C)]?

List operating mode ___ cryophilic
___ mesophilic ___ thermophilic

Yes No N/A 4. Temperature monitoring location and frequency sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP or with Class A pathogen reduction requirements for PFRP (Thermophilic aerobic digestion only)?

Average Temperature: ____°C or °F

Yes No N/A 5. Solids Retention Time (SRT) or Mean Cell Residence time (MCRT) calculated properly?*

Yes No N/A 6. SRT or MCRT sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP or with Class A pathogen reduction requirements for PFRP (Thermophilic digestion only)?

Average SRT or MCRT: ____days

Yes No N/A 7. Aerobic conditions verified through dissolved oxygen monitoring?

*For batch operated digesters with no recycle:

$$\text{SRT or MCRT} = \frac{\text{Mass of solids in digester, kg}}{\text{Solids removed, kg/day}}$$

This formula can be used to estimate SRT or MCRT for all digester systems. For calculating SRT or MCRT for other systems configurations, use the WEF Manual of Practice or other references. Always write down the calculation used by the facility no matter what the configuration is.

Comments:

R0014902

UNIT PROCESSES (Continued)

Composting

1. Type of composting performed:

____ In vessel ____ Static piles ____ Windrows

2. Type of sludge composted:

____ Primary ____ Secondary ____ Combined

Yes No N/A 3. Is the moisture content monitored?

Yes No N/A 4. Is compost mixed? Method _____

Frequency of turnings? _____

Yes No N/A 5. Is oxygen content monitored?

Yes No N/A 6. Is temperature monitored?

Yes No N/A 7. Are total and total volatile solids monitored?

8. Active phase ____ days
Curing phase ____ days

Yes No N/A 9. Is site runoff treated? Where? _____

Yes No N/A 10. Temperature monitoring location and frequency sufficient to demonstrate compliance with Class B pathogen reduction requirements for PSRP or with Class A pathogen reduction requirements for PFRP?

Yes No N/A 11. Temperature and/or oxygen monitoring sufficient to determine compliance with vector attraction reduction requirements?

Comments:

R0014903

LAND APPLICATION OF SEWAGE SLUDGE

Yes No N/A 1. Sewage sludge or material derived from sewage sludge is land applied to:

Agricultural Land _____ Forest _____
Public Contract Site (park, etc.) _____
Reclamation Site _____ Lawn or Home Garden _____

Yes No N/A 2. Do monitoring results show pollutant concentrations below values shown in 40 *CFR* Part 503.13(b)(1) Table 1? [503.13(a)(1)] (2)

Yes No N/A 3. Do monitoring results show pollutant concentrations below values shown in 40 *CFR* Part 503.13(b)(3)? (3)

4. Classifications of Sewage Sludge with respect to Pathogens: [503.30] (4)

Class A_____ Class B_____ Unknown_____

Yes No N/A 5. Are Class A Pathogen reductions requirements met? [503.15(a)] (4)

6. Indicate which method is used to meet Class A requirements: [503.32(a)]

___ Fecal coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Time/Temperature requirements. [503.32(a)(3)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and pH requirements. [503.32(a)(4)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova reduction requirements. [503.32(a)(5)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova density requirements. [503.32(a)(6)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Process to Further Reduce Pathogens (PFRP). [503.32(a)(7)] and [503 Appendix B] (5)

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and equivalent PFRP. [503.32(a)(8)] and [503 Appendix B] (5)

LAND APPLICATION OF SEWAGE SLUDGE (Continued)

Yes No N/A 7. Are Class B Pathogen reduction requirements met? [503.32(b)] (4)

8. Indicate which method(s) is used to meet Class B requirements:

___ Geometric mean of seven samples which Fecal Coliform <2,000,000 MPN/g total solids or <2,000,000 Colony Forming Units/g total solids. [503.32(b)(2)]

___ Treated by Process to Significantly Reduce Pathogens (PSRP). [503.32(b)(3)] and [503 Appendix B] (5)

___ Treated by equivalent PSRP. [503.32(b)(4)] and [503 Appendix B] (5)

Yes No N/A 9. For Class B sludge which is land applied, are Site Restrictions practiced? [503.32 (b)(5)] (4)

10. Indicate Site Restrictions practiced where applicable:

___ Food crops (above ground) are harvested >14 months after application of sewage sludge? [503.32(b)(5)(i)]

___ Food Crops (below ground) are harvested >20 months after application of sewage sludge when sludge stays on land for >4 months prior to incorporation into soil? [503.32(b)(5)(ii)]

___ Food Crops (below ground) are harvested >38 months after application of sewage sludge when sludge stays on land for <4 months prior to incorporation into soil? [503.32(b)(5)(iii)

___ Food Crops, feed crops, and fiber crops are harvested >30 days after application of sewage sludge? [503.32(b)(5)(iv)]

___ Animal grazing allowed on land only >30 days after application of sewage sludge? [503.32(b)(5)(v)]

___ Turf grown on land where sewage sludge was applied placed on high public expose land or lawn is harvested >1 year after application of sewage sludge? [503.32(b)(5)(vi)]

___ Public access is restricted to land with a potential for high public exposure for 1 year? [503.32(b)(5)(vii)]

___ Public access is restricted to land with a potential for low public exposure for 30 days? [503.32(b)(5)(viii)]

LAND APPLICATION OF SEWAGE SLUDGE (Continued)

Yes No N/A

11. Is a Vector Attraction Reduction method practiced? [503.15(c)] (6)

12. Indicate Vector Attraction Reduction method: [503.33(b)]

___ 38% Volatile Solids Reduction. [503.33(b)(1)] (7)

___ 40 day test - Volatile Solids reduced <17%. [503.33(b)(2)] (Anaerobic Digestion Only)

___ 30 day test - Volatile Solids reduced <15%. [503.33(b)(3)] (Aerobic Digestion Only)

___ Specific Oxygen Uptake Rate (SOUR) <=1.5 mg/hr/gm TS @ 20°C. [503.33(b)(4)]

___ Aerobic Process for >14 days @ >40°C with average sludge temperatures >45°C. [503.33(b)(5)]

___ pH >12 for 2 hours and pH >11.5 for 22 hours [503.33(b)(6)]

___ Sludge (with no unstabilized solids) contains >75% Total Solids prior to mixing with other materials. [503.33(b)(7)]

___ Sludge (contains unstabilized solids) contains >90% Total Solids prior to mixing with other materials. [503.33(b)(8)]

___ Subsurface Injection. [503.33(b)(9)]

___ Soil Incorporation. [503.33(b)(10)]

Yes No N/A

13. Are general requirements (503.12) and management practices (503.14) applied for sludge not meeting Table 3 pollutant concentrations, Class pathogen reduction requirements, and vector attraction reduction methods? [503.10], [503.12], [503.14]

14. Indicate management practices where applicable:

_____No threatened or endangered species present or critical habitat affected at the location(s) where bulk sludge is applied.

___ Bulk sludge not applied to frozen or snow covered ground.

___ Bulk sludge applied >10 meters from waters of the U.S.

LAND APPLICATION OF SEWAGE SLUDGE (Continued)

___ Bulk sludge applied at a rate equal to or less than agronomic rate.

___ Label affixed on bag or information sheet provided to user of sold and given away sludge indicating name of sludge preparer, application instructions, and maximum annual whole sludge application rate.

15. Indicate general requirements practiced where applicable:

___ Sludge is not applied to a site where the cumulative pollutant loading or annual application rate has been reached.

___ Notification given to the sludge applier regarding total nitrogen content of the sludge.

___ Sufficient information required to comply with 40 *CFR* Part 503 is given to preparers/appliers/land owners.

___ Written notification given to permitting authority (including States) regarding the location of land application sites, appropriate NPDES permit numbers.

Yes No N/A 16. Description of how management practices are met for each land application site available?

Comments:

R0014907

LAND APPLICATION OF SEWAGE SLUDGE (Continued)

FOOTNOTES

(1) Permits are not required -503 is self-implementing. 503 does not require industrial sludges or grit and screenings.

(2) 503.13(b)(1), Table 1 values must be met to land apply sludge:

Table 1 (mg/kg)

Arsenic	75	Mercury	57
Cadmium	85	Molybdenum	75
Chromium	3000	Nickel	420
Copper	4300	Selenium	100
Lead	840	Zinc	7500

(3) 503.13(b)(3), Table 3 must be met for any sludge applied to a lawn or home garden. For bulk sludge, Table 3 must be met or the sludge is subject to cumulative loading limits in 503.13(b)(2). For sewage sludge sold and given away in a bag or other container, Table 3 must also be met or the sludge is subject to annual pollutant loadings in 503.13(b)(4). This also signals that additional recordkeeping requirements of 503.12 and 503.17 apply.

Table 1 (mg/kg)

Arsenic	41	Mercury	17
Cadmium	39	Molybdenum	18
Chromium	1200	Nickel	420
Copper	1500	Selenium	36
Lead	300	Zinc	2800

(4) Class A requirements must be met when bulk sludge is land applied to a lawn or home garden, or when sewage sludge is sold or given away in a bag or other container. Also, Class A requirements or Class B requirements combined with appropriate site restrictions must be met for when bulk or bulk material derived from sludge is applied to agricultural land, reclamation site, forest, or public contact site.

(5) Process to Significantly Reduce Pathogens (PSRP)—Includes Aerobic Digestion, Air Drying, Anaerobic Digestion, Composting, and Lime Stabilization. Process to Further Reduce Pathogens (PFRP)—Includes Composting, Heat Drying, Heat Treatment, Thermophilic Aerobic Digestion, Beta Ray Irradiation, Gamma Ray Irradiation, and Pasteurization. Each process has required operating conditions to demonstrate compliance. See 503 Appendix B and Unit Process Checklists.

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LAND APPLICATION OF SEWAGE SLUDGE (Continued)

FOOTNOTES

(6) One of the methods 503.33(b)(1)-(10) must be used when land applying bulk sewage sludge to agricultural land, forest, a public contact site, or a reclamation site. One of the methods 503.33(b)(1)-(8) must be met when land applying bulk sludge to a lawn or home garden, or when sewage sludge or derived material is sold or given away in a bag or other container.

(7) Volatile solids reduction through the sludge treatment train only is calculated using the following general formula:

$$\% \text{ VS Reduction} = \frac{(\text{Mass of solids in, kg} \cdot X \text{ Mass of solids out, kg}) \times 100}{\text{Mass of solids in, kg}}$$

Variations of this formula are presented in the document *Environmental Regulations and Technology-Control of Pathogens and Vector Attraction in Sewage Sludge*, EPA-625/R-92/013. See for specific calculations.

R0014909

SURFACE DISPOSAL

Yes No N/A 1. Does each Surface Disposal Unit (SDU) have a liner and leachate collection system?

2. Smallest distance from active SDU boundary to property boundary is _____ ft.

Yes No N/A 3. For an active SDU (property boundary is greater that 150 meters from SDU) and without a liner or leachate collection system, do monitoring results show pollutant concentrations below values shown in 40 *CFR* Part 503.23(a)(1) Table 1? [503.23(a)(1)] (1)

Yes No N/A 4. For an active SDU without a liner and leachate collection system (property boundary is less than 150 meters from SDU), do monitoring results show pollutant concentrations below values shown in 40 *CFR* Part 503.23(a)(2) Table 2? [503.23(a)(1)] (2)

Yes No N/A 5. Are management practices employed? [503.24]

6. List management practices where applicable:

___ No threatened or endangered species present or critical habitat affected at the location where bulk sludge is surface disposed.

___ Surface disposal unit shall not restrict flow of base flood.

___ If in seismic impact zone, design will withstand recorded horizontal ground acceleration.

___ Located > 60 meters from any fault displaced in Holocene time.

___ Not located in unstable area or wetlands.

___ Runoff collection and treatment with 25-year 24-hour storm runoff event storage capacity.

___ Leachate collection system operated and maintained for 3 years after closure of the surface disposal unit.

___ Leachate treated and disposed of in accordance with applicable requirements, i.e., NPDES permit?

___ Is methane contained under covered units at a concentration less than 25% of the LEL for methane?

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SURFACE DISPOSAL (Continued)

___ Is methane contained under a final cover placed on a closed unit maintained at a concentration less than 25% of the LEL for methane for three years after closure?

___ Is methane concentration at the property line maintained at a concentration less that the LEL for methane for three years after closure of the unit?

___ No feed or food crops grown on active unit. (3)

___ No animal grazing allowed on active unit. (3)

___ Public access restricted for the period of time while a unit is active and for three years after last active unit in a site closes.

___ Sludge placed in an active unit does not contaminate groundwater aquifers. (4)

Yes No N/A 7. Is a Vector Attraction Reduction method practiced? [503.25(b)] (5)

8. Indicate Vector Attraction Reduction method: [503.33(b)]

___ 38% Volatile Solids reduction. [503.33(b)(1)]

___ 40 day test - Volatile solids reduced <17%. [503.33(b)(2)] (Anaerobic Digestion Only)

___ 30 day test - Volatile Solids reduced <15%. [503.33(b)(3)] (Aerobic Digestion Only)

___ Specific Oxygen Uptake Rate (SOUR) ≤1.5 mg/hr/gm TS @ 20°C. [503.33(b)(4)]

___ Aerobic Process for >14 days @ >40° C with average sludge temperature >45° C. [503.33(b)(5)]

___ pH >12 for 2 hours and pH >11.5 for 22 hours [503.33(b)(6)]

___ Sludge (with no unstabilized solids) contains >75% Total Solids prior to mixing with other materials. [503.33(b)(7)]

___ Sludge (contains unstabilized solids) contains >90% Total Solids prior to mixing with other materials. [503.33(b)(8)]

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SURFACE DISPOSAL (Continued)

___ Subsurface Injection. [503.33(b)(9)]

___ Soil Incorporation. [503.33(b)(10)]

___ Sludge covered with soil or other material at the end of the day. [503.33(b)(11)]

9. Classification of Sewage Sludge with respect to Pathogens: [503.30]

Class A_____ Class B_____ Unknown_____

Yes No N/A 10. Are Class A Pathogen reduction requirements met? [503.25(a)] (6)

11. Indicate which method is used to meet Class A requirements: [503.32(a)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Time/Temperature requirements. [503.32(a)(3)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and pH requirements. [503.32(a)(4)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova reduction requirements. [503.32(a)(5)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and enteric viruses or helminth ova density requirements. [503.32(a)(6)]

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and Process to Further Reduce Pathogens (PFRP). [503.32(a)(7)] and [503 Appendix B] (7)

___ Fecal Coliform <1000 MPN/g total solids, or Salmonella <3 MPN/4 g total solids, and equivalent PFRP. [503.32(a)(7)] and [503 Appendix B] (7)

Yes No N/A 12. Are Class B pathogen reduction requirements met? [503.32(b)] (6)

R0014912

SURFACE DISPOSAL (Continued)

13. Indicate which method(s) is used to meet Class B requirements:

___ Geometric mean of seven samples with Fecal Coliform <2,000,000 MPN/g total solids or <2,000,000 Colony Forming Units/g total solids. [503.32(b)(2)]

___ Treated by Process to Significantly Reduce Pathogens. [503.32(b)(3)] and [503 Appendix B] (7)

___ Treated by equivalent Process to Significantly Reduce Pathogens. [503.32(b)(4)] and [503 Appendix B] (7)

Yes No N/A 14. Have any SDUs been closed?

Yes No N/A 15. Has facility submitted closure and post closure plan for any active SDU 180 days prior to closing? [503.22(c)]

Comments:

SURFACE DISPOSAL

FOOTNOTES

(1) Table 1 of 503.23(a)(1) must be met for all sludge placed in an active surface disposal unit with a distance of greater than 150 meters from the boundary of the surface disposal unit to the property line. Site specific limits can also be set by the permitting authority in accordance with 503.23(b).

Table 1 (dry weight basis)

Pollutant	Concentration (mg/kg)
Arsenic	73
Chromium	600
Nickel	420

(2) Table 2 of 503.23(a)(2) must be met for all sludge placed in an active surface disposal unit with a distance of less than 150 meters from the boundary of the surface disposal unit to the property line. Site specific limits can also be set by the permitting authority in accordance with 503.23(b).

Table 2 (dry weight basis)

Unit boundary to property line Distance (meters)	Pollutant Concentration (mg/kg) Arsenic	Chromium	Nickel
0 to less than 25	30	200	210
25 to less than 50	34	220	240
50 to less than 75	39	260	270
75 to less than 100	46	300	320
100 to less than 125	53	360	390
125 to less than 150	62	450	420

(3) Unless specific approval from the permitting authority has been obtained by the facility.

(4) Facility must have results of groundwater monitoring study developed by a qualified groundwater scientist or a certification from a qualified groundwater scientist to demonstrate no contamination.

(5) Facility must meet vector attraction reduction requirements of 503.33(b) to surface dispose sludge.

SURFACE DISPOSAL

FOOTNOTES (Continued)

(6) Facility must meet Class A pathogen reduction requirements of 503.32(a) or Class B 503.32(b)(2) through (b)(4) unless vector attraction reduction method 503.33(b)(11), covering sludge at the end of the day, is used.

(7) Process to Significantly Reduce Pathogens (PSRP) - Includes Aerobic Digestion, Air Drying, Anaerobic Digestion, Composting, and Lime Stabilization. Process to Further Reduce Pathogens (PFRP) - Includes Composting, Heat Drying, Heat Treatment, Thermophilic Aerobic Digestion, Beta Ray Irradiation, Gamma Ray Irradiation, and Pasteurization. Each process has required operating conditions to demonstrate compliance. See 503 Appendix B and Unit Process Checklist.

R0014915

SEWAGE SLUDGE INCINERATION

Yes No N/A 1. Does the incinerator meet the definition of a sewage sludge incinerator?

Yes No N/A 2. Do sewage sludge monitoring results show pollutant concentrations below permit limits?

Yes No N/A 3. Does THC monitoring show concentrations below 100 ppm (monthly average)?

Yes No N/A 4. Are there instruments installed that continuously measure and record THC (or alternatively CO), oxygen concentration, moisture content, and combustion temperatures?

Yes No N/A 5. Is the THC instrument calibrated as required by 503.45 (once every 24-hour period using propane) or the permit?

Yes No N/A 6. Are the other instruments calibrated as required by the permit?

Yes No N/A 7. Are the instruments operated and maintained as specified by the permit?

8. How many times was the incinerator operated at above the maximum combustion temperature specified in the permit? __

   For how long was the incinerator in operation above the maximum combustion temperature? _____

9. How many times was the incinerator operated outside the range of the air pollution control devices operating parameters specified in the permit? _____

   For how long was the incinerator in operation outside the ranges? _____

Yes No N/A 10. Are the following records maintained:

Yes No N/A Concentration of lead, arsenic, cadmium, chromium, and nickel in the sewage sludge fed to the sewage sludge incinerator.

Yes No N/A THC concentrations in the exit gas.

Yes No N/A Information that indicates NESHAP for beryllium in Subpart C of 40 *CFR* Part 61 are met.

R0014916

SEWAGE SLUDGE INCINERATION (Continued)

Yes	No	N/A		Information that indicates NESHAP for mercury in Subpart E of 40 *CFR* Part 61 are met.
Yes	No	N/A		Combustion temperatures, including maximum combustion temperature.
Yes	No	N/A		Values for air pollution control device operating parameters
Yes	No	N/A		Oxygen concentration.
Yes	No	N/A		Information used to measure moisture content in the exit gas.
Yes	No	N/A		Sewage sludge feed rate.
Yes	No	N/A		Stack height of incinerator.
Yes	No	N/A		Dispersion factor for the site.
Yes	No	N/A		Control efficiency for lead, arsenic, cadmium, chromium, and nickel.
Yes	No	N/A		Risk specific concentration for chromium (if applicable).
Yes	No	N/A		Calibration and maintenance log for the instruments used to measure THC (or CO), oxygen concentration, moisture content, and combustion temperatures.
Yes	No	N/A		Are these records maintained for 5 years?
Yes	No	N/A	11.	Have all instances of noncompliance been reported as specified by the permit?

Comments:

APPENDIX J

APPROVED METHODS FOR THE ANALYSIS OF SEWAGE SLUDGE (40 *CFR* 503)

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Arsenic	AA Gaseous Hydride SW-845 Method 7061 AA Furnace SW-846 Method 7060 Inductively Coupled Plasma SW-846 method 6010	6 Months Cool 4°C Plastic or Glass Container Samples need to be digested prior to analysis	All samples must be digested using SW-846 Method 3050 (using equivalent to 1 gram dry weight prior to analysis by any of the procedures indicated. The AA Direct Aspiration analyses are applicable at moderate concentration levels in clean complex matrix systems. AA Furnace methods can increase sensitivity if matrix effects are not severe. Inductively Coupled Plasma (ICP) methods are applicable over a broad linear range and are especially sensitive for refractory elements. Detection limits for AA Furnace methods are generally higher than for ICP methods.
Cadmium	AA Direct Aspiration SW-846 Method 7130 AA Furnace SW-846 Method 7131 Inductively Coupled Plasma SW-846 Method 6010		
Chromium	AA Direct Aspiration SW-846 Method 7190 AA Furnace SW-846 Method 7191 Inductively Coupled Plasma SW-846 Method 6010		
Copper	AA Direct Aspiration SW-846 Method 7210 Inductively Coupled Plasma SW-846 Method 6010		

R0014919

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503) (Continued)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Lead	AA Direct Aspiration SW-846 Method 7420 AA Furnace SW-846 Method 7421 Inductively Coupled Plasma SW-846 Method 6010		
Molybdenum	AA Direct Aspiration SW-846 Method 7480 AA Furnace SW-846 Method 7481 Inductively Coupled Plasma SW-846 Method 6010		
Nickel	AA Direct Aspiration SW-846 Method 7520 Inductively Coupled Plasma SW-846 Method 6010		
Selenium	AA Furnace SW-846 Method 7740 Inductively Coupled Plasma SW-846 Method 6010 AA Gaseous Hydride SW-846 Method 7741		

R0014920

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503) (Continued)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Zinc	AA Direct Aspiration SW-846 Method 7950 Inductively Coupled Plasma SW-846 Method 6010		
All metals samples must be prepared prior to analysis using SW-846 Method 3050			
Mercury	Cold Vapor (manual) SW-846 Method 7470 SW-846 Method 7471	28 days Cool 4°C Plastic or Glass Container Samples need to be digested prior to analysis.	SW-846 Method 7470 applies to Mercury in Liquid Wastes. SW-846 Method 7471 applies to Mercury in solid or semisolid wastes. The digestion procedure is contained in the analytical method.
Fecal Coliform	SM-9221.C (MPN) SM-9222 D (Membrane Filter, MF)	6 hours Cool 4°C Plastic or Glass Container	Both procedures are very temperature sensitive. Samples must be analyzed within defined holding times.
Salmonella, sp.	SM-9260 D.1 or Kenner	6 hours Cool 4°C Plastic or Glass Container	Large sample volumes are needed because of the low concentration of *Salmonella* in wastewater and sludge. Also, due to the large number of *Salmonella* species, more than one procedure may be necessary to adequately determine the presence of *Salmonella*.

R0014921

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503) (Continued)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Enteric Viruses	ASTM-Method D 4994-89	2 hours at up to 25°C or 48 hours at 2 to 10°C. Plastic or glass Container	Concentration of sample is necessary due to the presumably low numbers of viruses in the sample.
Helminth Ova	Yanko	5 days Cool 4°C Plastic or Glass Container	Analyst must also be familiar with other Ova test methods that are also found in this same document. Due to the complexity in determining viable Ova, all Ova identified will be considered viable.
Total, Fixed, and Volatile Solids	SM-2540 G	7 days Cool 4°C Plastic or Glass Container	Method 2540 G is the recommended procedure for solid and semisolid samples.
Specific Oxygen Uptake Rate (SOUR)	SM-2710 B	Perform as soon as possible Plastic or Glass Container	Quite sensitive to sample temperature variation and lag time between sample collection and test initiation. Replicate samples are suggested.
Total Volatile Acids	SM-5560 C	7 days Cool 4°C Plastic or Glass Container	Method C can be used as a control test for anaerobic digestion even though it gives somewhat variable recovery. Recovery factors should be determined.

R0014922

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503) (Continued)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Total Phosphorous	SM-4500-P	28 days Cool 4°C Plastic or Glass Container	Pay close attention to sample preparation requirements found in section 4500-P B.
pH	SW-9045	Immediate No preservation Plastic or Glass Container	Sample is mixed with a prescribed liquid and pH determined with probe. Temperature fluctuations may cause measurement errors.
Conductivity	SW-9050	28 days Cool 4°C Plastic or Glass Container	Sample should be measured at 25°C or temperature corrections made and results reported at 25°C.
Total Kjeldahl Nitrogen (TKN)	SM-4500-N_{org}	28 days Cool 4°C Plastic or Glass Container	Total kjeldahl nitrogen is the sum of the organic and ammonia nitrogen in a sample. Sample digestion and distillation are required and are included or referenced in the method.
Ammonia Nitrogen (NH_3-N)	SM-4500-NH_3	28 days Cool 4°C Plastic or Glass Container	All samples must be distilled using procedure SM-4500-NH_3 B prior to analysis by one of the specific analysis procedures listed.

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503) (Continued)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Nitrite Nitrogen (NO_2-N)	SM-4500-NO_2	48 hours Cool 4°C Plastic or Glass Container	Nitrite nitrogen is an intermediate oxidation state of nitrogen and can be converted by bacteria to NO_3 or NH_3. Analyze within holding time to prevent this conversion.
Nitrate Nitrogen (NO_3-N)	SM-4500-NO_3 SW-846 Method 9200	28 days Cool 4°C Plastic or Glass Container	Nitrate nitrogen is the fully oxidized state of nitrogen. Organics may interfere with the method.
Organo-chlorine Pesticides and PCBs	Analysis procedure, SW-846 Method 8080 Extraction procedure, SW-846 Method 3540/ 3550 (Method used is dependent on acceptable detection limits.)	14 days Cool 4°C Amber Glass Jar	Both the pesticides and PCBs are bioaccumulative, stable and toxic. Phthalate esters can pose a major interference problem when using an EC detector.

R0014924

Approved Methods for the Analysis of Sewage Sludges (40 *CFR* Part 503) (Continued)

Pollutant	Analysis Method Description	Maximum Holding Time Sample Preservation Sample Container Sample Preparation	Comments
Semivolatile Organics	Analysis procedure, SW-846 Method 8270 Extraction Procedure, SW-846 3640/3610/3611/3620/3630/3650/3660 (Method used is dependent on acceptable detection limits.)	14 days Cool 4°C Amber Glass Jar with Teflon liner.	Method is used to quantify most B/N/A organic compounds that are soluble in methylene chloride. Such compounds include polynuclear aromatic hydrocarbons and pesticides, phthalate esters, ketones, anilines, pyridines, quinolines, aromatic nitro compounds and phenols.
Volatile Organics	Analysis procedure, SW-846 Method 8240 Extraction procedure, Purge and trap	14 days Cool 4°C Glass Jar with Teflon liner.	Method is used to quantify most volatile organic compounds that have boiling points below 200°C and that are insoluble or slightly soluble in water. Such compounds include low-molecular-weight halogenated hydrocarbons, aromatics, ketones, nitrites, acetates, acrylates, ethers, and sulfides. The laboratory where volatile analysis is performed should be completely free of solvents.

References:

SM—*Standard Methods for the Examination of Water and Wastewater,* 18th Edition. American Public Health Association, Washington, DC, 1992

SW—*Test Methods for Evaluating Solid Waste,* SW-846. EPA, November 1986.

ASTM—*Standard Practice for Recovery of Viruses from Wastewater Sludge.* Annual Book of ASTM Standards: Section 11, Water and Environmental Technology, 1992.

Kenner—Kenner, B.A. and H.P. Clark, *Detection and Enumeration of Salmonella and Pseudomonas aeruginosa.* J. Water Pollution Control Federation, 46(9): 2163-2171, 1974.

Yanko—Yanko, W.A., *Occurrence of Pathogens in Distribution and Marketing of Municipal Sludges.* EPA 600/1-87-014, 1987. NTIS PB 88-154273/AS

R0014925

APPENDIX K

EPA INDUSTRIAL GENERAL PERMIT CHECKLIST STORM WATER POLLUTION PREVENTION PLAN ANALYSIS

EPA INDUSTRIAL GENERAL PERMIT CHECKLIST

Storm Water Pollution Prevention Plan

1. Pollution Prevention Team
   - ☐ Identify specific individuals
   - ☐ Outline their responsibilities
2. Description of potential pollutant sources, including:
   - ☐ Site map indicating:
     - ☐ Drainage areas
     - ☐ Drainage patterns/outfalls
     - ☐ Structural and non-structural controls
     - ☐ Surface waters
     - ☐ Significant materials exposed to precipitation
     - ☐ The location of leaks or spills that have occurred in the last 3 years
     - ☐ Location of industrial activities exposed to precipitation including:
       - ☐ Fueling stations
       - ☐ Vehicle/equipment maintenance or cleaning areas
       - ☐ Loading/unloading areas
       - ☐ Waste treatment, storage, or disposal areas
       - ☐ Liquid storage tanks
       - ☐ Processing areas
       - ☐ Storage areas
   - ☐ A list of pollutants likely to be present in the discharges
   - ☐ Description of significant materials handled, treated, stored, or disposed of such that exposure to storm water occurred in the last 3 years
     - ☐ Description of the method and location of storage or disposal
     - ☐ Description of all material management practices
     - ☐ Description and location of existing structural and non-structural controls
   - ☐ List of significant spills and leaks that occurred in the 3 years prior to the effective date of the permit
   - ☐ Summary of existing storm water sampling data
   - ☐ Description of areas with a high potential for significant soil erosion
   - ☐ A narrative summarizing potential pollutant sources

R0014927

Storm Water Pollution Prevention Plan (Continued)

3. A description of appropriate measures and controls, including:
   - ☐ Good housekeeping procedures
   - ☐ Preventive maintenance procedures
   - ☐ Spill prevention and response procedures
   - ☐ Inspection procedures
   - ☐ Employee training program
   - ☐ Recordkeeping and internal reporting procedures
   - ☐ Non-storm water discharge certification or failure to certify non-storm water discharge certification
     - ☐ Identify authorized non-storm water discharges and appropriate controls
   - ☐ Erosion and sediment controls for areas with a high erosion potential
   - ☐ A narrative consideration of traditional storm water management practices
   - ☐ Plans for implementation and maintenance of traditional measures found to be reasonable and appropriate
4. ☐ Annual site compliance evaluation reports (prepared after the inspection is performed) including:
   - ☐ A summary of the scope of the inspection
   - ☐ Personnel making the inspection
   - ☐ Major observations
   - ☐ Actions taken to revise the Pollution Prevention Plan
   - ☐ Certification of compliance or a list of incidents of non-compliance
5. ☐ If discharging to a large or medium municipal separate storm sewer, compliance with applicable requirements in the municipal storm water management program
6. ☐ Consistency of the storm water pollution prevention plan with other plans
7. Additional requirements for facilities subject to Emergency Planning and Community Right to Know Act (EPCRA) Section 313 requirements
   - ☐ A description of the measures used in areas where section 313 water priority chemicals are stored, processed, or otherwise handled to:
     - Minimize the potential contact or storm water run-on with the chemicals
     - Prevent exposure of the chemicals to storm water and wind
   - ☐ A discussion of the measures taken to minimize the discharge of Section 313 water priority chemicals from the following areas:
     - ☐ Liquid storage areas
     - ☐ Non-liquid storage areas
     - ☐ Truck and railcar loading areas
     - ☐ Transfer, processing, or handling areas
     - ☐ Other areas

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Storm Water Pollution Prevention Plan (Continued)
☐ Preventive maintenance and housekeeping
☐ Facility security
☐ Training
☐ Professional Engineer (PE) certification every 3 years
8. ☐ Assurance that any salt storage piles present onsite are covered or enclosed

APPENDIX L

INDUSTRIAL SOURCE CONTROL BMP QUESTIONS

Industrial Source Control BMP Questions

FUELING

1: Has spill and overfill prevention equipment been installed?
2: Are vehicle fuel tanks often "topped off"?
3: Have steps been taken to protect fueling areas from rain?
4: Is runon to the fueling area minimized?
5: Are oil/water separators or oil and grease traps installed in storm drains in the fueling area?
6: Is the fueling area cleaned by hosing or washing?
7: Do you control petroleum spills?
8: Are employees aware of ways to reduce contamination of storm water at fueling stations?
9: Where does the water drain from the fueling area?

SUMMARY OF FUELING STATION BMPs
• Consider installing spill and overflow protection. • Discourage topping off of fuel tanks. • Reduce exposure of the fuel area to storm water. • Use dry cleanup methods for the fuel area. • Use proper petroleum spill control. • Encourage employee participation.

MAINTAINING VEHICLES AND EQUIPMENT

1: Are parts cleaned at the facility?
2: Has the facility looked into using nontoxic or less toxic cleaners or solvents?
3: Are work areas and spills washed or hosed down with water?
4: Are spills or materials washed or poured down the drain?
5: Are oil filters completely drained before recycling or disposal?
6: Are incoming vehicles and equipment checked for leaking oil and fluids?
7: Are wrecked vehicles or damaged equipment stored onsite?
8: Does the facility recycle any of the automotive fluids or parts?
9: Can the facility reduce the number of different solvents used?
10: Are wastes separated?
11: Does the facility use recycled products?

R0014931

SUMMARY OF VEHICLE MAINTENANCE AND REPAIR BMPs
• Check for leaking oil and fluids. • Use nontoxic or low-toxicity materials. • Drain oil filters before disposal or recycling. • Do not pour liquid waste down drains. • Recycle engine fluids and batteries. • Segregate and label wastes. • Buy recycled products.

PAINTING VEHICLES AND EQUIPMENT

1: Is care taken to prevent paint wastes from contaminating storm water runoff?
2: Are wastes from sanding contained?
3: Are parts inspected before painting?
4: Is the facility using painting equipment that creates little waste?
5: Are employees trained to use spray equipment correctly?
6: Does the facility recycle paint, paint thinner, or solvents?
7: Are wastes separated?
8: Can the facility reduce the number of solvents used?
9: Does the facility use recycled products?

SUMMARY OF PAINTING OPERATION BMPs
• Inspect parts prior to painting. • Contain sanding wastes. • Prevent paint waste from contacting storm water. • Use proper interim storage of waste paint, solvents, etc. • Evaluate efficiency of equipment. • Recycle paint, paint thinner, and solvents. • Segregate wastes. • Buy recycled products.

WASHING VEHICLES AND EQUIPMENT

1: Has the facility considered using phosphate-free biodegradable detergents?
2: Are vehicles, equipment, or parts washed over the open ground?

SUMMARY OF VEHICLE AND EQUIPMENT WASHING BMPs
• Consider use of phosphate-free detergent. • Use designated cleaning areas. • Consider recycling wash water.

R0014932

LOADING AND UNLOADING MATERIALS

1: Are tank trucks and material delivery vehicles located where spills or leaks can be contained?
2: Is loading/unloading equipment checked regularly for leaks?
3: Are loading/unloading docks or areas covered to prevent exposure to rainfall?
4: Are loading/unloading areas designed to prevent storm water runon?
5: Is piping system routinely checked for leaks?

SUMMARY OF LOADING/UNLOADING OPERATIONS BMPs

- Contain leaks during transfer.
- Check equipment regularly for leaks.
- Limit exposure of material to rainfall.
- Prevent storm water runon.

LIQUID STORAGE IN ABOVE-GROUND TANKS

1: Do storage tanks contain liquid hazardous materials, hazardous wastes, or oil?
2: Are operators trained in correct operating procedures and safety activities?
3: Does the facility have safeguards against accidental discharge?
4: Are tank systems inspected, and is tank integrity tested regularly?
5: Are tanks bermed or surrounded by a secondary containment system?

SUMMARY OF BMPs FOR LIQUID STORAGE IN ABOVE-GROUND TANKS

- Comply with applicable State and Federal laws.
- Properly train employees.
- Install safeguards against accidental release.
- Routinely inspect tanks and equipment.
- Consider installing secondary containment.

INDUSTRIAL WASTE MANAGEMENT AND OUTSIDE MANUFACTURING

1: Has the facility looked for ways to reduce waste at the facility?
2: Has the facility considered waste reduction BMPs?
3: Are industrial waste management and outside manufacturing areas checked often for spills and leaks?
4: Are industrial waste management areas or manufacturing activities covered, enclosed, or bermed?
5: Are vehicles used to transport wastes to the land disposal or treatment site equipped with anti-spill equipment?
6: Does the facility use loading systems that minimize spills and fugitive losses such as dust or mists?
7: Are sediments or wastes prevented from being tracked offsite?
8: Is storm water runoff minimized from the land disposal site?

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SUMMARY OF INDUSTRIAL WASTE MANAGEMENT AND OUTSIDE MANUFACTURING BMPs
• Conduct a waste reduction assessment. • Institute industrial waste source reduction and recycling BMPs. • Prevent runoff and runon from contacting the waste management area. • Minimize runoff from land application sites.

OUTSIDE STORAGE OF RAW MATERIALS, BY-PRODUCTS, OR FINISHED PRODUCTS

1: Are materials protected from rainfall, runon, and runoff?

SUMMARY OF BMPs FOR OUTSIDE STORAGE OF RAW MATERIALS, BY-PRODUCTS, OR FINISHED PRODUCTS
• Cover or enclose materials.

SALT STORAGE

1: Are salt piles protected from rain?
2: Is storm water runon prevented from contacting storage piles and loading and unloading areas?

SUMMARY OF SALT STORAGE FACILITIES BMPs
• Put salt under a roof. • Use temporary covers. • Enclose or berm transfer areas.

APPENDIX M

EPA BASELINE CONSTRUCTION GENERAL PERMIT REQUIREMENTS PRE-CONSTRUCTION CHECKLIST

EPA BASELINE CONSTRUCTION GENERAL PERMIT REQUIREMENTS PRE-CONSTRUCTION CHECKLIST

Storm Water Pollution Prevention Plan

1. A site description, including:
   - ☐ The nature of the activity
   - ☐ Intended sequence of major construction activities
   - ☐ The total area of the site
   - ☐ The area of the site that is expected to undergo excavation
   - ☐ The runoff coefficient of the site after construction is complete
   - ☐ Existing soil or storm water data
   - ☐ A site map with:
     - ☐ Drainage patterns
     - ☐ Approximate slopes after major grading
     - ☐ Area of soil disturbance
     - ☐ Indication of areas that will not be disturbed
     - ☐ Location of major structural and non-structural controls
     - ☐ Areas where stabilization practices are expected to occur
     - ☐ Surface waters
     - ☐ Storm water discharge locations
   - ☐ The name of the receiving water(s).
2. A description of controls:
   - 2.1 Erosion and sediment controls, including:
     - ☐ Stabilization practices for all areas disturbed by construction
     - ☐ Structural practices for all drainage/discharge locations
   - 2.2 Erosion and sediment controls, including:
     - ☐ Measures used to control pollutants occurring in storm water discharges after construction activities are complete
     - ☐ Velocity dissipation devices to provide nonerosive flow conditions from the discharge point along the length of any outfall channel
   - 2.3 Other controls including:
     - ☐ Waste disposal practices that prevent discharge of solid materials to waters of the United States
     - ☐ Measures to minimize offsite tracking of sediments by construction vehicles
     - ☐ Measures to ensure compliance with State or local waste disposal, sanitary sewer, or septic system regulations
   - 2.4 Description of the timing during the construction when measures will be implemented.
3. Are State or local requirements incorporated into the plans?
4. Are maintenance procedures for control measures identified in the plan?
5. Identification of allowable non-storm water discharges and pollution prevention measures.
6. Contractor certification.
7. Plan certification.

R0014936

EPA BASELINE CONSTRUCTION GENERAL PERMIT CHECKLIST

Storm Water Pollution Prevention Plan
Construction/Implementation Checklist

1. Maintains records of construction activities, including:
   - ☐ Dates when major grading activities occur
   - ☐ Dates when construction activities temporarily cease on a portion of the site
   - ☐ Dates when construction activities permanently cease on a portion of the site
   - ☐ Dates when stabilization measures are initiated on the site.
2. Prepare inspection reports summarizing:
   - ☐ Name of inspector
   - ☐ Qualifications of inspector
   - ☐ Measures/areas inspected
   - ☐ Observed conditions
   - ☐ Changes necessary to the SWPPP.
3. Report releases of reportable quantities of oil or hazardous materials (if they occur):
   - ☐ Notify National Response Center 800/424-8802
   - ☐ Notify permitting authority in writing within 14 days
   - ☐ Modify the Pollution Prevention Plan to include:
     - the date of release
     - circumstances leading to the release
     - steps taken to prevent recurrence of the release.
4. Modify Pollution Prevention Plan as necessary to:
   - ☐ Comply with minimum permit requirements when notified by EPA that the plan does not comply
   - ☐ Address a change in design, construction operation or maintenance that has an effect on the potential for discharge of pollutants
   - ☐ Prevent recurrence of reportable quantity releases of a hazardous material or oil.

EPA BASELINE CONSTRUCTION GENERAL PERMIT CHECKLIST

Storm Water Pollution Prevention Plan
Final Stabilization/Termination Checklist

1. All soil disturbing activities are complete.
2. Temporary erosion and sediment control measures have been removed or will be removed at an appropriate time.
3. All areas of the construction site not otherwise covered by a permanent pavement or structure have been stabilized with a uniform perennial vegetative cover with a density of 70% or equivalent.

POLLUTION PREVENTION PLAN FOR STORM WATER DISCHARGE ASSOCIATED WITH CONSTRUCTION ACTIVITIES
EROSION AND SEDIMENT CONTROL SELECTION CHECKLIST

INSTRUCTIONS: THIS CHECKLIST LISTS THE MINIMUM SEDIMENT EROSION CONTROL REQUIREMENTS UNDER THE USEPA GENERAL PERMIT. CHECK [✓] EACH ITEM AND FILL IN THE BLANKS BELOW TO EVALUATE COMPLIANCE FOR EACH DRAINAGE AREA AND LOCATION. NOTE: THIS CHECKLIST WAS PREPARED FOR THE USEPA GENERAL PERMIT. REQUIREMENTS FOR STATE GENERAL PERMITS MAY VARY.

Stabilization Practices

☐ Stabilization will be initiated on all disturbed areas where construction activity will not occur for a period of more than 21 calendar days by the 14th day after construction activity has permanently or temporarily ceased.

Stabilization measures to be used include:

☐	Temporary Seeding	☐	Sod Stabilization
☐	Permanent Seeding	☐	Geotextiles
☐	Mulching	☐	Other _____

Structural Practices

☐ Flows from upstream areas will be diverted from exposed soils. Measures to be used include:

☐	Earth Dike	☐	Pipe Slope Drain
☐	Drainage Swale	☐	Other _____
☐	Interceptor Dike and Swale		

Drainage locations serving less than 10 disturbed acres	**Drainage locations serving 10 or more disturbed acres**
☐ Sediment controls will be installed. Sediment controls include: ☐ Sediment Basin ☐ Sediment Trap ☐ Silt Fence or equivalent controls along all sideslope and downslope boundaries	☐ A Sediment Basin will be installed. ☐ A Sediment Basin is not attainable on the site; therefore, the following sediment controls will be installed: Sediment Trap Silt Fence or equivalent controls along the sideslope and downslope boundaries

Sediment Basin Runoff Storage Calculation

_____ acres area draining to the sediment basin

× 3,600 = cubic feet of storage/acre

_____ cubic feet of storage required for the basin.

APPENDIX N

CONSTRUCTION SOURCE CONTROL BMP QUESTIONS

Construction Source Control BMP Questions

SOIL EROSION AND SEDIMENT CONTROL PRACTICES

MINIMIZE THE AMOUNT OF DISTURBED SOIL

1: Does the site plan require a significant amount of grade changes?
2: Are there portions of the site that do not have to be cleared for construction to proceed?
3: Can construction be performed in stages, so that the entire site does not have to be cleared at one time?
4: Are there portions of the site that will be disturbed then left alone for long periods of time?
5: Does the facility stabilize all disturbed areas after construction is complete?
6: Does snow prevent the facility from seeding an area?
7: Is there enough rainfall to allow vegetation to grow?

PREVENT RUNON FROM FLOWING ACROSS DISTURBED AREAS

1: Does runoff from the undisturbed uphill areas flow onto the construction site?
2: Will runoff flow down a steeply sloped, disturbed area on the site?
3: Is there a swale or stream that runs through the construction site?
4: Does construction traffic have to cross drainage swales or streams?

SLOW DOWN THE RUNOFF TRAVELING ACROSS THE SITE

1: Is the site gently sloped?
2: Is the site stabilized with vegetation?
3: Does runoff concentrate into drainage swales on the site?

REMOVE SEDIMENT FROM ONSITE RUNOFF BEFORE IT LEAVES THE SITE

1: Does the construction disturb an area 10 acres or larger that drains to a common location?
2: Is a sediment basin attainable on the site?
3: Does runoff leave the disturbed area as overland flow?
4: Is the flow concentrated in channels as it leaves the disturbed areas?
5: Are structural controls located along the entire downhill perimeter of all disturbed areas?
6: Is there a piped storm drain system with inlets in a disturbed area?

R0014940

MEET OR EXCEED LOCAL/STATE REQUIREMENTS FOR EROSION AND SEDIMENT CONTROL

1: Does the State or local government require erosion and sediment control for construction projects?
2: Does the State or local government have an erosion and sediment control requirement that is different from the requirements of the NPDES storm water permit?

OTHER CONTROLS

GOOD HOUSEKEEPING

1: Does the facility appear to implement good housekeeping practices?

WASTE DISPOSAL

1: What steps are taken to ensure that construction waste is properly disposed of?
2: What management practices are used to minimize or prevent impacts on storm water from hazardous products on the construction site?
3: Are concrete trucks allowed to washout or dump onsite?
4: Is sandblasting performed at the site? If so, what is done with the used grit?

MINIMIZING OFFSITE VEHICLE TRACKING OF SEDIMENTS

1: What measures have been taken to prevent offsite vehicle tracking?

SANITARY/SEPTIC DISPOSAL

1: How are sanitary or septic wastes managed?
2: How does the facility demonstrate compliance with State or local sanitary or septic system regulations?

MATERIAL MANAGEMENT

1: What types of materials are found on the construction site?
2: How are these materials managed?
3: What risks are present onsite as a result of material management practices?
4: Is the facility implementing any methods to reduce potential risks from material management?
5: If applicable, how are pesticides managed at the site?
6: If applicable, how are petroleum products managed at the site?
7: If applicable, what steps are taken to reduce nutrient pollution from fertilizers and detergents?

SPILLS

1: Does the facility have a spill control plan for the site?
2: Does the facility know what spill prevention methods and responses will be used?

R0014941

CONTROL OF ALLOWABLE NON-STORM WATER DISCHARGES

1: What non-storm water discharges are present at the site?
2: How does the facility manage the non-storm water discharges?
3: How are allowable non-storm water discharges addressed in the storm water Pollution Prevention Plan?
4: What types of controls or practices are used to prevent pollution from non-storm water discharges?
5: What types of controls are used for discharges that have sediments?

R0014942

APPENDIX O

MONITORING REQUIREMENTS IN EPA'S GENERAL PERMIT

EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS[1]

Type of Facility	Type of Storm Water Discharge	Parameters	Monitoring Frequency	Reporting Frequency
EPCRA, Section 313 Facilities Subject to Reporting Requirements for Water Priority Chemicals	Storm water discharges that come into contact with any equipment, tank, container, or other vessel or area used for storage of a Section 313 water priority chemical, or located at a truck or rail car loading or unloading area where a Section 313 water priority chemical is handled	Oil and Grease, BOD_5, COD, TSS, Total Kjeldahl Nitrogen, Total Phosphorus, pH, acute whole effluent toxicity[2], any Section 313 water priority chemical for which the facility reports	Semi-annual	Annual
Primary Metal Industries (SIC 33)	All storm water discharges associated with industrial activity	Oil and Grease, COD, TSS, pH, acute whole effluent toxicity[2], Total Recoverable Lead, Total Recoverable Cadmium, Total Recoverable Copper, Total Recoverable Arsenic, Total Recoverable Chromium, and any pollutant limited in an effluent guideline to which the facility is subject	Semi-annual	Annual
Land Disposal Units/ Incinerators/ BIFs	Storm water discharges from active or inactive land disposal units without a stabilized cover that have received any waste from industrial facilities other than construction sites and storm water discharges from incinerators and BIFs that burn hazardous waste	Total Recoverable Magnesium, Magnesium (dissolved), Total Kjeldahl Nitrogen (TKN), COD, TDS, TOC, Oil and Grease, pH, Total Recoverable Arsenic, Total Recoverable Barium, Total Recoverable Cadmium, Total Recoverable Chromium, Total Cyanide, Total Recoverable Lead, Total Mercury, Total Recoverable Selenium, Total Recoverable Silver, acute whole effluent toxicity[2]	Semi-annual	Annual

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EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS[1]

Type of Facility	Type of Storm Water Discharge	Parameters	Monitoring Frequency	Reporting Frequency
Wood Treatment Facilities	Storm water discharges from areas that are used for wood treatment, wood surface application or storage of treated or surface protected wood	Oil and Grease, pH, COD, TSS	Semi-annual	Annual
Facilities that use chlorophenolic formulations		Plus Pentachlorophenol and acute whole effluent toxicity[2]		
Facilities that use creosote formulations		Plus acute whole effluent toxicity[2]		
Facilities that use chromium-arsenic formulations		Plus Total Recoverable Arsenic, Total Recoverable Chromium, Total Recoverable Copper		
Industrial Facilities with Coal Piles	Storm water discharges from coal pile runoff	Oil and Grease, pH, TSS, Total Recoverable Copper, Total Recoverable Nickel, Total Recoverable Zinc	Semi-annual	Annual
Battery Reclaimers	Storm water discharges from areas for storage of lead acid batteries, reclamation products, or waste products and from areas used for lead acid battery reclamation	Oil and Grease, COD, TSS, pH, Total Recoverable Copper, Total Recoverable Lead	Semi-annual	Annual
Airports (with over 50,000 flight operations per year)	Storm water discharges from aircraft or airport deicing areas	Oil and Grease, BOD_5, COD, TSS, pH, and the primary ingredient used in the deicing materials	Annual	Retain onsite
Coal-Fired Steam Electric Facilities	Storm water discharges from coal handling sites (other than runoff from coal piles, which is not eligible for coverage under this permit)	Oil and Grease, pH, TSS, Total Recoverable Copper, Total Recoverable Nickel, Total Recoverable Zinc	Annual	Retain onsite

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EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS[1]

Type of Facility	Type of Storm Water Discharge	Parameters	Monitoring Frequency	Reporting Frequency
Animal Handling/ Meat Packing Facilities	Storm water discharges from animal handling areas, manure management areas, production waste management areas exposed to precipitation at meat packing plants, poultry packing plants, facilities that manufacture animal and marine fats and oils	BOD_5, Oil and Grease, COD, TSS, TKN, Total Phosphorus, pH, Fecal Coliform	Annual	Retain onsite
Chemical and Allied Product Manufacturers/ Rubber Manufacturers (SIC 28 and 30)	Storm water discharges that come into contact with solid chemical storage piles	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite
Automobile Junkyards	Storm water discharges exposed to: (a) over 250 auto/truck bodies with drivelines, 250 drivelines, or any combination thereof (b) over 500 auto/truck units (c) over 100 units dismantled per year where automotive fluids are drained or stored	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite
Lime Manufacturing Facilities	Storm water discharges that have come into contact with lime storage piles	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite
Oil-fired Steam Electric Power Generating Facilities	Storm water discharges from oil handling sites	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite
Cement Manufacturing Facilities and Cement Kilns	All storm water discharges associated with industrial activity (except those from material storage piles that are not eligible for coverage under this permit)	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite

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EPA FINAL GENERAL PERMIT MONITORING REQUIREMENTS[1]

Type of Facility	Type of Storm Water Discharge	Parameters	Monitoring Frequency	Reporting Frequency
Ready-mix Concrete Facilities	All storm water discharges associated with industrial activity	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite
Ship Building and Repairing Facilities	All storm water discharges associated with industrial activity	Oil and Grease, COD, TSS, pH, any pollutant limited in an effluent guideline to which the facility is subject	Annual	Retain onsite

[1]A discharger is not subject to the monitoring requirements provided the discharger makes a certification for a given outfall, on an annual basis, under penalty of law, that material handling equipment or activities, raw materials, intermediate products, final products, waste materials, by-products, industrial machinery or operations, significant materials from past industrial activities, or, in the case of airports, deicing activities, that are located in areas of the facility that are within the drainage area of the outfall, are not presently exposed to storm water, and will not be exposed to storm water for the certification period.

[2]A discharger may, in lieu of monitoring for acute whole effluent toxicity, monitor for pollutants identified in Tables II and III of Appendix D of 40 *CFR* Part 122 that the discharger knows or has reason to believe are present at the facility site. Such determinations are to be based on reasonable best efforts to identify significant quantities of materials or chemicals present at the facility. (Tables II and III of 40 *CFR* Part 122 Appendix D are provided below.)

TABLE II. ORGANIC TOXIC POLLUTANTS IN EACH OF FOUR FRACTIONS IN ANALYSIS BY GAS CHROMATOGRAPHY/MASS SPECTROSCOPY (GS/MS)

Volatiles

1V	acrolein	12V	dichlorobromomethane	22V	methylene chloride
2V	acrylonitrile	14V	1,1-dichloroethane	23V	1,1,2,2-tetrachloroethane
3V	benzene	15V	1,2-dichloroethane	24V	tetrachlororoethylene
5V	bromoform	16V	1,1-dichloroethylene	25V	toluene
6V	carbon tetrachloride	17V	1,2-dichloropropane	26V	1,2-trans-dichloroethylene
7V	chlorobenzene	18V	1,3-dichloropropylene	27V	1,1,1-trichloroethane
8V	chlorodibromomethane	19V	ethylbenzene	28V	1,1,2-trichloroethane
9V	chloroethane	20V	methyl bromide	29V	trichloroethylene
10V	2-chloroethylvinyl ether	21V	methyl chloride	31V	vinyl chloride
11V	chloroform				

Acid Compounds

1A	2-chlorophenol	5A	2,4-dinitrophenol	9A	pentachlorophenol
2A	2,4-dichlorophenol	6A	2-nitrophenol	10A	phenol
3A	2,4-dimethylphenol	7A	4-nitrophenol	11A	2,4,6-trichlorophenol
4A	4,6-dinitro-o-cresol	8A	p-chloro-m-cresol		

Base/Neutral

1B	acenaphthene	17B	4-chlorophenyl phenyl ether	32B	fluorene
2B	acenaphthylene	18B	chrysene	33B	hexachlorobenzene
3B	anthracene	19B	dibenzo(a,h)anthracene	34B	hexachlorobutadiene
4B	benzidine	20B	1,2-dichlorobenzene	35B	hexachlorocyclopentadiene
5B	benzo(a)anthracene	21B	1,3-dichlorobenzene	36B	hexachloroethane
6B	benzo(a)pyrene	22B	1,4-dichlorobenzene	37B	indeno(1,2,3-cd)pyrene
7B	3,4-benzofluoranthene	23B	3,3'-dichlorobenzidene	38B	isophorone
8B	benzo(ghi)perylene	24B	diethyl phthalate	39B	naphthalene
9B	benzo(k)fluoranthene	25B	dimethyl phthalate	40B	nitrobenzene
10B	bis(2-chloroethoxy)methane	26B	di-n-butyl phthalate	41B	N-nitrosodimethylamine
11B	bis(2-chloroethyl)ether	27B	2,4-dinitrotoluene	42B	N-nitrosodi-n-propylamine
12B	bis(2-chloroisopropyl)ether	28B	2,6-dinitrotoluene	43B	N-nitrosodiphenylamine
13B	bis(2-ethylhexyl)phthalate	29B	di-n-octyl phthalate	44B	phenanthrene
14B	4-bromophenyl phenyl ether	30B	1,2-diphenylhydrazine (as azobenzene)	45B	pyrene
15B	butylbenzyl phthalate			46B	1,2,4-trichlorobenzene
16B	2-chloroanaphthalene	31B	fluroranthene		

Pesticides

1P	aldrin	10P	dieldrin	18P	PCB-1242
2P	alpha-BHC	11P	alpha-endosulfan	19P	PCB-1254
3P	beta-BHC	12P	beta-endosulfan	20P	PCB-1221
4P	gamma-BHC	13P	endosulfan sulfate	21P	PCB-1232
5P	delta-BHC	14P	endrin	22P	PCB-1248
6P	chlordane	15P	endrin aldehyde	23P	PCB-1260
7P	4,4'-DDT	16P	heptachlor	24P	PCB-1016
8P	4,4'-DDE	17P	heptachlor epoxide	25P	toxaphene
9P	4,4'-DDD				

TABLE III. OTHER TOXIC POLLUTANTS (METALS AND CYANIDE) AND TOTAL PHENOLS

Antimony, Total	Copper, Total	Silver, Total
Arsenic, Total	Lead, Total	Thallium, Total
Beryllium, Total	Mercury, Total	Zinc, Total
Cadmium, Total	Nickel, Total	Cyanide, Total
Chromium, Total	Selenium, Total	Phenols, Total

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APPENDIX P

RAIN ZONES OF THE UNITED STATES

Figure P-1

Rain Zones of the United States

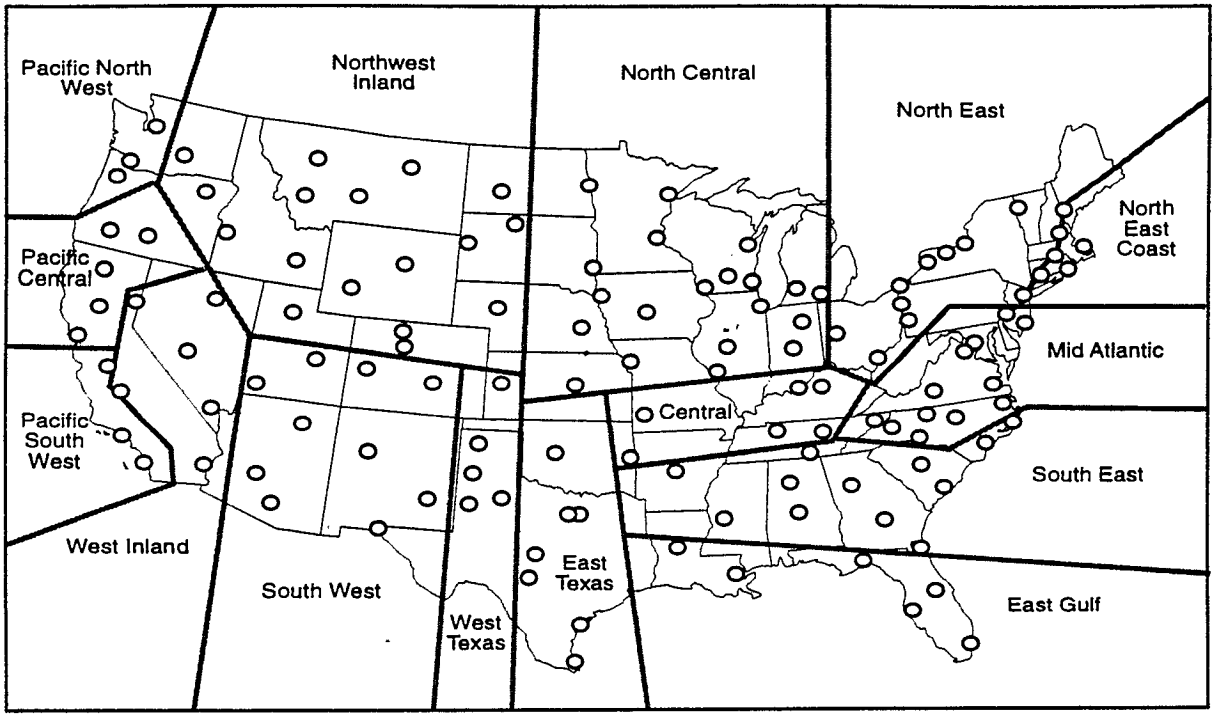

Table P-1.

Typical Values of Annual Storm Event Statistics for Rain Zones

Rain Zone	Annual Statistics				Independent Storm Event Statistics							
	No. of Storms		Precip		Duration		Intensity		Volume		DELTA	
	Avg	COV	Avg	COV	Avg	COV	Avg	COV	Avg	COV	Avg	COV
			(in)		(hrs)		(in/hr)		(in)		(hr)	
North East	70	0.13	34.6	0.18	11.2	0.81	0.067	1.23	0.50	0.95	126	0.94
North East-Coastal	63	0.12	41.4	0.21	11.7	0.77	0.071	1.05	0.65	1.03	140	0.87
Midatlantic	62	0.13	39.5	0.18	10.1	0.84	0.082	1.20	0.64	1.01	143	0.97
Central	66	0.14	41.9	0.19	9.2	0.85	0.097	1.09	0.62	1.00	133	0.99
North Central	55	0.16	29.8	0.22	9.5	0.83	0.067	1.20	0.55	1.01	167	1.17
Southeast	65	0.15	49.0	0.20	8.7	0.92	0.122	1.09	0.75	1.10	136	1.03
East Gulf	68	0.17	53.7	0.23	6.4	1.05	0.176	1.03	0.80	1.19	130	1.25
East Texas	41	0.22	31.2	0.29	8.0	0.97	0.137	1.08	0.76	1.16	213	1.26
West Texas	30	0.27	17.3	0.33	7.4	0.98	0.121	1.13	0.57	1.07	302	1.53
Southwest	20	0.30	7.4	0.37	7.6	0.88	0.079	1.16	0.37	0.88	473	1.46
West Inland	14	0.38	4.9	0.43	9.4	0.75	0.055	1.06	0.36	0.87	766	1.54
Pacific South	19	0.36	10.2	0.42	11.6	0.76	0.054	0.76	0.54	0.96	476	2.09
Northwest Inland	31	0.23	11.5	0.29	10.4	0.82	0.057	1.20	0.37	0.83	304	1.43
Pacific Central	32	0.25	18.4	0.33	13.7	0.80	0.048	0.85	0.58	1.05	265	2.00
Pacific Northwest	71	0.15	56.7	0.19	15.9	0.80	0.035	0.73	0.50	1.09	123	1.50

COV - Coefficient of Variation - Standard Deviation / Mean
DELTA - Interval between storm midpoints

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APPENDIX Q

TYPICAL "c" COEFFICIENTS

TYPICAL "c" COEFFICIENTS FOR 5- TO 10-YEAR FREQUENCY DESIGN STORMS	
Description of Area	**Runoff Coefficients**
Business	
• Downtown areas	0.70-0.95
• Neighborhood areas	0.50-0.70
Residential	
• Single-family areas	0.30-0.50
• Multi-units (detached)	0.40-0.60
• Multi-units (attached)	0.60-0.75
Residential (suburban)	0.25-0.40
Apartment dwelling areas	0.50-0.70
Industrial	
• Light areas	0.50-0.80
• Heavy areas	0.60-0.90
Parks and cemeteries	0.10-0.25
Playgrounds	0.20-0.35
Railroad yard areas	0.20-0.40
Unimproved areas	0.10-0.30
Streets	
• Asphalt	0.70-0.95
• Concrete	0.80-0.95
• Brick	0.70-0.85
Drives and walks	0.75-0.85
Roofs	0.75-0.95
Lawns—course textured soil (greater than 85 percent sand)	
• Slope: Flat (2 percent)	0.05-0.10
Average (2-7 percent)	0.10-0.15
Steep (7 percent)	0.15-0.20
Lawns—fine textured soil (greater than 40 percent clay)	
• Slope: Flat (2 percent)	0.13-0.17
Average (2-7 percent)	0.18-0.22
Steep (7 percent)	0.25-0.35

Source: *Design and Construction of Sanitary and Storm Sewers*, with permission from the publisher, American Society of Civil Engineers, *Manual of Practice*, page 37, New York, 1960.

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APPENDIX R

POLLUTION PREVENTION CHECKLISTS

A. Pollution Prevention Checklist for Industry

General

Is there a written facility policy regarding pollution prevention?

Is there a pollution prevention program currently in place?

Is there a specific person assigned to oversee the success of the program?

Are there management/employee initiatives and incentive programs related to pollution prevention?

If yes, do these include:

- Quality circles (free forums between employees and supervisors) to identify pollution prevention options?
- Opportunities for employee suggestions on pollution prevention options?

Has the facility previously conducted a pollution prevention assessment?

Has the facility used better cost accounting and cost allocation to provide incentives to reduce wastes or resource consumption?

- Is cost accounting performed accurately for all process areas and wastestreams?
- Are utility costs (energy, water) and waste treatment and disposal costs allocated to the operations that generate the waste?

Storage Areas

Are there designated material storage areas?

Are storage areas clean and organized?

Are containers stored in such a way as to allow for visual inspection for corrosion and/or leaks?

Are containers stacked in a way to minimize the chance of tipping, puncturing, or breaking?

Are there adequate distances from incompatible chemicals and different types of chemicals to prevent cross-contamination?

Is one person responsible for maintaining storage areas?

Does the layout of the facility result in minimizing traffic through material storage areas?

Are stored items protected from damage, contamination, and exposure to weather?

Are all storage tanks routinely monitored for leaks?

Is containment, such as a curb or dike, installed in storage areas to contain leakage and to minimize the area contaminated by a spill?

Are leak detection systems installed for underground storage tanks?

Are floating-roof tanks used for VOC control?

Are conservation vents used on fixed roof tanks?

Does the facility use vapor recovery systems?

Materials Inventory

Is there an inventory control system designed to prevent materials from deteriorating in storage (first in, first out to prevent expiration)?

Is obsolete raw material returned to the supplier?

Does the facility try to order smaller containers of infrequently used materials to avoid disposing of large quantities of unused obsolete materials?

Has the facility tried to order larger containers of frequently used materials to reduce the number of small containers that must be cleaned and disposed of?

Does the facility use or maintain:

- Hazardous chemicals inventory lists?
- Material safety data sheet files?

Are all in-plant containers of hazardous chemicals labeled, tagged, or marked with:

- Identity of the hazardous chemical(s)?
- Appropriate hazard warnings?

Has the facility reexamined its need for each raw material?

Does the facility have a way to use off-spec material, where possible?

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Material Handling

Are raw materials tested for quality before being accepted from suppliers?

Does the facility follow proper procedures when transferring materials?

Are expired materials tested for effectiveness before being disposed of?

Are drums, packages, and containers inspected for damage before being accepted?

Are containers properly resealed after use?

Are containers emptied thoroughly before cleaning or disposal?

Does the facility segregate its wastes as much as possible:

- Solid wastes from aqueous wastes?
- Nonhazardous from hazardous?
- Segregated according to type of contaminant?
- Different types of solid waste to improve recycling/reuse?
- Different types of solvents, cleaner wastes, and lubricants (e.g., organic solvents from mineral oils)?

Process Operations

Are water conservation measures, recycling, and reuse techniques practiced in processes that use water or generate a wastewater (e.g., cleaning and rinsing operations)?

Has material substitution been tried for any hazardous materials used in process?

Have any techniques been used to increase the life of any process baths?

Are any wastes being recycled, reused, or recovered in some manner?

Have any equipment or process modifications been made to increase material use efficiency and thus reduce material waste generation?

Do processes employ any detectors to alert personnel of malfunctions that could produce/generate excessive wastes?

Spills and Leaks

When a spill occurs:

- What cleanup methods are employed?
- Would different cleaning methods allow for direct reuse or recycling of the water?

Are there preventative maintenance procedures designed to reduce incidents of equipment breakdowns, inefficiency, spills, or leaks?

Material Substitution

Could the facility modify or completely change a given process to use water-based coolants and fluids instead of oil-based fluids?

Solvent Use

Can solvent cleaning be replaced with less toxic cleaning, such as:

- A dry process (e.g., bead or sand blasting or other abrasives)?
- Steam cleaning?
- Cryogenic?
- Caustic cleaning?

Are non-chlorinated solvents substituted for chlorinated solvents?

Are parts wiped to remove oil and dirt prior to solvent cleaning?

Is the loss of cleaning ability of the solvent monitored before the solvent is replaced?

Are solvents reused or recycled?

Is an onsite distillation unit for solvent recovery and reuse installed?

Is solvent use standardized?

Rinse Waters

Have excessive rinses been evaluated and eliminated?

Is rinse water reclaimed, pretreated, and reused?

Are water softeners used only where necessary?

Training

Are there formal personnel training programs on raw material handling, spill prevention, proper storage techniques, and waste handling procedures?

Are employees trained in pollution prevention techniques?

How often is training given and by whom?

Good Operating Practices

Are plant material balances performed routinely?

Are they performed separately for each material of concern?

Are records kept for each waste, documenting sources of origin and eventual disposal?

Are operators provided with detailed operating manuals or instruction sets?

Are all operator job functions well defined?

Are regularly scheduled training programs offered to operators?

Has the facility integrated pollution prevention into supervision and management by:

- Closer supervision to improve production efficiency and reduce inadvertent waste generation (increased opportunity for early detection of mistakes)?
- Management By Objectives (MBO) with defined and achievable goals for waste minimization (better coordination among the various parts of an overall operation)?

Has the facility improved production scheduling and planning to include:

- Maximizing batch sizes
- Dedicating equipment to a single product
- Altering batch sequencing to minimize cleaning frequency
- Scheduling production to minimize cleaning frequency?

Is corrective maintenance practiced, such as resetting control valves or adjusting process temperatures, to increase efficiency and to prevent raw material loss through waste streams?

Does the facility forbid operators to bypass interlocks and alarms, or to significantly alter setpoints without authorization?

Are overflow or malfunction alarms installed on tanks and equipment?

Housekeeping Practices

Good housekeeping is the maintenance of a clean, orderly work environment. Does the facility:

- Maintain neat and orderly storage of chemicals?
- Promptly remove spillage?
- Maintain dry and clean floors by use of brooms and/or vacuum cleaners?
- Provide proper walkways with no containers protruding into walkways?
- Minimize the accumulation of liquid and solid chemicals on the ground or floor?
- Stimulate employee interest in good housekeeping?

Checklist derived from Waste Reduction Assessment and Technology Transfer (WRATT) Training Manual, 2nd Edition, University of Tennessee

B. Pollution Prevention Checklist for Municipal Wastewater Treatment Plants

Age

What year was the wastewater treatment plant constructed or the last major expansion to increase the capacity of the plant completed?

What sewerage system improvements does the municipality have under consideration for the next 10 years?

What is the expected community and industrial growth? Is there any major development (industrial, commercial, or residential) anticipated in the next 2 to 3 years, such that either the flow or pollutant loadings could significantly increase?

Treatment Efficiency

Compare influent actual flow to influent design flow. When will actual hydraulic loading exceed design?

- Has the plant initiated expansion plans and financing sufficiently in advance to avoid overloading?
- Has the plant investigated measures for reducing flow?

Compare conventional pollutant loadings (BOD, TSS, ammonia, phosphorus) to design loadings. When will actual loadings exceed design?

- Has the plant initiated expansion plans and financing sufficiently in advance to avoid overloading?
- Has the plant investigated measures for reducing loadings?

Review operating records. How many months were the effluent concentrations or loadings above 90 percent of the permit limits?

- BOD?
- COD?
- Fecal coliform?
- Other conventional pollutants limited by permit (ammonia, phosphorus)?
- Metals or other toxics?

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How many times were permit limits violated (in the last year)?

What types of violations have occurred in the last 5 years?

- Are any of a recurrent nature?
- What were the causes?
- Have effective solutions been implemented to prevent future recurrence?

How many bypasses have occurred?

- What were the causes?
- Have effective solutions been implemented to prevent future recurrence?

What are the future regulatory or permit requirements that may require modifications to the plant or its operations?

- Can the facility currently meet any future anticipated water quality standards or effluent discharge limits?

Has the plant investigated ways to maximize operating efficiency?

Has the plant investigated improvements to the chlorination system to decrease chlorine usage?

Sludge

Does the plant have sufficient sludge treatment, storage, and disposal capacity?

What percentage of the methane gas is captured and used? Has the plant investigated ways to increase the amount of gas captured and used?

Has the plant investigated ways to decrease the amount of dewatering chemicals used?

Collection System

How many overflows within the collection system have occurred?

How many backups at any point in the collection system have occurred for any reason?

- What were the causes?
- Have effective solutions been implemented to prevent future recurrence?

Has the plant investigated ways to decrease infiltration/inflow?

Preventive Maintenance Program

Does the plant have a written preventive maintenance program on major equipment items and the sewer collection system?

Does the preventive maintenance program depict frequency of intervals, types of lubrication, types of repair and other preventive maintenance tasks necessary for each piece of equipment or each section of the sewer?

Are these preventive maintenance tasks, as well as equipment and sewer collection problems being recorded, filed, and reviewed so future maintenance problems can be assessed properly?

Materials Usage

Has the plant identified all supplies used in the operation and maintenance of the plant?

Has the plant identified materials that could be substituted for less toxic materials?

Does the plant reuse or recycle any materials used?

Has the plant investigated ways to reduce chemical usage without compromising preventive maintenance or treatment?

Personnel Resources

Review personnel resources, training, and certifications. Are there sufficient numbers. Do all have appropriate certifications and periodic training?

- Do all personnel certifications meet or exceed required levels?
  - How many are below required level?
- Is staffing level equal to or does it exceed O & M manual recommendations?

What percentage of the wastewater budget is dedicated for training?

Financial

Are the funds for the plant separate from other municipal funds?

Are funds sufficient for adequate operations?

Are funds sufficient for adequate preventive maintenance?

Are funds available for necessary improvements, expansion?

Is there a capital improvement fund?

Is the equipment replacement fund in a segregated account?

What financial resources are available to pay for improvements/expansion/reconstruction?

Municipal Pollution Prevention Projects

Does the plant have a pollution prevention program or strategy?

Has the plant conducted a self-audit on the adequacy of its maintenance, operation, funding, and operator training?

Does the pretreatment program include a pollution prevention component or specific pollution prevention projects?

Does the municipality have any pollution prevention projects aimed at reducing toxic/hazardous waste discharges, conventional loadings, or flow (e.g., water conservation) from:

- Households?
- Commercial businesses?
- Industries?

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APPENDIX S

MEDIA-SPECIFIC INSPECTION COMPONENTS

EXCERPTED (AND UPDATED) FROM EPA'S *MULTIMEDIA INVESTIGATION MANUAL*

The information in this appendix was excerpted from NEIC's *Multimedia Investigation Manual*

The information presented in this appendix includes many significant tasks for several media-specific inspection areas. Media discussed include hazardous waste, air, drinking water, toxic substances, and pesticides; emergency planning/community right-to-know and the Superfund program are also discussed.

A. Resource Conservation and Recovery Act (RCRA)

Subtitle C Hazardous Wastes

Evaluating Compliance

Under RCRA Subtitle C, hazardous wastes are subject to extensive regulations on generation, transportation, storage, treatment, and disposal. A manifest system tracks shipments of hazardous wastes from the generator through ultimate disposal. This "cradle to grave" management is implemented through regulations and permits.

In determining the facility status under RCRA, the investigator must decide whether the facility is a generator, transporter, and/or Treatment, Storage, and Disposal Facility (TSDF), and whether the facility is permitted or has interim status. Generally, EPA Regional and State offices maintain files for the facility to be inspected. Information may include:

- A list of wastes that are treated, stored, and disposed and how each is managed (for TSDFs)
- A list of hazardous wastes generated, their origins, and accumulation areas (for generators)
- Biennial, annual, or other reports required by RCRA and submitted to the regulatory agencies; these include any required monitoring reports
- A detailed map or plot plan showing the facility layout and location(s) of waste management areas
- The facility RCRA Notification Form (Form 8700-12)
- The RCRA Part A Permit Application (for TSDFs)
- The RCRA Part B Permit application (for TSDFs, if applicable)

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- The RCRA permit (for TSDFs, if applicable)
- Notifications and/or certifications for land disposal restrictions (for generators).

Generators

Hazardous waste generators are regulated under 40 *CFR* Parts 262 and 268. These regulations contain requirements for:

- Obtaining an Environmental Protection Agency (EPA) Identification Number
- Determining whether a waste is hazardous
- Managing wastes before shipment
- Accumulating and storing hazardous wastes
- Manifesting waste shipments
- Recordkeeping and reporting
- Restricting wastes from land disposal (also regulated under Part 268).

The generator regulations vary, depending upon the volume of hazardous wastes generated. The investigator must determine which regulations apply. Additionally, the investigator should do the following:

- Verify that the generator has an EPA Identification Number that is used on all required documentation (e.g., reports, manifests, etc.).
- Confirm that the volume of hazardous wastes generated is consistent with reported volumes. Examine the processes generating the wastes to assure that all generated hazardous wastes have been identified. Look for improper mixing or dilution.
- Ascertain how the generator determines/documents that a waste is hazardous. Check to see wastes are properly classified. Collect samples, if necessary.
- Determine whether pre-transport requirements are satisfied, including those for packaging, container condition, labeling and marking, and placarding.
- Determine the length of time that hazardous wastes are being stored or accumulated. Storage or accumulation for more than 90 days requires a permit. Generators storing for less than 90 days must comply with requirements outlined in 40 *CFR* 262.34.
- Verify RCRA reports and supporting documentation for accuracy, including inspection logs, biennial reports, exception reports, and manifests (with land disposal restriction notifications and/or certifications).
- Watch for accumulation areas which are in use but have not been identified by the generator. Note: Some authorized State regulations do not have provisions for "satellite storage" accumulation areas.

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- Determine whether a generator has the required contingency plan and emergency procedures, whether the plan is complete, and if the generator follows the plan/ procedures.

- Determine whether hazardous waste storage areas comply with applicable requirements.

- Facilities with their own vehicle maintenance garage should be evaluated to assure that wastes such as used oil, anti-freeze, solvents, and paints are disposed of properly.

Transporters

Hazardous waste transporters (e.g., by truck, ship, or rail) are regulated under 40 Code of Federal Regulations *CFR* Part 263, which contains requirements for:

- Obtaining an EPA Identification Number
- Manifesting hazardous waste shipments
- Recordkeeping and reporting
- Sending bulk shipments (by water, rail).

Storage regulations apply if accumulation times at transfer stations are exceeded. Transporters importing hazardous wastes, or mixing hazardous wastes of different Department of Transportation (DOT) shipping descriptions in the same container, are classified as generators and must comply with 40 *CFR* Parts 262 and 268. Investigators evaluating transporter compliance should do the following:

- Verify that the transporter has an EPA identification number that is used on all required documentation (e.g., manifests).

- Determine whether hazardous waste containers stored at a transfer facility meet DOT pre-transport requirements.

- Verify whether the transporter is maintaining recordkeeping and reporting documents, including manifests, shipping papers (as required), and discharge reports. All required documents should be both present and complete.

Treatment, Storage, and Disposal Facilities

Permitted and interim status TSDFs are regulated under 40 *CFR* Parts 264 and 265, respectively. (Part 264 applies only if the facility has a RCRA permit (i.e., a permitted facility); Part 265 applies if the facility does not have a RCRA permit (i.e., an interim status facility). These requirements include three categories of regulations consisting of administrative requirements, general standards, and specific standards. The investigator should do the following activities to determine compliance with Subparts A through E:

- Verify that the TSDF has an EPA Identification Number that is used on all required documentation.

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- Determine what hazardous wastes are accepted at the facility, how they are verified, and how they are managed.
- Compare wastes managed at the facility with those listed in the Hazardous Waste Activity Notification (Form 8700-12), the Parts A and B permit applications, and the permit.
- Verify that the TSDF has and is following a waste analysis plan kept at the facility; inspect the plan contents.
- Identify and inspect security measures and equipment.
- Review inspection logs to ensure they are present and complete. Note problems and corrective measures.
- Review training documentation to ascertain that required training has been given to employees.
- Inspect waste management areas to determine whether reactive, ignitable, and incompatible wastes are handled pursuant to requirements.
- Review preparedness and prevention practices and inspect related equipment.
- Review contingency plans; examine emergency equipment and documented arrangements with local authorities.
- Examine the waste tracking system and associated recordkeeping/reporting systems. Required documentation includes manifests and biennial reports, and may include unmanifested waste reports and spill/release reports. Relevant documents may include on-site waste tracking forms.
- Verify that the operating record is complete according to 40 *CFR* 264.73 or 265.73.

The investigator can determine compliance with standards in Subparts F through H by doing the following:

- For permitted facilities, verify compliance with permit standards with respect to ground water monitoring, releases from solid waste management units, closure/post-closure, and financial requirements.
- For interim status facilities required to monitor ground water, determine what kind of monitoring program applies.
- Depending on the type of investigation, examine the following items to determine compliance:
  - Characterization of site hydrogeology
  - Sampling and analytical records

- Statistical methods used to compare analytical data
- Analytical methods
- Compliance with reporting requirements and schedules
- Sampling and analysis plan (for content, completeness, and if it is being followed)
- Conditions, maintenance, and operation of monitoring equipment, including wellheads, field instruments, and sampling materials
- Construction/design of monitoring system
- Assessment monitoring outline and/or plan
- Corrective action plan for permitted facilities and for interim status facilities under 3008(h) enforcement actions.

- For waste management units undergoing closure, review the closure plan (including amendments and modifications), plan approval, closure schedule, and facility and regulatory certification. Examine response actions to any release of hazardous waste constituents from a closed or closing regulated unit.
- For waste management units in post closure care, inspect security measures, ground water monitoring and reporting, and the maintenance and monitoring of waste containment systems.
- Verify that the owner/operator has demonstrated financial assurance regarding closure.

Specific Hazardous Waste Management Units

The technical standards in Part 264 (Subparts I through O and Subpart X) and Part 265 (Subparts I through R) govern specific hazardous waste management units used for storage, disposal, or treatment (e.g., tanks, landfills, incinerators). Standards for chemical, physical, and biological treatment at permitted facilities under Part 264 have been incorporated under Miscellaneous Units, Subpart X. The investigator should do the following:

- Identify all hazardous waste management areas and the activity in each area; compare the areas identified in the field with those listed the permit or permit application, as appropriate. Investigate inconsistencies between actual practice and the information submitted to regulatory agencies.
- Verify that the owner/operator is complying with applicable design, installation, and integrity standards; field-check the design, condition, and operation of waste management areas and equipment.

- Determine how incompatible wastes and ignitable or reactive wastes are managed.
- Verify that the owner/operator is conducting self-inspections where and when required; determine what the inspections include.
- Identify and inspect required containment facilities for condition and capacity; identify lead detection facilities.
- Determine whether hazardous waste releases have occurred and how the owner/operator responds to leaks and spills.
- Verify that the owner/operator is complying with additional waste analysis and trial test requirements, where applicable.
- Check the closure/post-closure procedures for specific waste management units (surface impoundments, waste piles, etc.) for regulatory compliance.
- For landfills, determine how the owner/operator manages bulk and contained liquids.
- Field-check security and access to waste management units.
- Determine the facility monitoring requirements (for air emissions, ground water, leak detection, instrumentation, equipment, etc.) and inspect monitoring facilities and records.

Land Treatment Facilities

When inspecting land treatment facilities, the investigator should also review the following items:

- Soil monitoring methods and analytical data.
- Comparisons between soil monitoring data and background concentrations of constituents in untreated soils to detect migration of hazardous wastes.
- Waste analyses done to determine toxicity, the concentrations of hazardous waste constituents, and, if food-chain crops are grown on the land, the concentrations of arsenic, cadmium, lead, and mercury in the waste(s). The concentrations must be such that hazardous waste constituents can be degraded, transformed, or immobilized by treatment.
- Runon and runoff management systems.

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Incinerators

When evaluating compliance of interim status incinerators, the investigator also should review and/or inspect the following items:

- Waste analyses done to enable the owner/operator to establish steady-state operating conditions and to determine the pollutants that might be emitted.
- General procedures for operating the incinerator during start-up and shut-down.
- Operation of equipment used for monitoring combustion and emissions control, monitoring schedules, and data output.
- The incinerator and associated equipment.

For permitted incinerators, the investigator must evaluate the incinerator operation against specific permit requirements for waste analysis, performance standards, operating requirements, monitoring, and inspections. The investigator also should do the following:

- Verify that the incinerator burns only wastes specified in the permit
- Verify methods to control fugitive emissions
- Determine waste management practices for burn residue and ash.

Thermal Treatment Facilities

The investigator evaluating compliance of thermal treatment facilities in interim status also should review the following items:

- General operating requirements, to verify whether steady-state operating conditions are achieved, as required.
- Waste analysis records, to ensure that (a) the wastes are suitable for thermal treatment and (b) the required analyses in Part 265.375 have been performed.

Thermal treatment facilities permitted under 40 *CFR* Part 264 Subpart X will have specific permit requirements.

Biological Treatment Facilities

The investigator evaluating compliance of chemical, physical, and biological treatment facilities in interim status also should do the following:

- Determine the general operating procedures.

- Review the waste analysis records and methods to determine whether the procedures are sufficient to comply with 40 *CFR* 265.13.
- Review trial treatment test methods and records to determine whether the selected treatment method is appropriate for the particular waste.
- Examine procedures for treating ignitable, reactive, and incompatible wastes for compliance with Subpart Q requirements.

Chemical, physical, and biological treatment facilities permitted under Subpart X will have specific permit requirements.

TSDF Air Emission Standards

Owners/operators of TSDFs must also comply with air emission standards contained in Subparts AA and BC of 40 *CFR* Parts 264 and 265. These subparts establish standards for equipment containing or contacting hazardous wastes with organic concentrations of at least 10 percent. This equipment includes:

- Process vents
- Pumps in light liquid service
- Compressors
- Sampling connecting systems
- Open-ended valves or lines
- Valves in gas/vapor service or in light liquid service
- Pumps and valves in heavy liquid service, pressure relief devices in light liquid or heavy liquid service, and flanges and other connections.

Total organic emissions from process vents must be reduced below 1.4 kg/hr and 2.8 mg/yr. The other equipment types above must be marked and monitored routinely to detect leaks. Repairs must be initiated within 15 days of discovering the leak.

The facility operating record should contain information documenting compliance with the air emission standards. A complete list of required information is in 40 *CFR* 264.1035, 264.1064, 265.1035, and 265.1064. Permitted facilities must submit semiannual reports to the Regional Administrator outlining which valves and compressors were not fixed during the preceding 6 months. The investigator can do the following things:

- Visually inspect the equipment for marking.
- Review documentation in the operating record and cross-check this information with that submitted to the Regional Administrator in semiannual reports.

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Land Disposal Restrictions

Land Disposal Restrictions (LDR) in 40 *CFR* Part 268 are phased regulations prohibiting land disposal of hazardous wastes unless the waste meets applicable treatment standards as listed in 40 *CFR* 268.40-43. The treatment standards are expressed as (1) contaminant concentrations in the extract or total waste or (2) specified technologies.

Notifications and certifications comprise the majority of required LDR documentation. Notifications tell the treatment or storage facility the appropriate treatment standards and any prohibition levels (California List wastes) that apply to the waste. Certifications are signed statements telling the treatment or storage facility that the waste already meets the applicable treatment standards and prohibition levels.

The regulations divide hazardous wastes into restricted waste groups and apply a compliance schedule of different effective dates for each group (40 *CFR* Part 268, Appendix VII).

Investigators evaluating hazardous waste generators for LDR compliance should do the following:

- Determine whether the generator produces restricted wastes; review how/if the generator determines a waste is restricted.
- Review documentation/data used to support the determination that a waste is restricted, based solely on knowledge.
- Determine how/if a generator determines the waste treatment standards and/or disposal technologies.
- Verify whether the generator satisfies documentation, recordkeeping, notification, certification, packaging, and manifesting requirements.
- Ascertain whether the generator is, or might become, a TSDF and subject to additional requirements.
- Determine who completes and signs LDR notifications and certifications and where these documents are kept.
- Review the waste analysis plan if the generator is treating a prohibited waste in tanks or containers.

Investigators evaluating TSDFs should do the following:

- Ensure the TSDF is complying with generator recordkeeping requirements when residues generated from treating restricted wastes are manifested offsite.
- Verify whether the treatment standards have been achieved for particular wastes prior to disposal.

- Review documentation required for storage, treatment, and land disposal; documentation may include waste analyses and results, waste analysis plans, and generator and treatment facility notifications and certifications.

Subtitle I—Underground Storage Tanks (USTs)

Evaluating Compliance

Because the tanks are located underground, visual/field observations have limited application in determining compliance for USTs. The UST program relies heavily on the use of documents to track the status and condition of any particular tank.

Interviews with facility personnel are important when determining compliance with any environmental regulation. Questions regarding how the facility is handling its UST program will give the inspector insight into the types of violations that may be found. Topics to be covered.in the interview include:

- Age, quantity, and type of product stored for each onsite tank.
- How and when tanks have been closed.
- Type of release detection used on each tank (if any); some facilities may have release detection on tanks where it is not required.
- Type of corrosion protection and frequency of inspections.
- Which tanks have pressurized piping associated with them.

Visual/field observations are used to determine if any spills or overfills have occurred that have not been immediately cleaned up. The presence of product around the fill pipe indicates a spill or overfill. Proper release detection methods can also be verified with field observations. During the interviews, ask the facility if monthly inventory control along with annual tightness testing is used. If monthly inventory control is used, check the measuring stick for divisions of 1/8 inch. A field check of the entire facility can also be done to determine if any tanks may have gone unreported. Fillports and vent lines can indicate the existence of a UST.

Documents take up the largest portion of time during a UST inspection. Documents that should be reviewed include:

- Notifications for all UST systems
- Reports of releases including suspected releases, spills and overfills, and confirmed releases
- Initial site characterization and corrective action plans
- Notifications before permanent closure

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- Corrosion expert's analysis if corrosion protection is not used
- Documentation of operation of corrosion protection equipment
- Recent compliance with release detection requirements, including daily inventory sheets with the monthly reconciliation
- Results of site investigation conducted at the time of permanent closure.

Document retention rules also apply, so be sure to get all of the documents a facility may be required to keep. To determine if the implementing agency has been notified of all tanks, compare the notifications to general UST lists from the facility. Usually, the facility will keep a list of tanks separate from the notifications and tanks may appear on that list that do not appear on a notification form. Also, compare the notifications to tank lists required in other documents, like the Spill Prevention Control and Countermeasures Plan.

Subtitle J—Medical Wastes

Subtitle J was added to RCRA in November 1988 to address concerns about the management of medical wastes. EPA enacted interim final regulations in March 1989. The regulations, found in 40 *CFR* Part 259, establish a demonstration program with requirements for medical waste generators, transporters, and Treatment, Destruction, and Disposal Facilities (TDDFs). The demonstration program was effective during the period June 22, 1989, to June 22, 1991. The regulations applied to regulated medical wastes generated in Connecticut, New Jersey, New York, Rhode Island, and Puerto Rico.

Basic Program

Medical waste is defined in 40 *CFR* 259.10 as any solid waste generated in the diagnosis, treatment, or immunization of human beings or animals, in related research, biological production, or testing. The following are exempt from 40 *CFR* Part 259 requirements;

- Any hazardous waste identified or listed under 40 *CFR* Part 261
- Any household waste defined in 40 *CFR* 261.4(b)(1)
- Residues from treatment and destruction processes or from the incineration of regulated medical wastes
- Human remains intended to be buried or cremated
- Etiologic agents being shipped pursuant to the Federal regulations
- Samples of regulated medical waste shipped for enforcement purposes.

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Regulated medical waste is a subset of all medical wastes and includes seven categories:

1. Cultures and stocks of infectious agents
2. Human pathological wastes (e.g., tissues, body parts)
3. Human blood and blood products
4. Sharps (e.g., hypodermic needles and syringes used in animal or human patient care)
5. Certain animal wastes
6. Certain isolation wastes (e.g., waste from patients with highly communicable diseases)
7. Unused sharps (e.g., suture needles, scalpel blades, hypodermic needles).

Etiological agents being transported interstate and samples of regulated medical waste transported offsite by EPA or State-designated enforcement personnel for enforcement purposes are exempt from the requirements during the enforcement proceedings.

Mixtures of solid waste and regulated medical waste are also subject to the requirements. Mixtures of hazardous and regulated medical waste are subject to the 40 *CFR* Part 259 requirements only if shipment of such a mixture is not subject to hazardous waste manifesting (e.g., the hazardous waste is shipped by a conditionally exempt generator).

Generators, transporters, and owners or operators of intermediate handing facilities or destination facilities that transport, offer for transport, or otherwise manage regulated medical waste generated in a Covered State must comply with the regulations even if such transport or management occurs in a non-Covered State. Vessels at port in a Covered State are subject to the requirements for those regulated medical wastes transported ashore in the Covered State. The owner or operator of the vessel and the person(s) removing or accepting waste from the vessel are considered co-generators of the waste.

A generator who treats and destroys or disposes of regulated medical waste onsite [e.g., incineration, burial, or sewer disposal covered by section 307(b) through (d), of the Clean Water Act] is not subject to tracking requirements for that waste. However, such onsite waste management may subject the generator to additional Federal, State, or local laws and regulations.

Evaluating Compliance

The inspector should evaluate whether the generator has determined what regulated medical waste streams are generated and/or managed. Generators of less than 50 pounds per month are exempt from certain transportation and tracking requirements. Compliance should be evaluated by doing the following:

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- Prior to shipping waste offsite, verify that the wastes are segregated and packed in the appropriate containers. Verify that containers are properly marked. If containers are reused, verify that they are decontaminated.

- Verify that the generator uses tracking forms and that copies of the forms and any exception reports are kept for 3 years. Determine if the generator exports medical waste for treatment, destruction, or disposal? If so, the generator must request that the destination facility provide written confirmation that the waste was received; an exception report must be filed if such a confirmation is not received within 45 days. If the generator incinerates medical waste onsite, verify whether the recordkeeping and reporting regulations for onsite incinerators are being followed.

The transportation requirements apply to transporters, including generators that transport their own waste, and owners and operators of transfer facilities engaged in transporting regulated medical waste generated in a Covered State. The inspector should verify that:

- The proper labeling and marking of regulated medical waste accepted for transportation has taken place or has been done

- If the waste is handled by more than one transporter, that each transporter attaches a water resistant identification tag below the generator's marking and that the required information is on the tag

- The transporter submitted the required notification(s) for each Covered State

- The vehicles are fully enclosed, leakproof, maintained in sanitary condition, secured when unattended, and marked with the proper identification

- The applicable requirements for rail shipments are followed

- Tracking forms are used properly

- Recordkeeping and reporting requirements are followed.

The requirements for treatment, destruction, and disposal facilities apply to owners and operators of facilities that receive regulated medical waste generated in a Covered State, including facilities located in non-Covered States. The facilities include destination facilities, intermediate handlers, and generators that receive regulated medical waste required to be accompanied by a tracking form. The inspector should verify the following:

- Whether tracking forms are used and have been properly completed
- Whether tracking forms discrepancies have been resolved
- Whether the recordkeeping requirements are being followed
- Whether any additional information required by the Administrator has been reported.

For rail shipments of regulated medical waste, the inspector should determine whether the tracking forms are used properly.

Pollution Prevention

EPA is developing an Agency-wide policy for pollution prevention. Present authorities were established in the 1984 Hazardous and Solid Waste Amendments to RCRA (Section 3002). The October 1990 Pollution Prevention Act established pollution prevention as a national priority.

Evaluating Compliance

EPA has developed a policy regarding the role of inspectors in promoting waste minimization (OSWER directory number 9938.10). As stated in the policy, to evaluate compliance, the Inspector should:

- Check hazardous waste manifests for a correctly worded and signed waste minimization certification.
- Determine whether this certification was manually signed by the generator or authorized representative.
- Confirm that a waste minimization program is in place by requesting to see a written waste minimization plan, or requesting that the plan be described orally, or requesting that evidence of a waste minimization program be demonstrated. The inspector can, and should, visually check for evidence of a "program in place" onsite.
- Check the Biennial Report and/or Operating record of generators and TSDFs, as appropriate. These documents should contain descriptions of waste minimization progress and a certification statements. If known omissions, falsifications, or misrepresentations on any report or certification are suspected, criminal penalties may apply and the case should be referred for criminal investigation.
- Check any waste minimization language included in the facility's permits, any enforcement order, and settlement agreements. Verify that waste minimization requirements are being satisfied.

The policy also states that the inspector should promote waste minimization by:

- Being familiar with, recommending, and distributing waste minimization literature.
- Referring the facility to the appropriate technical assistance program for more specific or technical information.
- Providing limited, basic advice to the facility of obvious ways they can minimize their waste. This advice should be issued in an informal manner with the caveat that it is not binding in any way and is not related to regulatory compliance.

The multi-media inspection team can also document cross-media transfers of waste streams, that can result in false claims of waste minimization. For example, a facility could treat a

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solvent wastewater stream in an air stripper that has no air pollution control devices. On paper, the amount of solvent discharged to a land disposal unit or sewer system could show a reduction, but the pollutants are going into the air, possibly without a permit. Another example would be a facility claiming a reduction in hazardous waste generated because the waste steam was delisted.

B. Clean Air Act (CAA)

The Clean Air Act (CAA) is the legislative basis for air pollution control regulations. It was first enacted in 1955 and later in 1963, 1965, 1970, 1977, and 1990. The 1955 and the 1963 Amendments called for the abatement of air pollution through voluntary measures. The 1965 amendments gave Federal regulators the authority to establish automobile emission standards.

Basic Program

The CAA Amendments of 1970 significantly broadened the scope of the Act, forming the basis for Federal and State air pollution control regulations. Section 109 of the 1970 Amendments called for the attainment of National Ambient Air Quality Standards (NAAQS, 40 *CFR* Part 50) to protect public health and welfare from the known or anticipated adverse effects of six air pollutants (as of 1990 the standards were for small particulates, sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, and lead). The States were required to develop and submit to EPA implementation plans that were designed to achieve the NAAQS. These State Implementation Plans (SIPs) contained regulations that limited air emissions from stationary and mobile sources. They were developed and submitted to EPA on a continuing basis and became federally enforceable when approved.

Section 111 of the 1970 Amendments directed EPA to develop standards of performance for new stationary sources. These regulations, known as New Source Performance Standards (NSPS, 40 *CFR* Part 60), limited air emissions from subject new sources. The standards are pollutant and source specific.

Section 112 of the 1970 amendments directed EPA to develop standards for hazardous air pollutants. These regulations, known as the National Emission Standards for Hazardous Air Pollutants (NESHAPs, 40 *CFR* Part 61), limited hazardous air emissions from both new and existing sources.

The CAA Amendments of 1977 addressed the failure of the 1970 amendments to achieve the NAAQS by requiring permits for major new sources. The permit requirements were based on whether the source was located in an area that did not meet the NAAQS (non-attainment areas). The permit program for sources in attainment areas was referred to as the Prevention of Significant Deterioration (PSD) program.

The CAA Amendments of 1990 significantly expanded the scope of the Act. Section 112 amendments have amended the NESHAP program with the new provisions called "Title III - Hazardous Air Pollutants." Title III listed 189 hazardous air pollutants (Appendix O) and required EPA to start setting standards for categories of sources that emit these pollutants within 2 years (1992) and finish setting all standards within 10 years (2000). It also contains provisions for a prevention-of-accidental-releases program.

Section 211 of the CAA regulates any fuel or fuel additive for use in motor vehicles if the resulting emission would cause or contribute to air pollution that may reasonably be anticipated to endanger public health or welfare, or if the emission products would significantly impair any emission control device or system in general use. There are several provisions under CAA section 211 which regulate fuels such as gasoline, diesel fuel, and fuel additives.

The Federal tampering prohibition is contained in Section 203(a)(3) of the CAA, 42 U.S.C. 7522(a)(3). Section 203(a)(3)(A) of the Act prohibits any person from removing or rendering inoperative any emission control device or element of design installed on or in a motor vehicle or motor vehicle engine prior to its sale and delivery to an ultimate purchaser. Section 203(a)(3)(A) also prohibits any person from knowingly removing or rendering inoperative any such device or element of design after such sale and delivery and the causing thereof.

Section 203(a)(3)(B) of the Act prohibits any person from manufacturing, selling, offering for sale, or installing any part or component intended for use with, or as part of, any motor vehicle or motor vehicle engine where a principal effect of the part or component is to bypass, defeat, or render inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations under this title, and where the person knows or should know that such part or component is being offered for sale or is being installed for such use.

Section 609 of the CAA Amendments of 1990 requires facilities that perform service on vehicle air conditioners to have recycling or recovery equipment and the technicians who use the equipment to be certified by an EPA-approved §609 program.

Evaluating Compliance

The following procedures are used to evaluate compliance with the Clean Air Act.

Before an onsite inspection, the documents listed below should be obtained from State or EPA files and reviewed to determine what regulations apply and what compliance problems may exist.

- The State air pollution control regulations contained in the SIP (State regulations and permits form the basis for the air compliance inspection and will vary from State to State).
- The State operating and construction permits.

- The most current emissions inventory (check for sources subject to SIP, NSPS, and NESHAPs requirements).
- The Volatile Organic Compound (VOC) emissions inventory. (The VOC inventory may not be included in the emissions inventory, but reported separately under SARA Title III Form R submittal. More information on the former submittal is found in the Emergency Planning and Community Right-to-Know section.).
- The consent decrees/orders/agreements still in effect and related correspondence.
- The most recent inspection reports.
- The most recent monthly or quarterly Continuous Emission Monitoring/Continuous Opacity Monitoring (CEM/COM) reports:
- AIRS Facility Subsystem (AFS) reports.
- Process descriptions, flow diagrams, and control equipment for air emission sources.
- Facility plot plan that identifies and locates the air pollution emission points.

The onsite inspection should include a review of the records and documents listed below:

- Process operating and monitoring records to determine if permit requirements are being followed.
- Fuel analysis reports (including fuel sampling and analysis methods) to determine if sulfur dioxide emission limits and/or other fuel requirements are being met.
- Reports of process/control equipment malfunctions causing reportable excess emissions (refer to SIP to determine reportable malfunctions and report requirements).
- Source test reports to determine if NSPS, NESHAPs, and/or major sources have demonstrated compliance with emission standards.
- CEM reports to determine if NSPS and SIP reporting requirements are being met (reported emissions should be checked against raw data for accuracy, and reported corrective actions should be checked for implementation).
- CEMS/COMS certification tests (relative accuracy and calibration drift) to verify that performance specifications at 40 *CFR* Part 60, Appendix B, are met.
- Records and reports specified in SIP regulations, NSPS and NESHAP subparts, and applicable permits.

The onsite inspection should also include the following:

- Visible Emission Observations (VEOs), by inspectors certified to read smoke within the last 6 months, to determine compliance with SIP, NSPS, or NESHAPs opacity limits (document non-compliance with EPA Method 9, 40 *CFR* Part 60, Appendix A).

- A check of real time CEM measurements to determine compliance SIP, NSPS, or NESHAPs limits (opacity CEM measurements can be compared against VEOs).

- A review of CEM/COM calibration procedures and frequency to determine if the zero/span check requirements and analyzer adjustment requirements of 40 *CFR* Part 60 are being met.

- Observations of process and control equipment operating conditions to determine compliance with permit conditions (if no permit conditions apply, control equipment operating conditions can be compared to baseline conditions from stack tests or manufacturer's specifications for proper operation).

- Observation of control equipment operating conditions and review of equipment maintenance practices and records to determine proper operation of control equipment.

- When inspecting a fuel refinery or terminal and when time permits, the investigator should review records to assess compliance with fuel regulations under CAA section 211. Things to look for include compliance with the new reformulated gasoline requirements including Reid vapor pressure levels (during summer months only) and oxygenate levels of outgoing gasoline, the sulfur content of outgoing diesel fuel, and the lead level of unleaded gasoline leaving the refinery.

- When inspecting a facility with its own fleet of vehicles or garage, maintenance records for the vehicles should be reviewed to determine compliance with Section 203 of the CAA. A review of air conditioning repair/maintenance records should also be conducted to determine compliance with Section 609 of the CAA.

- A review of all sources to determine if existing, new, modified, or reconstructed sources have construction and operating permits required by SIP (note other process changes that may not require a permit but could affect emissions). For example:

  - Are there any boilers, stationary diesel engines (emergency generators, lift pumps), or waste gas boilers of any size? What are their capacities, when installed or altered?

  - Are there any incinerators for sludge, grease, grit, screenings, etc.? When were they installed or altered?

  - Are there any storage tanks storing any liquid except water? What are their capacities, when installed or altered?

  - Are there any solvent or gasoline tanks? What are their capacities, when installed or altered?

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- Are there any storage silos for storing solid particles (e.g., lime)? What are their capacities, when installed or altered?

- Are there any air pollution control devices of the following types? When where they installed or altered?

  -- Odor control equipment (carbon adsorbers, scrubbers) on such equipment as sludge handling/storage tanks, pump stations, wet-wells, metering stations, grit screening, headworks building?

  -- Waste gas burners such as digester flares, boilers, etc.?

  -- Scrubbers on pH adjustment process or pretreatment equipment (usually HCl control)?

- Is there any shop equipment of the following types? When was it installed or altered?

  -- Paint spray booths
  -- Shotblast booths, controlled (any size) or uncontrolled
  -- Solvent degreasers

- Is there any wastewater or water treatment equipment designed to reduce Volatile Organic Compounds (VOCs), which may emit air contaminants, such as aeration basins, surface impoundments, air strippers, roughing filters, trickling filters, or oil/water separators? When was the equipment installed or altered?

- At industrial/commercial wastewater and pretreatment facilities, are there any aeration basins, lagoons, or settling basins? When were they installed or altered?

- At industrial/commercial treatment works, is there equipment used to dispense odor reducing/masking agents? When was it installed or altered?

- At industrial/commercial treatment works, is there equipment used directly to manufacture fertilizers (including mixers, blenders, conveyors, etc.)? When was it installed or altered?

C. Safe Drinking Water Act (SDWA)

Basic Program

Public drinking water supply systems (i.e., that serve at least 25 people or have 15 service connections) are regulated by the Safe Drinking Water Act (SDWA) Amendments of 1986. EPA sets standards [known as Maximum Contaminant Levels (MCLs)] for the quality of water that can be served by public water systems. Public systems must sample their water periodically and report findings to the State (or EPA, if the State has not been delegated the authority to enforce the SDWA). The systems must notify consumers if they do not meet the standards or have failed to monitor or report. EPA is on a statutory schedule for promulgating a large number of new MCLs.

The Underground Injection Control (UIC) program was developed pursuant to the SDWA (Public Law 93-523), Part C—Protection of Underground Sources of Drinking Water (40 *CFR* Parts 124 and 144 through 148). The UIC program regulates five classes of injection wells, summarized as follows:

Class I Industrial, municipal, or hazardous waste disposal beneath the lowermost underground source of drinking water (USDW)

Class II Oil and gas-related wells used for produced fluid disposal, enhanced recovery, hydrocarbon storage, etc.

Class III Mineral extraction wells

Class IV Hazardous or radioactive waste disposal above or into a USDW

Class V Injection wells not included in Classes I through IV.

Evaluating Compliance

Monitoring requirements for water supply systems and whether the system can be reasonably expected to routinely provide safe potable water should be determined. Many facilities purchase their potable water supply from a nearby municipality. If no further treatment is provided (e.g., chlorination by the facility), the facility remains a "consumer" rather than becoming a "supplier," and consequently does not have the monitoring or reporting requirements that a supplier would have. Nevertheless, the facility does have a responsibility to ensure that their actions do not result in contamination of the municipal water supply (e.g., through cross-connection). The audit team should be alert to these possibilities.

R0014986

Inspectors should:

- Verify public water system records of monitoring and reports of exceedances of MCLs
- Interview water system personnel to identify potential operations and maintenance problems
- Obtain water source, treatment, and service area information
- Verify that sample locations are appropriate.

For UIC inspections, the following should be reviewed:

- Current status of wells (active, abandoned, under construction repairs)
- Types of wastes discharged to wells
- Injection well construction
- Potential pathways of endangerment to Underground Sources of Drinking Water (USDWs)
- Protection of USDWs from endangerment
- Frequency and type of Mechanical Integrity Testing (MIT)
- Annular pressure
- Annular pressure monitoring
- Radioactive tracer surveys
- Installation methods for well plugging
- Remedial operation
- Applicability of land disposal restrictions to injection well operations
- Recordkeeping and evidence documentation
- Outlets for floor drains
- Connection to "dry" wells
- Evidence of surface ponding.

Several States and industries have requested approval of alternative mechanical integrity testing methods or variances to accommodate special local hydrogeological conditions,

historical practices, or industry interests. Inspectors and field investigators should be cautioned to keep current with special permit conditions and the status of any pending approvals/denials of alternative mechanical integrity testing procedures and variances.

D. Toxic Substances Control Act (TSCA)

This section describes those specific aspects of toxic substances control that are addressed by the Toxic Substances Control Act (TSCA) and its associated rules and regulations (40 *CFR* Parts 702 through 799).

Basic Program

The regulation of toxins under TSCA is divided into two components for Agency enforcement program management purposes.

1. "Chemical control" covers enforcement aspects related to specific chemicals regulated under Section 6 of TSCA, such as Polychlorinated Biphenyls (PCBs), Chlorofluorocarbons (CFCs), and asbestos.

2. "Hazard evaluation" refers to the various recordkeeping, reporting, and submittal requirements specified in Sections 5, 8, 12, and 13 of TSCA; although, some elements of what might be termed "chemical control" are also addressed in these sections. Sections 12 and 13 of TSCA, which pertain to chemical exports and imports, respectively, will not be covered in this manual because of their special nature and unique requirements.

Prior to discussing TSCA activities at a facility, the investigator must present appropriate facility personnel with copies of two TSCA inspection forms:

1. Notice of Inspection—Shows purpose, nature, and extent of TSCA inspection.

2. TSCA Inspection Confidentiality Notice—Explains a facility's rights to claim information at the facility as TSCA Confidential Business Information.

Before leaving the site, two additional forms must be completed, as appropriate:

1. Receipt for Samples and Documents—Itemizes all documents, photos, and samples received by the investigator during the inspection.

R0014988

2. Declaration of Confidential Business Information—Itemizes the information that the facility claims to be TSCA Confidential Business Information.

Evaluating Compliance

Chemical Control

Although the controlled substances most frequently encountered during multi-media investigations are PCBs, the investigator should determine if other regulated toxic substances are present at the facility. Currently these include metal working fluids (Part 747), fully halogenated chlorofluoroalkanes (40 *CFR* Part 762), and asbestos (40 *CFR* Part 763); additional toxic substances may be regulated in the future. Because the probability of finding PCBs and PCB-items at the facility is greater than finding other TSCA-regulated substances, the following discussion is directed toward an evaluation of compliance with proper PCB and PCB-item handling procedures. If other TSCA-regulated substances are found, the investigator should consult the regulations for appropriate requirements.

Management of PCBs/PCB-items is regulated under 40 *CFR* Part 761. In general, these regulations address recordkeeping, marking and labeling, inspections, storage, and disposal.

Facilities that store and/or dispose of PCBs and PCB-items should have EPA-issued letters of approval that contain facility operating and recordkeeping requirements in addition to those specified in 40 *CFR* Part 761. The investigator must obtain a copy of these approvals and any subsequent notifications to evaluate facility compliance. The inspector should review Part 761.30 to identify uses of PCB transformers which are prohibited beginning October 1, 1990, but with effective dates extending to October 1, 1993. The inspector should also review the requirements found in Part 761.30 that allow the installation of PCB transformers for emergency use.

In general, the compliance evaluation includes obtaining and reviewing information from Federal, State, and local regulatory agency files; interviewing facility personnel regarding material handling activity; examining facility records and inspecting materials handling units. Specific investigation tasks include:

- Inspect all in-service electrical equipment, known or suspected of containing PCBs, for leaks or lack of proper marking. A similar inspection should also be made of any equipment that the facility is storing for reuse. Make certain that any remedial actions were quick and effective in the case of leaks, spills, etc.

- If the above equipment includes any PCB transformers or capacitors, make certain that all relevant prohibitions are being met, such as those involving enhanced electrical protection, as well as other requirements in the Use Authorization section of the PCB Rule. Make certain that any hydraulic or heat transfer systems suspected of containing PCB fluids have been properly tested.

R0014989

- Determine whether the facility is involved with servicing PCB items or using/collecting/producing PCBs in any manner. If so, make certain that the appropriate requirements of the PCB Rule are being met.

- Determine whether the facility is involved with either the storage or disposal of PCBs/PCB-items. Inspect all storage for disposal facilities for proper containment, leaking items, proper marking, dates/time limits, location, protection from elements, and other necessary requirements. If the facility disposes of PCBs, make certain that proper methods are being employed and that design and operation of disposal units is in accordance with regulatory requirements.

- Determine whether storage/disposal facilities are complying with the notification and manifesting requirements contained in Subpart K of the PCB Rule.

- Thoroughly review, for purposes of adequacy and regulatory compliance, all records and reports required by the PCB Rule including the following:

  - Annual documents
  - Inspection logs
  - PCB transformer registration letters
  - Manifests/certificates of destruction
  - Test data
  - Spill cleanup reports
  - EPA-issued permits or letters of approval
  - SPCC plan, if one is necessary
  - Operating records
  - Notification of PCB activity.

Hazard Evaluation

Establishing compliance with the various hazard evaluation aspects of TSCA is best accomplished through review and evaluation of the recordkeeping, reporting, and submittal data required by the various regulatory components of Sections 5 and 8. In general, Section 5 addresses new chemicals (i.e., those not on the TSCA Chemical Substances Inventory) and Section 8 addresses existing chemicals (i.e., those chemicals that are on the TSCA Chemical Substances Inventory).

Much of the information obtained and reviewed under these two sections of TSCA will be declared "TSCA Confidential Business Information" by company official, and thus special security procedures must be followed during review and storage of the documents.

40 *CFR* Parts 703 through 723 should be consulted for an explanation of TSCA terms and definitions. The following list summarizes the different objectives for inspections of the key TSCA Sections 5 and 8 components.

R0014990

1. Premanufacture Notification (PMN)

   a. Verify that all commercially manufactured or imported chemicals are on the TSCA Chemical Substances Inventory, are covered by an exemption, or are not subject to TSCA.

   b. Verify that commercial manufacture or import of new chemicals did not begin prior to the end of the 90-day review date, and not more than 30 days before the Notice of Commencement (NOC) date. If commercial manufacture or import has not begun, verify that no NOC has been submitted.

   c. Verify the accuracy and documentation of the contents of the PMN itself.

2. Research and Development (R&D) Exemption

   a. Verify that the recordkeeping and notification requirements are being met for all R&D chemicals.

   b. Verify that "Prudent Laboratory Practices" and hazardous data searches are adequately documented.

3. Test Marketing Exemption (TME)

   a. Verify that the conditions spelled out in the TME application are being met, particularly with respect to dates of production, quantity manufactured or imported, number of customers and use(s).

   b. Verify that the TME recordkeeping requirements are being met.

4. Low Volume Exemption (LVE) and Polymer Exemption (PE)

   a. Verify that specific conditions of the exemption application are being met, and that all test data have been submitted.

   b. For an LVE, verify that the 1,000-kg limit per 12-month period has not been exceeded. For a PE, ensure that the chemical structure and monomer composition(s) are accurate.

   c. Verify that recordkeeping requirements for both LVEs and PEs are being met.

5. 5(e)/5(f) Order, Rule, or Injunction

   a. Verify that all conditions of the order, rule, or injunction are being followed, including use of protective equipment, glove testing, training, and recordkeeping.

   b. If a testing trigger is specified, verify production volume and status of testing activity.

6. Significant New Use Rule (SNUR)

   a. Verify that no commercial production has occurred prior to the 90-day review date.

   b. Verify that SNUR notices (i.e., Significant New Use Notices [SNUNs] have been submitted for all applicable manufactured, imported, or processed chemicals.

   c. Verify technical accuracy of SNUN and completeness of required recordkeeping.

7. Bona Fide Submittals

   Determine the commercial production (or import) status and R&D history of those bona fide chemicals not found on the confidential 8(b) inventory. Verify findings against applicable PMN, TME, and other exemption.

8. Section 8(a) Level A PAIR and CAIR Report

   a. Determine if Preliminary Assessment Information Rule (PAIR) and Comprehensive Assessment Information Rule (CAIR) reports have been submitted for all 8(a) Level A listed chemicals manufactured or imported by the facility.

   b. Verify the accuracy of submitted PAIR information, particularly the reported figures for total production volume and worker exposure levels.

   c. Verify the accuracy of submitted CAIR information and if the report meets the date specified in the regulation.

9. Section 8(b) Inventory Update Rule (IUR)

   a. Verify the accuracy of the information submitted in response to the IUR.

   b. Determine that required information was submitted by the deadline for all chemicals subject to IUR.

10. Section 8(c) Recordkeeping

   a. Determine if the facility has a Section 8(c) file and that allegations of significant health and environmental harm on record are properly filed and recorded.

   b. Determine that all applicable allegations have been recorded and filed.

   c. Determine if the facility has a written Section 8(c) policy and if the policy includes outreach to the employees.

R0014992

11. Section 8(d) Reporting

Determine if copies (or lists) of all unpublished health effects studies have been submitted by manufacturers, importers, and processors for any Section 8(d) listed chemical.

12. Section 8(e) Reporting

a. Verify that all Section 8(e) substantial risk reports to the Agency were accurate and submitted within the required time frames.

b. Verify that all substantial risk incidents and/or test results have been reported to EPA.

c. Determine that the company has an adequate written policy addressing Section 8(e), and that it relieves employees of individual liability.

E. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Basic Program

Pesticides are regulated by FIFRA and regulations promulgated pursuant to FIFRA. Many States have primary enforcement responsibility for FIFRA. Under FIFRA, pesticide products must be registered by EPA before they are sold or distributed in commerce. EPA registers pesticides on the basis of data adequate to show that, when used according to label directions, they will not cause unreasonable adverse effects on human health or the environment.

To ensure that previously registered pesticides meet current scientific and regulatory standards, in 1972 Congress amended FIFRA to require the "reregistration" of all existing pesticides.

Evaluating Compliance

The following list is used in conjunction with specific storage/use/disposal requirements found on pesticide labels. FIFRA requires a written Notice of Inspection and written Receipt for Samples collected.

- Determine types and registration status of all pesticides produced, sold, stored, and used at the facility, particularly if any are restricted or experimental use pesticides.

- Determine use(s) of each pesticide.
- Determine certification status of facility/handlers.
  - Verify who certifies facility/pesticide handlers (EPA, State, Department of Defense).
  - Determine if commercial or private application.
  - If restricted-use pesticides are used, check if pesticide applicators are authorized to use these pesticides.
  - Check expiration dates on licenses/certificates.
- Review applicable records.
  - Check previous inspection records and complaints.
  - Check application records.
  - Check restricted-use pesticides records (must be kept at least 2 years). Document suspected violations accordingly.
  - Check inventory records.
  - Check training records.
  - Check equipment repair records.
- Inspect storage, mixing/loading, and container disposal areas
  - Check bulk storage areas for compliance with Federal/State rules.
  - Check location, ventilation, segregation, shelter, and housekeeping of pesticide storage handling areas. Check security, fire protection, and warning signs, as may be required by State regulations.
  - Check mixing equipment/procedures for reducing handlers' exposures to pesticides.
  - Check for safety equipment/procedures/use.
  - Check container cleanup and disposal procedures.
- Pesticide waste disposal
  - Check to see that pesticides are disposed of in accordance with applicable label and RCRA requirements.

R0014994

- Determine measures taken to ensure worker safety.
  - Check pesticide use records for re-entry time limit notation.
  - Check pesticide use records for informing farmer(s) or warning workers and/or posting fields.
- Observe actual pesticide application.
  - Observe mixing/loading and check calculations for proper use dilution.
  - Observe when spray is turned on/off with respect to ends of field.
  - Watch for drift or pesticide mist dispersal pattern.
  - Note direction of spraying pattern and trimming techniques.
  - Record wind speed and direction, air temperature, and relative humidity.
  - Observe application with respect to field workers, houses, cars, power lines, and other obstacles.
  - Determine if applicator and assisting personnel are wearing safety gear required by the label.

F. Emergency Planning and Community Right-to-Know Act (EPCRA)

Basic Program

The Emergency Planning and Community Right-To-Know Act of 1986 is a free-standing law contained within the Superfund Amendments and Reauthorization Act (SARA) of 1986. EPCRA is also commonly known as SARA Title III. EPCRA requires dissemination of information to State and community groups and health professionals on chemicals handled at regulated facilities.

An EPCRA inspection verifies that the facility owner/operator has notified State and local agencies of regulated activities; has submitted information to specific State and local agencies; and has prepared and submitted all other required reports.

Evaluating Compliance

Emergency Planning (Sections 301 through 303)

EPA promulgated regulations that identify extremely hazardous substances and the levels to be regulated under EPCRA. The inspector should determine whether the facility is subject to EPCRA regulation. If the facility does meet the requirements, the inspector should verify whether the facility owner/operator:

- Notified the State emergency response agency and the local emergency planning committee that the facility is regulated under EPCRA.
- Designated a facility emergency coordinator to assist the local emergency planning committee in the planning process.
- Notified the local emergency planning committee of the emergency coordinator's identity.

Emergency Notification (Section 304)

The owner/operator of a facility subject to EPCRA must immediately report releases of hazardous substances. Substances subject to this requirement are the extremely hazardous substances listed in 40 *CFR* Part 355 and substances subject to the emergency notification requirements under CERCLA Section 103(a) or (c). The inspector should verify whether an immediate notification was made to the:

- State emergency response commission
- Local emergency planning committee
- National Response Center for spills involving CERCLA reportable quantities.

Community Right-to-Know Requirements (Sections 311 through 312)

Manufacturing facilities subject to the Occupational Safety and Health Act (OSHA) Hazardous Communication regulation (29 *CFR* Part 1910) are required to prepare Material Safety Data Sheets (MSDS) for each hazardous chemical handled at the facility. Manufacturing facilities contained within Standard Industrial Classification (SIC) Codes 20 through 39 are subject to these requirements. OSHA revised its Hazardous Communication Regulation, effective September 23, 1987, to require that MSDSs be prepared by nonmanufacturing facilities. The inspector should verify that the facility owner/operator has sent the following to the State emergency response commission, the local emergency planning committee, and the local fire department:

- MSDSs or a list of chemicals covered by MSDSs found at the facility
- An annual inventory of hazardous chemicals found at the facility.

R0014996

Toxic Chemical Release Reporting (Section 313)

Covered facilities (40 *CFR* 372.22) that manufacture, import, process, or use certain chemicals above specified amounts must annually report releases to the environment. The inspector should determine whether the facility owner/operator is required to submit this annual report (Form R). The following criteria are applied to determine if the facility is required to report:

- The facility has the equivalent of 10 or more full-time employees.
- The facility conducts general manufacturing activities that fall within SIC Codes 20-39.
- The facility manufactured on processed in excess of 25,000 pounds or used in any other manner 10,000 pounds or more of the chemicals listed on the Toxic Release Inventory (TRI).

APPENDIX T

NATIONAL MULTI-MEDIA SCREENING INSPECTION CHECKLIST

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MEMORANDUM

OFFICE OF ENFORCEMENT

SUBJECT: National Multi-Media Screening Inspection Checklist Used as a Guideline

FROM: Steven A. Herman
Assistant Administrator

TO: Regional Administrators
Headquarters Compliance Program Directors

Thank you for your comments on the proposed National Multi-Media Screening Inspection Checklist (3/29/93), developed by the Environmental Services Divisions (ESDs), and led by Region III under the auspices of the Enforcement Management Council (EMC). The national checklist consolidated the best of the existing screening questions into one guideline as requested by the EMC. This was a useful project and I commend it.

This memorandum responds to four key issues raised in your comments: 1) the use of the national checklist as a model or guideline; 2) the amount of flexibility that Regions will have to implement screening; 3) the use of multi-media screening in all single media inspections versus targeted use of screening; and 4) time to complete screening relative to the amount of time required for completion of routine single media inspections. The approach, recommended both by my office and Greene Jones (ESD Director, Region III) who organized the national checklist project, was discussed and endorsed by the EMC on April 28, 1993.

Use of the National Multi-Media Screening Inspections Checklist As a General Guideline in FY 1993

The majority of Regions have developed and are using regional checklists. These Regions should review the attached national checklist and make further modifications of their checklists as they see fit. Any Region that was not using a screening inspection checklist in FY 1993 should adopt the national checklist as is or modify it to address regional needs. In either case, multi-media screening should continue during this fiscal year. Region III has reviewed the comments on the checklist and made minor modifications to that portion where there was a consensus concerning the RCRA Program. The revised national checklist is attached (dated 5/12/93).

Frequency of Use of Screening

The goal in FY 1993 has been to use multi-media screening in all single media inspections at facilities with potential multi-media impacts. Regions have adopted different approaches to the use of screening, but all those who commented prefer a targeted use of multi-media screening inspections at this time. I recognize that multi-media screening may not

be productive or beneficial at some facilities. However, I believe that at the majority of facilities screening will be useful, and I encourage you to incorporate multi-media screening inspections in as many single-media inspections as possible.

Creation of a Multi-Media Screening Inspection Work Group

To answer the many questions that still remain about the best approaches to realizing the benefits of multimedia screening inspections, the EMC agreed that OE should work with the Regions and Headquarters to share and to evaluate current practices. We agreed that OE will create a screening inspection work group, reporting to the EMC, with representatives of Headquarters' and Regions' Compliance Programs, the Regional Counsels, the National Enforcement Investigations Center (NEIC), and the ESDs, but OE will keep this group as small as possible.

The work group will build upon the ESDs' effort and focus on the key issues raised in your comments. This will include sharing approaches to the following: managing and organizing multi-media screening inspections; making use of screening-level information; and evaluating the results and benefits of screening inspections. The group will also explore the need, if any, for national consistency in multi-media screening inspections while preserving regional flexibility. Regions will be asked to assess their multi-media screening inspection programs for the fiscal year in a manner that will be defined by the work group. OE will provide further details on this new project in a separate memorandum.

If you have any questions, please contact Cheryl Wasserman, Chief, Compliance Policy and Planning Branch or Becky Barclay, Program Analyst on (202) 260-7550.

Attachment: National Multi-Media Screening Inspection Guidance and Checklist (5/12/93)

cc:
Deputy Regional Administrators
Regional Counsels
Regional Division Directors
OE Office Directors
OE Enforcement Counsels
OCAPO Managers
Enforcement Management Council
Steering Committee on the State/Federal Enforcement Relationship

MULTI-MEDIA SCREENING INSPECTION PROGRAM GUIDANCE AND NATIONAL CHECKLIST (5/12/93)

I. PROGRAM OBJECTIVES

Greater use of multi-media field screening means that EPA is bringing a multi-media outlook into the enforcement process at an earlier stage, rather than at the later stages of case development or settlement. By having multi-media screening information earlier, in the process, EPA Regions can do the following: 1) better target resources for coordinated or consolidated inspections; 2) improve the planning for and coordination of single and multi-media cases; and 3) better assure that all significant releases to the environment are included in any facility-specific enforcement strategy.

The specific objectives of a multi-media screening inspection program are to identify the more obvious unpermitted activities and any other readily detectible instances of non-compliance by using indicators of non-compliance in environmental programs, beyond the primary objective of a single program inspection. Information obtained should be preserved as a whole and also should be referred to a compliance program office(s) or the State, as appropriate. Follow up action could include a coordinated or consolidated inspection (full inspections for one or more programs), or in some instances, an immediate enforcement action.

As a guide for making and recording observations and pertinent information, the compliance inspector will use a multi-media screening checklist. Examples of observations of potential compliance issues include the following: inoperable control systems; unusual emissions or discharge; evidence of spills or leaks; breached dikes, new emissions or discharges sources; lack of permits or Spill Prevention, Containment and Control (SPCC) Plan; abandoned drums; etc.

II. NATIONAL MULTI-MEDIA SCREENING INSPECTION CHECKLIST AS A GENERAL GUIDELINE IN FY 1993

The Environmental Services Divisions' Field Branch Chiefs and the National Enforcement Investigations Center (NEIC) have led the development and implementation of EPA's multi-media inspection program, including screening inspections. The attached National Multi-Media Screening Inspection Checklist (5/12/3) was developed as a general guideline by a regional work group led by Region III. Region III collected eight existing Regional checklists and analyzed the programs and types of questions contained in these.

From this analysis, Region III compiled a national checklist that serves the following purpose: 1) to detect unpermitted discharges, emissions or sources; 2) to gather information on suspected violations of existing regulations or permits across media at a facility or site; and 3) to identify other potentially significant environmental problems which may lie outside EPA's specific statutory mandates but that may warrant some type of follow up.

The national checklist is very broad in scope, covering eleven (11) programs with about seventy (70) questions. To answer these questions, about 45% require field observation and 55% require interview or file review. (See Table 1. Existing Regional Multi-Media Screening Checklists for a summary of programs covered by each Regional checklist.) The national checklist also includes a section, "Environmental Assessment", to identify other potentially significant environmental problems which may warrant some type of follow up. Given this breadth, the work group that developed the checklist estimates that one (1) work day would be required to complete the national checklist in its present form at most facilities.

The majority of Regions have developed and are using regional checklists. These Regions should review the attached national checklist (5/12/93) and make further modifications of their checklists as appropriate. Any Region that was not using a screening inspection checklist in FY 1993 should adopt the national checklist as is or modify it to address regional needs. In either case, multi-media screening should continue during this fiscal year using the national checklist as a general guideline.

Each Region should review the effectiveness of the multi-media screening inspection program once per year. This Review should consider factors such as the compliance issues discovered; success as a targeting tool; value of negative findings (e.g. no planning and development, etc). OE will work with the Regions and Headquarters to review their multi-media screening inspection programs by forming a multi-media screening inspection work group, reporting to the Enforcement Management Council.

III. IMPLEMENTATION OF MULTI-MEDIA SCREENING INSPECTIONS

1. FY 1993 Goal for Use of Multi-Media Screening Inspections Checklist/STARS Credit

As part of the overall effort to incorporate a multi-media perspective into all of EPA's enforcement activities, the Deputy Administrator requested that all single media inspections use a multi-media screening checklist during FY 1993. This goal was articulated in the "Overview" to the FY 1993 Operating Year Guidance (USEPA, 7/92).

Regions have adopted different approaches to the use of screening inspections and prefer a targeted use of these inspections at this time. OE recognizes that multi-media screening may not be productive or beneficial at some facilities, but that it may be useful at the majority or facilities. Therefore, OE encourages that multi-media screening be incorporated into as many single media inspections as possible.

To give recognition to multi-media screening, OE modified the Strategic Targeted Activities for Results Systems (STARS) for FY 1993 to include a measure for reporting the number of single media inspections with multi-media screening. Regional reporting will occur as planned in the third and fourth quarters of FY 1993 and in FY 1994.

2. Training in How to Use the National Checklist

Formal classroom training in how and why to use the national checklist and a multi-media screening inspection training manual (5-10 pages) will be available in FY 1994. The National Enforcement Investigations Center (NEIC), the ESDs and the National Enforcement

Training Institute (NETI) together will develop the necessary training materials for the checklist. Each Region can modify these materials to conform with the use of the checklist in that Region.

3. Pre-Inspection Preparation

Because of the breadth of the multi-media screening inspections guided by the national checklist, some pre-inspection preparation and use of existing information is highly desirable. However, the extent to which this can be done depends on the structure and location of Regional program files and records; the availability of information collection support for inspectors; and access to Integrated Data for Enforcement Analysis (IDEA). Each Region should review its regional checklist [national checklist] and identify existing sources of information for an inspector to easily access and use to complete portions of the checklist during pre-inspection preparation. Each checklist, regional or national, could be modified to denote (with an asterisk) those questions on the checklist for which EPA may already have information.

a. Focus on Questions to Answer in the Field

Depending on the facility or source, EPA compliance inspectors can anticipate answers to some questions, particularly those that require file reviews for the answers, by gathering the information from existing EPA files and databases where these are readily available. Requesting an IDEA report from the respective regional contact (or having direct access) as a routine part of pre-inspection preparation may also be valuable. Having this information prior to the inspection will allow the inspector to focus multi-media screening on changes to a facility's status or condition which are subjects that can only be determined on site.

b. Use of Screening Inspections at a Facility or Site More than Once Per Year

If during the course of the year, multiple single-media inspections are planned at a given facility or site, the compliance inspector should ascertain whether a completed multi-media screening inspection checklist already exists in EPA's records for the facility. If yes, then the screening inspection could focus, as appropriate, on identifying changes from the status or conditions of the facility that were recorded on a multi-media screening inspection checklist during a prior single media inspection.

3. Access to and Referral or Data in Completed Checklists

To get the greatest value from the completed checklist, each Region must ensure that a process exists for referring data on suspected violations or unpermitted discharges, emissions, or activities to the relevant programs(s). Each Region should also ensure that completed checklists are preserved as a whole, and that EPA compliance inspectors and other EPA personnel have easy access to completed checklists by establishing relevant filing or record keeping systems and procedures, manual or electronic. The referral process should include formal written procedures both for the inspector to refer potential compliance issues to the appropriate program and for the program to report back to the inspector. This should include a system for sharing completed checklists with States and referring matters to them as appropriate.

R0015003

4. States Use of the National Multi-Media Screening Inspection Checklist

As part of the Addendum on Multi-Media Enforcement (5/92), EPA agreed to share methods and materials with States to advance multi-media enforcement. Each Region should share this national checklist with the multi-media enforcement contact or coordinator designated by each State; however, use of these materials by a State is optional.

R0015004

MODEL MULTI-MEDIA SCREENING CHECKLIST

R0015005

GENERAL INFORMATION

1. Inspector(s) Name _____ 2. Date _____

3. Facility Name/Address

_____

_____

4. Facility Contact(s)/Title(s)

_____

_____

5. Description of Facility Operations

SIC Code _____

Number of Employees _____

Operating Schedule _____

_____

Major Products/Production Capacity

_____

_____

_____

_____

RCRA

Observations

1. Does the facility generate anything that looks like waste material that might contain hazardous constituents?

2. If so, describe what the facility says regarding the RCRA regulatory status of the waste material and their rational for such determination. (e.g., have they made a RCRA waste identification and what was that determination? Have they determined the waste to be exempt from regulation and why?

3. Describe the process that generates the waste material.

4. Do you see any containers of hazardous waste, land disposal units, lagoons, treatment units? Approximately how many?

5. Were any of the units that contain or handle hazardous wastes (containers, berms, dikes, tanks, piping, impoundments, etc.) in poor condition, unmarked, opened; leaking, cracked, corroded, or in a condition that would allow the release or potential release of hazardous wastes? If yes, describe unit(s). Any actual or evidence of past releases observed? If so, describe waste (i.e., liquid, sludge, etc.) unit(s), and location.

6. Does the facility operate a boiler or industrial furnace which burns hazardous wastes? Was there any incineration of hazardous waste on site?

7. Was there any evidence of spills, leaks, or discharges of hazardous wastes? If so, provide location and description.

_____
_____
_____

Interview Questions/Records Review

1. If the facility is a generator of hazardous waste was there a notification of hazardous waste activity? What is the quantity (kilograms/month) of hazardous wastes produced? How are they produced?

_____
_____
_____
_____

2. What is the EPA Identification Number? _____

3. What was the basis (i.e. test, knowledge of process and waste) for determining if the facility did or did not produce or handle hazardous wastes? Who made the determination?

_____
_____
_____

UST

Observations

1. Are there any underground storage tanks? _____

2. Approximately how many? What are the contents? (Wastes, virgin petroleum, or chemicals) _____

3. What type of leak detection is used? When was it last used?

4. Is there any evidence of leaks, spills, broken piping, broken fill/vent lines, or leaking pump joints or valves? Provide location and description.

Interview Questions/Records Review

1. If the tanks are for virgin petroleum or chemicals (not wastes), are they registered with the state? Date of registration? Date of tank(s) installation?

UST

Observations

1. Are there any underground storage tanks? _____

2. Approximately how many? What are the contents? (Wastes, virgin petroleum, or chemicals) _____

3. What type of leak detection is used? When was it last used?

4. Is there any evidence of leaks, spills, broken piping, broken fill/vent lines, or leaking pump joints or valves? Provide location and description.

Interview Questions/Records Review

1. If the tanks are for virgin petroleum or chemicals (not wastes), are they registered with the state? Date of registration? Date of tank(s) installation?

SPCC

Observations

1. Does the facility have the capacity to store oil either in above or below ground tanks? How many gallons? Does any tank have a capacity of more than 660 gallons in a single tank or does the facility have a capacity of more than 1320 gallons in a number of tanks or a capacity of more than 42,000 gallons below the ground?

2. What type of secondary containment is used at the facility? Were there any deficiencies in the secondary containment (cracks, broken, dikes left open)? Is it adequate to contain the entire contents of the largest tank?

Interview Questions/Records Review

1. Does the facility have a certified (signed by a P.E.) plan? When was it last updated?

2. Has there been any major changes to oil storage at the facility since the last modification of the plan?

WETLANDS

Observations

1. Are there any wet areas near the facility with wetland-type vegetation (cattails, rushes, sedges) that have been disturbed by waste disposal, ditching, or filling?

Interview Questions/Records Review

1. Does the facility have a federal section 404 permit or any state or local permit authorizing the fill?

FIFRA

Observations

1. Does the facility produce pesticides? _____
2. Is the facility applying pesticides? _____
3. Where are the pesticides stored?

Interview Questions/Records Review

1. If the facility produces pesticides what is the establishment's registration number?
   _____
2. If the facility is applying pesticides what is the registration number of the pesticides?
   _____

AIR

Observations

1. Is there any asbestos on site? _____

2. Is the facility undergoing or has the facility undergone any renovations or demolitions during the last 18 months which involve the removal or disturbance of asbestos-containing materials? Approximately how much asbestos (square feet or linear feet) was removed?

_____

_____

3. Does the facility have any coating or printing operations? Does the facility use any paints or organic solvents? What, if any, type of air pollution control is used? Was it operating?

_____

_____

_____

4. Were there any odors? What process was the source of the odors? Describe the odors.

_____

_____

_____

_____

5. Were there any visible (opaque smoke) emissions? What process was the source? Were their any fugitive (not from a stack) emissions? Was the air pollution control equipment, if any, operating? Describe source.

_____

_____

_____

_____

Interview Questions/Records Review

1. If asbestos was removed was notification provide to the State and EPA?

_____

2. If the facility has coating or printing operations are they water based or organic solvent based?

_____

3. Does the facility handle/emit any of the National Emission Standards for Hazardous Air Pollutants (NESHAP) chemicals other than asbestos (mercury, beryllium, vinyl chloride, benzene, arsenic, radionuclides)? Describe process.

4. Has the facility added new or expanded existing processes in the last two years? Was it permitted by EPA of the State?

TSCA-PCB'S

Observations

1. Did the facility have or does it have any PCB electrical equipment? What equipment (type and quantity) is on-site?

2. Does the facility have a PCB equipment storage area for disposal or reuse? Describe the storage area (i.e. concrete pad, walls, roof, curbs).

3. Are there any labels/markings on the PCB equipment?

4. Is there any leaking PCB electrical equipment? Describe.

5. Does the facility have any hydraulic systems? Any leaking?

Interview Questions/Records Review

1. If the facility has PCB electrical equipment was it tested? What were the test results?

2. If the facility has any hydraulic systems when were they tested for PCBs? What were the test results?

WATER-NPDES

Observations

1. Does the facility use water in it's manufacturing process?

2. Does the facility discharge to a stream, municipal sewer, or use subsurface disposal?

3. What process(es) generate wastewater? Is the wastewater treated? Is the effluent clear? Does the treatment plant appear to be maintained (look for rust, dry basins, abandoned equipment, etc.)?

4. Where does the storm water drain to?

5. Where do floor drains discharge?

Interview Questions/Records Review

1. How is the treatment plant's sludge disposed? How is it tested?

EPCRA

Interview Questions/Records Review

1. Were there any chemical releases in excess of the reportable Superfund quantities (see below)? Who was provided the notification? Was it oral or written?

2. Does the facility manufacture, process, or use any toxic chemicals in a quantity greater than 10,000 lbs/yr? Identity them. Are any of them section 313 chemicals (see below)?

3. If the answer to question 2 is yes, has the facility submitted the toxic chemical release form (R)?

4. Does the facility have the Material Safety Data Sheets on site and were they submitted to the State Emergency Response Commission (SERC) and/or the Local Emergency Planning Committee (LEPC)?

5. Has the facility submitted the Emergency and Hazardous Chemical Inventory forms to the LEPC and SERC?

R0015018

The chemicals subject to these requirements can be found in EPA publication number 560/4-92-011, January 1992, "Title III, List of Lists".

SDWA-UIC

Observations

1. Are there any discharges other than sanitary waste (i.e. industrial wastes) into or onto (including drain fields) the ground? Is an on-site septic disposal system used? Describe the discharges and disposal system.

_____

_____

_____

Interview Questions/Records Review

1. Does the facility have or has it had any wells (dug, drilled or driven), dry wells, leachfields, or septic systems? Did they receive(d) commercial or industrial waste (liquid and/or solid), cooling water, or drainage from roof drains, floor drains, or parking lots? If yes, give a description.

_____

_____

_____

2. Does the facility have a permit? _____

3. What is the current status of wells (active, abandoned, under construction, repairs)?

_____

_____

4. If the wells are inactive what was the date they were last used? _____

SDWA-PWS

Interview Questions/Records Review

1. What is the facility's source of drinking water? Does the facility have a private well? How many people does it serve?

2. Is the water sampled and analyzed for contaminants? Are the results reported to the state or EPA?

ENVIRONMENTAL ASSESSMENT

1. Is there any evidence of environmental impacts that haven't been addressed? Possible examples include:

- additional evidence of spills, leaks
- vegetation damage in the surrounding area
- odors in the surrounding neighborhood
- neighborhood covered with "dusts"
- poor water quality in streams near the facility

2. Were there situations of possible excessive occupational exposure that should be referred to OSHA?

R0015021

*U.S. GOVERNMENT PRINTING OFFICE:1997-521-739/90289 AIR FORCE:



United States
Environmental Protection Agency
(2223A)
Washington, DC 20460

Official Business
Penalty for Private Use
$300

R0015022

The Santa Monica Bay Restoration Plan

Actions for Bay Restoration

September 1994

Santa Monica Bay Restoration Project
101 Centre Plaza Drive
Monterey Park, CA 91754
(213) 266-7516

R0015023

Table 2-4a Examples of Facilities/Businesses Included in Standard Industrial Classifications

SIC	SIC DESCRIPTION AND EXAMPLES
02	AGRICULTURAL PRODUCTION (LIVESTOCK) - beef cattle, hogs, chickens, dairy farms, etc.
13	OIL AND GAS EXTRACTION - operating properties, producing natural gas liquids, field services,etc.
15	BUILDING CONSTRUCTION - single family housing, residential housing, non-residential housing, etc
16	HEAVY CONSTRUCTION - highways and streets, bridges, tunnels, earth moving, etc.
17	CONSTRUCTION (SPECIAL TRADE) - plumbing, heating, masonry, painting, carpentry, roofing, concrete, excavation, etc.
20	FOOD AND KINDRED PRODUCTS - meat products, dairy products, canned products, grain mill products, bakery products, sugar and confectionery products, fats and oils, beverages, etc.
22	TEXTILE MILL PRODUCTS - fabric mills, knitting mills, dyeing and finishing facilities, yarn and thread mills , etc.
24	LUMBER AND WOOD PRODUCTS - logging, sawmills and planing mills, structural wood members mfg., wood containers, etc.
26	PAPER AND ALLIED PRODUCTS - pulp mills, paper and paperboard mills, paperboard containers and boxes, converted paper products, etc.
27	PRINTING, PUBLISHING AND ALLIED INDUSTRIES - newspapers, periodicals, books, commercial printing, greeting cards, etc.
28	CHEMICALS AND ALLIED PRODUCTS - industrial inorganics, plastics materials, drugs, soaps and other cleaning preparations, cosmetics, industrial organics, agricultural chemicals, etc.
29	PETROLEUM REFINING AND RELATED INDUSTRIES - asphalt paving and roofing materials, petroleum and coal products, etc.
30	RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS - tires and inner tubes, rubber and plastic footwear and other products, gaskets and sealing devices, etc.
31	LEATHER AND LEATHER PRODUCTS - leather tanning and finishing, footwear, luggage, handbags, other personal leather goods, etc.
32	STONE, CLAY, GLASS AND CONCRETE PRODUCTS - pottery, glass and glassware, concrete and plaster products, cut and cut stone products, etc.
33	PRIMARY METALS INDUSTRIES - steel works, blast furnaces, rolling and finishing mills, foundries, smelting and refining, etc.
34	FABRICATED METAL PRODUCTS - metal cans and shipping containers, cutlery, handtools, plumbing fixtures, screw machine products, metal forging and stamping, coating and engraving, etc.
36	ELECTRONIC AND OTHER ELECTRICAL EQUIPMENT - electric transmissions, industrial apparatus, household appliances, lighting and wiring equipment, communications equipment, etc.
37	TRANSPORTATION EQUIPMENT - motor vehicles and motor vehicle equipment, aircraft and parts, ship and boat building and repairing, railroad equipment, motorcycles, bicycles, etc.
39	MISC. MANUFACTURING INDUST. - jewelry, silverware, plated ware, musical instruments, dolls, toys, games, pens, pencils, artist materials, notions, etc.
40	RAILROAD TRANSPORTATION - line haul operations, switching and terminal operations
41	LOCAL AND SUBURBAN TRANSIT - passenger transportation, taxicabs, buses, terminal and service facilities for motor vehicle transportation.
42	MOTOR FREIGHT TRANSPORTATION - trucking, warehousing and storage, terminal maintenance
43	U.S. POSTAL SERVICE - all establishments
44	WATER TRANSPORTATION - freight and passenger transportation, marina operations and services
45	TRANSPORTATION BY AIR - courier services, transportation, airports, flying fields, airport terminal services
49	ELECTRIC, GAS, AND SANITARY SERVICES - gas production and distribution, water supply, irrigation systems
50	WHOLESALE TRADE - motor vehicles and parts and supplies, furniture, lumber, commercial equip., metals, electrical goods, hardware, machinery, durable goods, etc.
55	AUTOMOTIVE DEALERS AND GASOLINE SERVICE STATIONS - car dealers, boat dealers, motorcycle dealers, etc.
75	AUTOMOTIVE REPAIR, SERVICES AND PARKING - car washes, upholstery shops, general repair shops, etc.

R0015024



FACILITIES IN THE SANTA MONICA BAY WATERSHED			POLLUTANT OF CONCERN														
SIC	INDUSTRIAL DESCRIPTION	# of fac *	Pb	Cr	Cd	Cu	Ni	Zn	Ag	PAH	PO4	NO3	NH4	TSS	BOD	COD	O&G
02	AGRICULTURAL PRODUCTION (LIVESTOCK)	5										X		X	X		
13	OIL AND GAS EXTRACTION	31	X	X				X		X			X	X	X	X	X
15	BUILDING CONSTRUCTION	79												X			
16	HEAVY CONSTRUCTION	6												X			
17	CONSTRUCTION (SPECIAL TRADE)	118												X			
20	FOOD AND KINDRED PRODUCTS	79				X		X					X	X	X	X	X
22	TEXTILE MILL PRODUCTS	39		X	X	X	X	X	X					X	X	X	X
24	LUMBER AND WOOD PRODUCTS	79	X	X	X	X		X						X	X	X	X
26	PAPER AND ALLIED PRODUCTS	11						X					X	X	X	X	X
27	PRINTING, PUBLISHING AND ALLIED INDUSTRIES	272	X	X								X		X	X	X	X
28	CHEMICALS AND ALLIED PRODUCTS	46	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
29	PETROLEUM REFINING AND RELATED INDUSTRIES	6	X	X				X		X	X		X	X	X	X	X
30	RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	32	X	X	X	X		X	X		X			X	X	X	X
31	LEATHER AND LEATHER PRODUCTS	20	X	X		X	X	X				X		X	X	X	X
32	STONE, CLAY, GLASS AND CONCRETE PRODUCTS	47	X	X		X		X					X	X	X	X	X
33	PRIMARY METALS INDUSTRIES	27	X	X	X	X	X	X	X	X		X	X	X		X	X
34	FABRICATED METAL PRODUCTS	131	X	X	X	X	X	X	X		X	X		X	X	X	X
36	ELECTRONIC AND OTHER ELECTRICAL EQUIPMENT	154	X	X	X	X	X	X	X					X	X	X	X
37	TRANSPORTATION EQUIPMENT	61	X	X		X								X	X	X	X
39	MISC. MANUFACTURING INDUST.	110		X	X	X	X		X	X				X			
40	RAILROAD TRANSPORTATION	11											X	X	X	X	
41	LOCAL AND SUBURBAN TRANSIT	33	X	X	X	X	X	X		X			X	X	X	X	X
42	MOTOR FREIGHT TRANSPORTATION	144	X		X	X	X	X		X			X	X	X	X	X
43	U.S. POSTAL SERVICE	21	X	X	X	X	X	X		X							X
44	WATER TRANSPORTATION	9	X		X	X	X	X		X							X
45	TRANSPORTATION BY AIR	41	X	X		X	X	X	X	X					X	X	X
49	ELECTRIC, GAS, AND SANITARY SERVICES	120		X		X	X	X						X	X	X	X
50	WHOLESALE TRADE	19	X	X	X	X	X	X		X				X		X	X
55	AUTOMOTIVE DEALERS AND GASOLINE SERVICE STATIONS	107	X	X	X	X	X	X	X	X				X	X	X	X
75	AUTOMOTIVE REPAIR, SERVICES AND PARKING	145	X	X	X	X	X	X	X	X				X	X	X	X

Pb	Lead	Ag	Silver	TSS	Total Suspended Solids
Cr	Chromium	NH4	Ammonia	BOD	Biochemical Oxygen Demand
Cd	Cadmium	PO4	Phosphate	COD	Chemical Oxygen Demand
Cu	Copper	NO3	Nitrate	O&G	Oil and Grease
Ni	Nickel	PAH	Poly Aromatic Hydrocarbons		
Zn	Zinc				

* Data provided by Los Angeles County, Department of Public Works for Santa Monica Bay Watershed; 1993

Table 2-4. Pollutants of Concern and Associated Standard Industrial Classification (SIC).

R0015025